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An Investigation of the Impact of a Flipped Classroom Instructional Approach on High School Students' Content Knowledge and Attitudes Toward the Learning Environment

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Toward the Learning Environment

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ABSTRACT

An Investigation of the Impact of a Flipped Classroom Instructional Approach
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The idea of the "flipped classroom" is a relatively new concept in education that has become increasingly popular. Instructors who flip their classrooms reverse the roles of school work and homework by recording video lectures for students to watch before coming to class. Students then work on their homework in the classroom while the instructor is present to help them. Very little research has been done on the effectiveness of the flipped classroom to determine if students can perform better on exams by learning in a flipped classroom environment, especially for high school demographics. The purpose of this research is to add to the body of knowledge and help provide data to investigate how well students learn physics content by using the flipped classroom in a high school physics class and identify students' attitudes towards the flipped classroom.

Seven periods of Physics with Technology at Lone Peak High School in Highland, UT were used in this study. Three of the classes were randomly assigned to be "flipped" while the other four were taught using what is considered a "traditional" method of instruction of physics, which is based on a guided inquiry method. The pacing and content was matched each day and all classes participated in the same labs, homework, quizzes and tests. The defining difference is the method which the content is covered. The flipped classes watched video lectures at home to learn the majority of the content, then did what is traditionally known as "homework" in class with the teacher present to help.

In this study, it was found that there was no statistically or practically significant difference in mean test scores for the first three units in a high school Physics with Technology class. Student responses on a survey also showed very little statistically different in the students' attitudes towards the classroom environment in either instructional method.

Keywords: flipped classroom, inverted, instruction, education

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1 INTRODUCTION

1.1 A Common Classroom Problem

Students frequently believe they fully understand a topic while it is being covered in class, but actually do not (Willingham 2003). Research shows us that two factors are especially important in causing this disparity: (1) the students' "familiarity" with a topic and (2) the students' "partial access" to information (Willingham 2003).

"Familiarity" is when a person or a topic appears to be familiar to an individual, even though the source of the familiarity is unknown. "Partial Access" is when an individual knows something about part of the topic. For example, a student might be asked a question that they do not know the answer to, but some related information comes to mind, which would make them think that they would recognize the correct answer if they could see it. A big problem with both "familiarity" and "partial access" in the classroom is that students may think they already understand the topic being taught, so they mentally shut down, which prohibits them from fully learning the topic (Willingham 2003). The students may then go home feeling confident in their knowledge, only to find out too late that they cannot complete their homework since they do not have the adequate comprehension. At this point, the teacher is not available to help answer any questions the student may have.

In addition to the issues of familiarity and partial access, the problems surrounding effective learning is further compounded by the fact that each student is unique and learns with their own style. To maximize student learning, teachers must be aware of how the students learn, and adjust their lesson plans to fit the needs of their students.

1.2 Learning Styles

Many educational professionals maintain that each student is unique and has his or her own style of learning (Ahanbor 2014). While some students prefer to work in groups, it has been shown that some students feel unfairly graded on group projects (Smith 2014). In addition, some students are inspired to be more creative when given more flexibility while other students need more guidance to be able to adequately complete a project. Gardner suggested that the brain has different styles in which it learns which he calls "intelligences" (Garner 2006). The multiple intelligences he proposed are: Musical-Rhythmic (mental acuteness to sounds, music, pitch, etc.), Visual-Spatial (ability to solve spatial problems such as navigation, mentally looking at an object from multiple angles, etc), Verbal-Linguistic (the ability to use words and language), Mathematical-Logical (dealing with logic, reasoning, numbers, etc), Bodily-Kinesthetic (control over bodily movements), Interpersonal (the ability to understand and work with others), and Intrapersonal (deeper understanding of one's self). These intelligences can be found in everyone; however, each person usually excels in one or two.

Even if students are consciously aware of their preferred learning style, they are usually not aware of each teacher's teaching style ahead of time and do not explicitly select their courses based on teaching style (Lage 2000). This means that under normal circumstances, each classroom is made up of students with various learning styles and are expected to learn from the teaching style presented to them. To help reach each student in the classroom, multiple teaching strategies have been developed and studied that have been shown to help students learn. Teachers should be aware of the various styles of students' learning and should study and implement the various teaching strategies to accommodate for the various students' needs.

1.3 Teaching Strategies

By using a variety of teaching strategies, teachers can more closely approach the learning styles of each of their unique students, rather than just the few who may learn in the same method that teachers prefer to teach. Becker and Watts (1995) explain, "[Teachers] should consider using a variety of teaching methods to actively engage our students. Variety in the pace and format of undergraduate classroom instruction-across different class periods and even within a particular class-may well be the missing spice of good teaching and enthusiastic learning."

Because of the diverse needs of all of the unique students, there are many different teaching strategies that have been studied and have shown merit to help students to increase learning in the classroom. From a review of literature, the following strategies have been found to be commonly used in physics classrooms. These teaching strategies typically fall into the categories of either direct instruction or inductive instruction.

One type of direct instruction is that of formal lecturing. Because formal lectures are frequently used in classroom teaching situations, this would seem to imply that there is some strong benefit to teaching in this method (Friesen 2011). However the strength of the traditional lecture based instruction has recently come under scrutiny (Conway 2014, Miller 2013). A minor modification to the lecture method that has shown improvements over a traditional lecture, especially for non-native English speakers, is to provide Lecture Captures (Shaw 2011). A Lecture Capture is when the instructor provides a video or audio recording of the lecture for students to watch on their own time. This model is still considered a "lecture model" as there are no other teaching strategies used other than providing an opportunity for students to re-watch a lecture that was performed earlier in class. Another modification to the lecture method is to break a large lecture-based class into smaller groups of between three to five students for study sessions. All the students still get the large lecture time as a class, but then get additional time to work in small groups, which provides time to better answer individual questions. When using this method, average test scores were anywhere between 10-20% higher for the students who participated in the afterhours study session, than students who did not (Lyon, 2008).

Many who oppose using lectures as the main source of teaching turn to inductive teaching methods. Inductive teaching is an umbrella term for any method that involves student participation by giving specific challenges or real-life problems to solve. The students then use that challenge as a prompt to guide their learning. Inductive learning most frequently involves using an Inquiry Approach, Problem-Based Learning, Project-Based Learning, Case-Based Learning, or just-in-time learning methods (Prince 2007).

Teachers who use Inquiry-Based methods present their students with a challenge that the students then complete in order to learn the material. There are varying levels of inquiry methods ranging from open inquiry to confirmation inquiry. Open inquiry is considered the highest level of inquiry where students form questions on their own, design an experiment to discover the answer to their question, and communicate their results to their peers and teacher. Confirmation inquiry is when students know the answer to a question ahead of time, and then complete an activity to confirm their knowledge. Inquiry Based Methods have been shown to be effective methods of instruction, especially in science classes. (Barthlow 2014)

Problem-Based Learning is a method of presenting a real-life scenario to small groups of students. The students first need to accurately identify what the problem is and then figure out what they need to know to solve their problem. Once they have identified what knowledge they are lacking to solve the problem, the instructor teaches the students, or guides them, to what they need to know to solve their problem.

Project-Based Learning is similar in structure to Problem-Based Learning, except instead of identifying a problem to solve, the students are given a challenge to produce something. Students are given a real life scenario, identify the problem, then develop or build something that would solve the problem. Students using Project-Based Learning have shown deeper understanding of the topics covered by offering interpretations of facts rather than simply fact-reporting (Tamim, 2013). It is also common for teachers to teach a hybrid method that involves both problem and project based learning activities.

In case-based instruction, students study historical or imaginary cases that have common scenarios that they might encounter in their lives. The major difference between case-based learning and problem-based learning is that case-based is typically more structured and students apply concepts that they are already familiar with. Case-based learning is most commonly taught in business management and law classes, but has been used to help teach science (Herried 1997).

Just-in-Time strategies involve the teacher adapting his or her lesson immediately based on student feedback. Students frequently are given questions to answer before class, which the instructor uses to modify his current lesson plans. An instructor may also use Just-in-Time as a strategy of teaching each student, or small groups of students, what they need only for a specific step on a task. Once the group gets stuck at the next step of the task, the teacher will step in again to give them just enough information to accomplish the next step in their task.

1.4 Traditional Classrooms

Since there are as many different teaching strategies as there are teachers, it is difficult to say that there is any one style of teaching that could be considered a "traditional classroom." These different strategies try to find ways to engage students in a more efficient manner, but all do so by completely different means. For this reason, educators should employ a variety of teaching strategies in an attempt to engage all of their students.

Although it is impossible to give a specific definition of a "typical" or "traditional" classroom, one common aspect between the various teaching styles is that the majority of learning happens in the classroom with the teacher providing the majority of the content knowledge and students are expected to practice and reinforce what they learned by doing homework after class. The term "traditional classroom" will refer to any teaching style where students come to class and the teacher presents content for the students to learn, and the students then practice what they were taught in school at home.

1.5 Flipped Classrooms

Each of the previously discussed teaching strategies attempts to increase not only the amount of teaching that happens in class, but the amount of learning that happens in each student. However, despite a teacher implementing one of the research strategies, students may still come away from lectures falsely believing that they understand the material (Willingham 2003). They may not realize they do not fully understand the material until later when trying to complete the homework on their own. A potential solution to this problem is a relatively new teaching strategy called “flipped learning.” Flipped learning attempts to have students learn a large portion of factual material at home, then come to class for enriching and strengthening activities to attempt to have students retain more information for a longer period of time.

Flipping the classroom (a.k.a “flipped classroom,” “flipped learning,” or “inverted learning”) is a teaching strategy that reverses the role of the classroom instruction and out-of-class homework. Students are provided instructional materials before class, which commonly involves a video lecture the teacher prepared in advance (Overmeyer, 2012). The students are required to watch the videos at home and take notes just as they would be expected to do during a classroom lecture. The students then come to class with a basic understanding of the content knowledge given from the video and complete what is traditionally known as “homework” in class in collaboration with the teacher. However, teachers are encouraged to not simply have students do rote paper work in class to fill the classroom time.

The two reasons why the flipped classroom can help solve the problem of students getting stuck on homework is that it: (1) opens more time in class for the teacher to go deeper into a topic which allows students to develop a better understanding of the content, and (2) the students are doing their homework in class where the teacher is available to help if they get stuck. The teacher is available to review the material as a group or help students one-on-one or in small groups with specific questions they have about the in-class work. The teacher can use any variety of strategies that a traditional classroom teacher might use. In this way, the flipped classroom is not simply a new technique to instruction that would replace other common classrooms strategies, but rather it is a way to maximize the amount of time teachers have with students doing higher level learning, rather than trying to get students to memorize a set of facts.

The idea of a flipped classroom has recently increased in popularity. As proof of that, the Flipped Learning Network, a leading website dedicated to the instruction of the flipped classroom, grew to over 14,000 members in the first year of being developed (flippedclassroom.org) and most recently reported over 22,000 registered users. This online network is designed as a massive forum for members to ask and answer questions, share video techniques, discuss their classroom experiences, and talk about their results. From the discussions on the forums, it is evident that teachers with a variety of teaching experience, as well as teachers from various grade levels, socioeconomic backgrounds, and ethnicities, are experimenting with flipped classroom strategies to motivate and teach their students. With all the growing excitement surrounding the flipped classroom, teachers need to know if students actually learn and retain information better while engaged in a flipped classroom environment.

1.6 Problem

From the review of literature, it was found that there are hundreds of articles and publications that refer to the flipped classroom, the teachers that use the method, or students' perceptions about it, but there is very little empirical data to quantify just how much students learn from the method (Hamdan, McKnight 2013). Of the limited data that exists, some of the data contradicts each other. Arnold-Gaza (2013) and Nielson (2012) have negative perceptions towards the flipped classroom as they found that many students prefer the traditional classroom over the flipped classroom or do not have the appropriate tools at home to perform the flipped classroom. However, Gaughan (2013) concluded that the flipped classroom was successful in their experiment. Goodwin (2013) stated, "To date there is no scientific research base to indicate exactly how well flipped classrooms work." The problem with understanding and accepting the flipped classroom as a valid method of instruction is that there has been comparatively little research done on the effectiveness and efficiency of students' learning from using the flipped classroom.

1.7 Purpose of the Research

The purpose of this research is to add to the body of knowledge and help provide data to investigate how well students learn physics content by using the flipped classroom in a high school physics class and to identify students' attitudes towards the flipped classroom.

1.8 Research Questions

Question #1:

Will exam scores of students in a flipped high school physics class differ statistically and practically from exam scores of students in a traditionally taught high school physics class when tested on content knowledge?

Question #2:

Will responses on a survey investigating students' attitudes toward the classroom environment differ between students in the flipped classroom and students in the traditional classroom and will these differences be large enough to be considered statistically and practically significant?

1.9 Definitions and Delimitations

The author realizes that some definitions are under debate by scholars. The following definitions will be used throughout this paper.

Flipped Classroom- (a.k.a flipped learning, inverted learning, flipped instruction) Any teaching style that involves a majority of the lower level learning (according to Blooms

Taxonomy) to be completed at home before class, usually by watching video lectures, and students then do what is traditionally known as "homework" in class the next day.

Traditional Classroom- Any style of teaching that involves the majority of lower level learning to be done in class with the teacher present, and students are expected to practice what they have learned by doing "homework" at home after the lesson has be taught.

Force Concept Inventory (FCI)- An internationally recognized test for students conceptual understanding of forces, kinematics, and Newton's laws.

2 REVIEW OF LITERATURE

2.1 History of Flipped Classrooms

The flipped classroom is considered a recent idea in the education field. The most commonly cited creators of the flipped model are Jonathan Bergmann and Aaron Sams when they flipped their high school chemistry classes in 2007 (The Flipped Classroom 2011). Though not commonly practiced before, some of the fundamental concepts of the flipped classroom have been around since the 1990's (Lage 2000). Bergmann and Sams flipped their classes and found that their students' test scores improved. They began publicizing their findings and developed a non-profit organization to assist other teachers in the process of flipping their classrooms. In only a few short years, their website, flippedlearning.org, reported that they grew to have over 22,000 registered users who are actively flipping their classroom.

2.2 Student Attitudes Towards Flipped Instruction

Some of the findings from research conducted thus far would indicate that students have a positive association with the flipped instruction (Herried 2013). For example, Zappe (2009) flipped a college architecture class and Ruddick (2012) flipped a college prep chemistry class and both found that students perceived the flipped instruction as a better or more efficient method of teaching. Additionally, Chester (2011) found that a flipped classroom improves student behavior.

In research done with an undergraduate world history course, 72% of respondents replied that the videos helped to prepare them either most of the time, or all of the time. 22% responded that the videos helped little to prepare for the following class (Gaughan 2014). In their survey, some students admitted to the difficulty in watching the videos ahead of time, which caused them to be unprepared for the following lecture. Although 72% responded that they watched either all or most of the videos, some students reported that some of the videos they watched were watched late. In all, Gaughan reported that the flipped classroom was, in her opinion, a "success" as a majority of students contributed to the class discussion with enthusiasm and comprehension (Gaughan 2014).

2.3 Improved Student Comprehension

In regards to improving student content knowledge, the findings in one recent research study have allowed researchers to indicate some improvement in student learning and total comprehension. Ruddick (2012) taught a college prep chemistry class and the research findings from this study indicated improvements in students in the flipped class's scores compared to student scores in a traditional classroom. He showed that not only was the average student score higher in the flipped class, but the percent of students performing at or above a C-level on the exam was greater in the flipped class. In a study at Virginia State University, an introductory course on psychology consisting primarily of African American students found that students in a flipped classroom environment scored 8.6% better in the class on average over the traditionally taught course (Talley 2013).

While testing the efficiency of Flipped Learning on undergraduate students in a multimedia class, Enfield (2013) found that after participating in Flipped Learning, 73.5 % of the students felt more confident in their ability to learn new material on their own as opposed to a formal class instruction model, while only 2.9% felt less confident. 61.8% responded that they are now more likely to use instructional videos to learn a new topic than they were before being introduced to the Flipped Classroom, while none responded that they were less likely to use instructional videos in the future. Even though videos occasionally had technical issues (streaming and downloading issues), only 32.4% reported that the technical issues negatively impacted their learning. 45.9% responded technical issues were annoying, but did not affect learning and 21.6% did not find technical issues to be annoying.

Evidence suggests that students require less time studying out of the classroom while participating in the flipped classroom. For example, when comparing students in an upper-level undergraduate engineering course, the traditional classroom reported spending 45% more time studying on average than students in the flipped classroom (8 hrs/week vs. 5.5 hrs/week on average) (Mason, 2013).

2.4 Negative Responses About the Flipped Classroom

Not all research has shown overwhelmingly positive responses. At Townson University, librarians decided to flip some of the courses they offer at the library. 90% of the 148 students who participated responded on a post-course survey that they had completed the pre-library (a.k.a. pre-class) assignments and that the pre-library assignments were helpful to learning. However, forty-five percent of the respondents still said that despite the pre-library sessions being helpful, they still prefer a traditionally taught class. The reasoning for nearly half of the class responding in favor of a traditional class was deemed inconclusive as very few respondents gave explanations or clarifications for their choices on the post-class survey (Arnold-Gaza 2014).

One educator gave 5 compelling reasons to be cautious of the flipped classroom (Nielson 2012). First, because of the strong dependence on technology, many students in underprivileged communities will not be able to watch videos ahead of time since they have limited access to technology at home. This argument may become less valid as time progresses and more underprivileged families can attain affordable technology. Second, lecture videos at home are still considered homework, which many students, especially K-12, are unmotivated to complete, regardless of which form the homework takes. The third argument is that flipping the classroom only provides more time for bad pedagogy. For example, one principal expressed optimism with the flipped classroom stating that it gave more time for teachers to prepare for tests. Nielson's concern is that some educators will use the flipped classroom as a method to give more information in a poor way, i.e. "teach to the test." The fourth argument is that the flipped classroom does not adequately adapt to students learning speeds. Students are required to watch one video at a time, staying on pace with the rest of the class. There is no mechanism to allow advanced students to progress through their education at an accelerated rate just by flipping a classroom.

The last argument from Nielson against the flipped classroom is that it is still considered a lecture based lesson, which is not a good method of learning for many students. Many students perform better under a more constructivist approach. This concern has been shared by others. One educator stated, "But just as the Khan Academy has recently come under fire from some in the education blogosphere for what critics say is flawed pedagogy, the flipped-classroom technique has also garnered criticism from some who believe that flipping is simply a high-tech version of an antiquated instructional method: the lecture" (Ash 2012). Ash continues by pointing out that simply flipping the classroom by making kids watch videos of lectures at home and doing homework in class does not actually change the way that students learn. It is simply a "better version of a bad thing." Ash concludes with some tips to better flip your classroom. She expresses that flipping your class entirely could be a bad thing, but by carefully selecting which parts to flip, and using the flipped technique as just one more educational tool, it could add value to students learning.

2.5 Force Concept Inventory

The Force Concept Inventory (FCI) is an internationally recognized test as a measurement of students understanding of force concepts. It was developed by David Hestenes, a professor at Arizona State University. The test focuses on six main topics; Kinematics, Newton's First Law, Newton's Second Law, Newton's third law, Superposition Principle, and kinds of forces. The FCI has been research extensively for validation and reliability (Savinainen 2008).

3 METHODOLOGY OF THE RESEARCH

3.1 Purpose

The purpose of this research was to add to the body of knowledge and help provide data to investigate how well students learn physics content by using the flipped classroom in a high school physics class and to identify students' attitudes towards the flipped classroom. The two research questions that were investigated were:

Question #1:

Will exam scores of students in a flipped high school physics class differ statistically and practically from exam scores of students in a traditionally taught high school physics class when tested on content knowledge?

Question #2:

Will responses on a survey investigating students' attitudes toward the classroom environment differ between students in the flipped classroom and students in the traditional classroom and will these differences be large enough to be considered statistically and practically significant?

3.2 Demographics

The target population is high school students enrolled in Physics with Technology at Lone Peak High School (LPHS) in Highland, Utah. Table 1 shows the demographics of LPHS as reported in the 2014 Report to Stakeholders.

Table 1 LPHS Demographics

Lone Peak High School Demographics	
Total Students Enrolled	2340
Student to Teacher Ratio	24-1
Racial Demographics	96% Caucasian 4% "Minority
Male/Female Percentages	51.5%/48.5%

Seven periods of Physics with Technology (PwT) with approximately 28-32 students in each class participated in the study. The students participate in classes scheduled as a "Block Schedule." They may register for eight total possible classes, with four classes that are specified as an "A day" class, and four classes assigned as a "B day" class. The schedule then alternates every other school day between A and B day schedules. Students in PwT consist of mostly sophomores (approximately 85%), with some juniors (10%) and seniors (5%). Four of the PwT classes were taught using traditional methods and three of the PwT's were taught using the flipped classroom. It was not possible to completely randomly assign students to different classes since students can select which courses to take. However, the classes can be considered quasi-randomly assigned since the computer that assigns classes uses an algorithm to place students in classes based on class sizes and availability. Although the individual students cannot be completely randomly assigned to a specific group, the classes were randomly assigned to either the control group or the treatment group by flipping a coin.

3.3 Baseline Knowledge

The Force Concept Inventory (FCI), a nationally accepted standard to measure students' comprehension of conceptual physics, was given to the students before instruction began to assist in setting a baseline for each class period's entry level knowledge. The FCI was not used as a final exam since the three units taught during the research time does not cover satisfactory information to see a noticeable difference in test scores. Instead, it was used to assist in setting a baseline to compare and confirm each period has similar average initial physics content knowledge at the start of the study.

Students in the treatment and control group were also compared by using their overall GPA prior to entering the physics class. Their overall GPA was the best method available to the researchers to compare students' previous study habits and learning aptitude. If the average GPA for each class is comparable, we can assume that the students have similar baselines in educational aptitude and work ethic, and would perform equally well in their physics class if conditions were similar.

3.4 Procedure for Flipped Classrooms

Three class periods were randomly assigned to participate in the treatment group as the classes that would be flipped. To implement flipped instruction, video lectures were recorded ahead of time by the instructor and uploaded for public viewing on YouTube. These lectures involve the teacher presenting information with visual graphics and real-life examples of the concepts being studied.

The style of the videos varied based on the instructor's time limits and/or preferences for a specific lesson. The first video of each unit was broader in the content that was covered to give an overview of what was going to be studied in the unit. The following videos were more specific and covered one or two topics for students to focus on. Some videos were "on-the-street" style where the instructor asked random participants in public places to participate in an interview or engage in an activity. These videos are edited to emphasize specific common misconceptions in the community and show methods of overcoming those misconceptions to gain a better understanding of the concept. Another type of video used in this study is a video lecture with the instructor lecturing and showing demonstrations. This approach is similar to a classroom lecture (although the setting of the lesson may or may not actually be in the classroom), except without any live audience participating in discussions. The most common style of video used in this study is a screen capture of a PowerPoint® lesson (or other similar presentation software). The instructor's face may be visible on screen while talking to the students.

The students were notified of which videos to watch by the teacher announcing it in class, as well as posted on the whiteboard and on the class calendar online. Students in the flipped class were required to watch the video lectures at home before coming to class the next day. Guided notes were available to download from the class website to help students take notes and focus on key elements in the video lecture.

From a pilot study conducted previously, it was determined that it was difficult to track which students watched the videos on time as software that records students watching behaviors was not available to the class. When asked about their video watching habits, students were quick to answer that they had completed the video lecture, but after only one or two probing questions from the teacher, oftentimes the students finally admitted that they had not completed the video on time. To help track which students watched the videos for this study, students were required to take an online quiz after watching the video and were allowed to use any notes they had taken during the video, which encouraged better note taking during the video lecture. They were informed that it was open notes and videos; if they were unsure of an answer to one of the quiz questions, they could look at their notes, or even re-watch the video to find the answer to the quiz question. The quizzes were online and graded immediately once submitted. If they got a question wrong, they could attempt the problem again for partial credit, but they could not redo an entire quiz once completed.

The two primary purposes of the online quiz taken at home is to more accurately record which students had completed the video lecture prior to class, and to help motivate students to watch the video before coming to class. Quizzes were graded and scored on a five-point system. The purpose of the five points was to help motivate students not only to watch the videos, but also pay closer attention to the lesson and try to do well on quizzes to evaluate their own learning. By the end of the experiment, the sum of all of the quizzes accounted for only 6% of their total grade.

At the beginning of class, the instructor led a class discussion, beginning with any questions the students had. The instructor was careful not to simply review the material in the video lesson again. The purpose of the discussion was not to give a complete review of the topic covered (although by talking about the subject, that automatically does become a review in and of itself), but to get feedback on what was not understood, or to give deeper explanations. Students then completed their "homework" in class in groups or partners with the teacher available for help, as well as work on labs or perform demonstrations of the concepts taught in the video.

3.5 Procedure for Control Group

The control group was taught using a teaching style that is commonly used to teach physics at the subject high school. This method primarily consists of guided inquiry method in which students explore concepts by being engaged in hands-on labs that demonstrate concepts being studied before any formal lecture is given. Following the labs and activities, classroom discussions were led by the teacher to help refine and expand upon principles learned by the labs or activities. Students also learned from demonstrations, lectures, discussions, and small group work. Students were then assigned homework problems that were similar to the problems and concepts learned in class that day. The following class period, students were administered a quiz to evaluate understanding on the previous day's content.

Content for both the control group and the flipped group was paced to match each day. All assignments, labs, activities, etc. that were recorded as part of students' scores were identical for both the control and treatment group. The instructor performing the experiment has experience with both the flipped classroom and guided inquiry methods of instruction.

3.6 Survey

At the end of the experiment, a survey was administered to each student to get their opinions towards the method of instruction they received. The first eight questions consist of a five-point Likert scale concerning their feelings towards school in general and how well they felt they learned in their physics class. Questions 9-13 were more specific about the flipped classroom and whether the students in the treatment group felt like the flipped class helped them to learn better (or if the control group thought that the flipped class would have helped to learn better.) The last question was an open-ended question where they could share their comments about the class. The entire survey is included in Appendix A.1.

3.7 Data and Instrumentation

The quizzes, labs, homework, etc. (any graded assignment) administered in each group were identical since the topics covered in each class each day were similar. The independent variable in this study was the method of teaching students; specifically, teaching one set of classes with a flipped method, while the control group was taught with variations on the inquiry-based method, a common method of teaching science classes. The dependent variable was identical end-of-unit tests administered to both groups for comparison. The end-of-unit tests were reviewed by five high school physics teachers to determine face validity as appropriate physics content covered during the units of instruction and on the test. At the end of the third unit, students completed a survey to compare students' attitudes towards the subject material, the class structure, and their teacher.

Students were compared based on end-of-unit test scores and survey responses over the space of three complete units (approximately one quarter of the school year). Three units of content were chosen in order to establish a sufficient time frame to see if there was any changing effects of using the flipped classroom. It was suspected that since the flipped classroom is a newer method of learning and many of the students have never participated before, it may take some time to become accustomed to the style of teaching. As students became more accustomed to the flipped classroom, there was the possibility that their average test scores may have increased.

3.8 Analysis

A comparison of difference in means using Analysis of Variance (ANOVA) was used to determine statistical significance of the class' survey responses and end-of-unit test scores. When multiple fields were analyzed simultaneously, Tukey-Kramer tests were used to help reduce the chance of an alpha type error. In addition to statistical significance, Standardized Mean Differences (SMD) were calculated to determine effect sizes and thus investigate any practical significance between the mean scores of the treatment and control groups. The advantage in using SMD is that it is independent from sample sizes. The effect size is defined as a difference in sample means expressed in numbers of pooled standard deviations. It was calculated by using the equation:

$$d = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{(\sigma_1^2 + \sigma_2^2)/2}} \quad \textbf{(3-1)}$$

Effect sizes are commonly considered to have small significance at a value of 0.20, a medium significance at 0.50 and large significance at 0.80. (Cohen, 1988)

4 FINDINGS

The purpose of this research was to provide data to investigate how well students learn physics content by using the flipped classroom in a high school physics class and to identify students' attitudes towards the flipped classroom. Class periods were randomly assigned into one of two groups by flipping a coin: the control group with a traditional instructional approach, and the treatment group that participated in the flipped classroom. The traditional group was taught using primarily guided inquiry with some direct instruction. The treatment group was taught by watching video lectures that were prepared by the instructor before coming to class, then participating in classroom discussions about the content covered in the video and doing their homework with a partner or small groups with the teacher present to help if needed.

Students were analyzed at the very beginning of the school year to determine if any difference in their average baseline physics knowledge exists for each class period. For the first three units (approximately the first quarter of the school year) the two groups' test scores were recorded and analyzed for tests of statistical and practical significance. A survey was administered at the end of the experiment to investigate any statistically or practically significant difference in the students' mean attitude towards the teaching method they received.

4.1 Student's Baseline Knowledge

Students in the Physics with Technology course (PwT) have a variety of backgrounds, prior knowledge, misconceptions, and work ethics. Therefore, the possibility exists that students could have either self-selected or randomly been assigned into different classes that would have a statistically significant impact on their test scores outside of the instructional process being used in the experiment (i.e. "smarter kids" were placed in one class more than another). Two methods were used to measure students' educational aptitude and prior physics content knowledge: comparison of the average cumulative high school GPA and the Force Concept Inventory (FCI) to test the average baseline knowledge of physics prior to taking the PwT class.

4.1.1 FCI-Comparing Baseline Prior Knowledge

The FCI was administered to both the treatment and control groups in the first week of school before any instruction on forces and motion had been given to either group. The data distribution is shown in Figure 1.

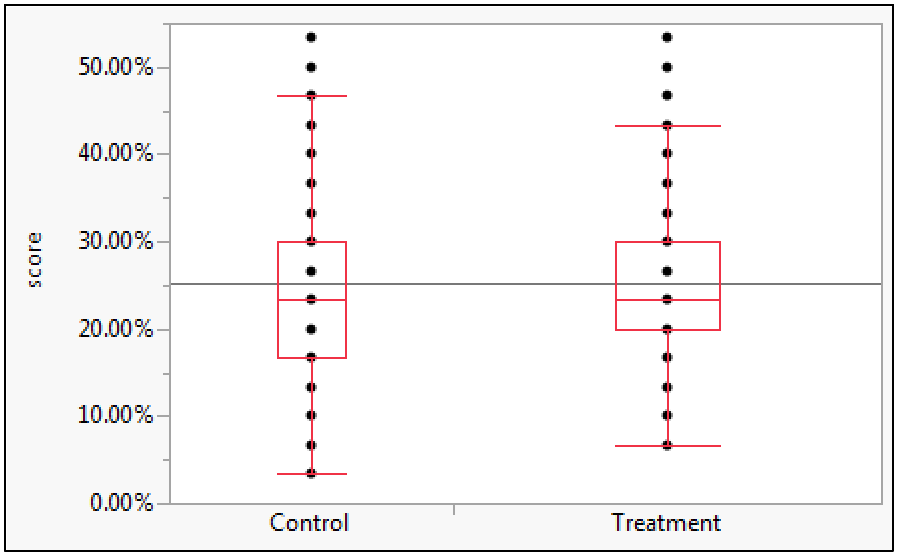

Figure 1: FCI

The mean score for the control group on the FCI was 0.2397 ($\bar{x}$ =23.97%) with a standard deviation of 0.113. The treatment group had a mean of 0.259 ($\bar{x}$ =25.9%) with a standard deviation of 0.104. The two sided p-value from a t-test with α=0.05 was reported to be 0.3008 which is large enough to determine that the difference in mean scores for the FCI was not statistically significant since any p-value larger than 0.05 is considered to be not statistically significant.

4.1.2 Comparing Cumulative GPAs

GPAs are commonly used to compare students' educational abilities and work ethic. Analyzing the cumulative GPAs for each class can help to identify baselines for each class. If the difference in means for the classes' average GPAs is negligible, we can assume the baseline for each class to be similar and any difference in means found in the experiment would represent real gains in learning through the different teaching styles. If any statistically significant difference in mean GPAs exists, it would need to be included in the statistical analysis of each test throughout the experiment to control for the initial bias. The box plots in Figure 2 graphically represent the distribution of GPAs.

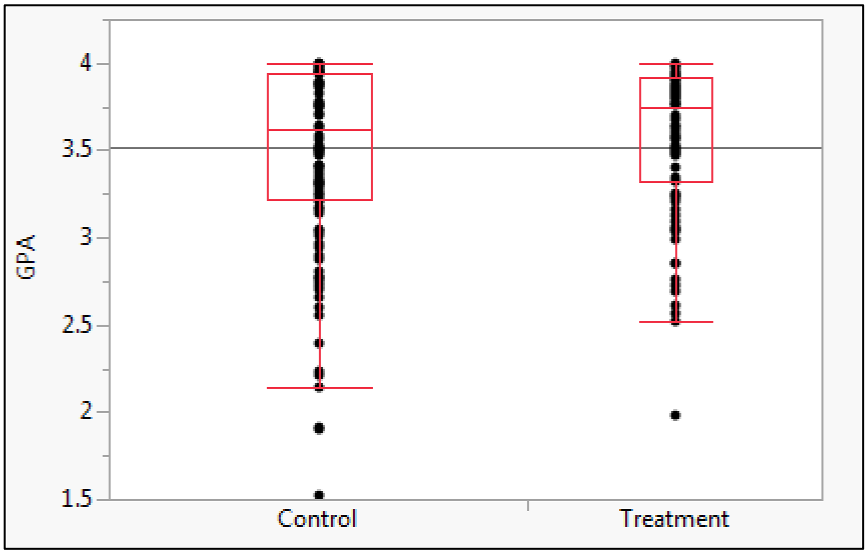

Figure 2: Cumulative GPA

The mean GPA for the control group was found to be 3.49 with a standard deviation of 0.534. The mean GPA for the treatment group was 3.56 with a standard deviation of 0.467. The two sided p-value of a t-test with $\alpha=0.05$ was 0.3413 which is large enough to show that the difference in means was not statistically significant.

Both methods of comparing the baseline of the students show that there was no statistically significant difference between the treatment and control groups' baseline knowledge. For this reason, we can assume that any difference in means on their end-of-unit test scores can be attributed to the method of instruction used.

4.2 Findings Relevant to Question 1

The first research question asked if there would be a statistically or practically significant difference in mean test scores between students participating in a flipped classroom vs students in a traditional classroom. Each test was analyzed individually to determine if there was any statistically or practically significant difference in means between the control group and treatment group. The end-of-unit tests are summarized in Table 1.

Table 1: End-Of-Unit Tests Summary

End-of-Unit Test	Mean Score (Control)	S.D. (Control)	Mean Score (Treatment)	S.D. (Treatment)	P-value (α=0.05)	SMD Effect Size
Unit 1	81.95	14.66	82.65	13.74	0.719	0.0500
Unit 2	78.85	19.07	79.72	14.83	0.7204	0.0509
Unit 3	65.82	19.09	67.56	18.09	0.5100	0.0935

4.2.1 Unit 1 Test Scores

Unit 1 was covered in the first approximately 3 weeks of school. While the unit does contain some new physics content, the majority of the content covered in this unit was review material of graphing and finding equations of lines that was taught in their previous year's math class. The mean test score for the control group was 81.95 with a standard deviation of 14.66. The mean for the treatment group was 82.65 with a standard deviation of 13.74. Figure 3 represents the distribution of scores for both groups.

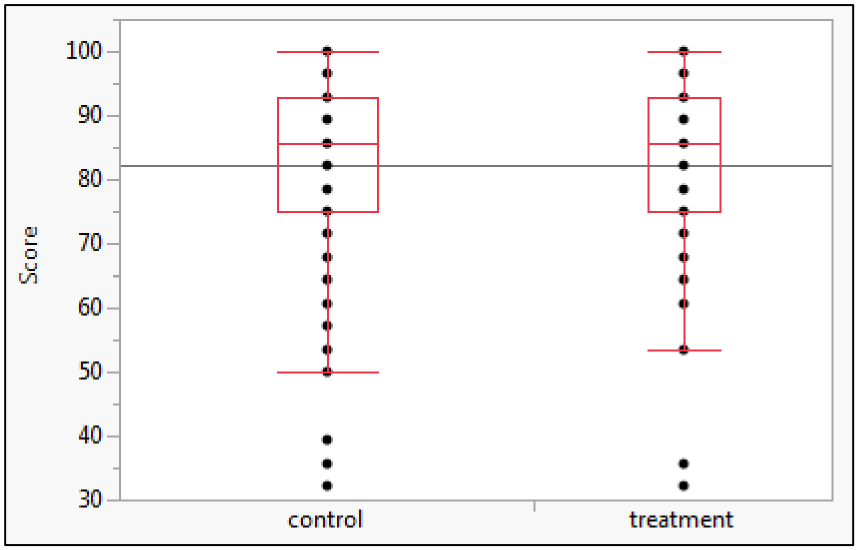

Figure 3: Unit 1 Test

By doing an ANOVA test, the p-value with α=0.05 is reported as 0.719. Practical significance was tested and an SMD effect size of 0.0500 was obtained. The P-value shows that there was no statistically significant difference in student mean scores for the Unit 1 test. The effect size is considered negligible since it is smaller than 0.2.

4.2.2 Unit 2 Test Scores

The control group's mean score for the Unit 2 test was 78.85 with a standard deviation of 19.07. The treatment group's Unit 2 mean score was 79.72 with a standard deviation of 14.83. Figure 4 represents the distribution of the data.

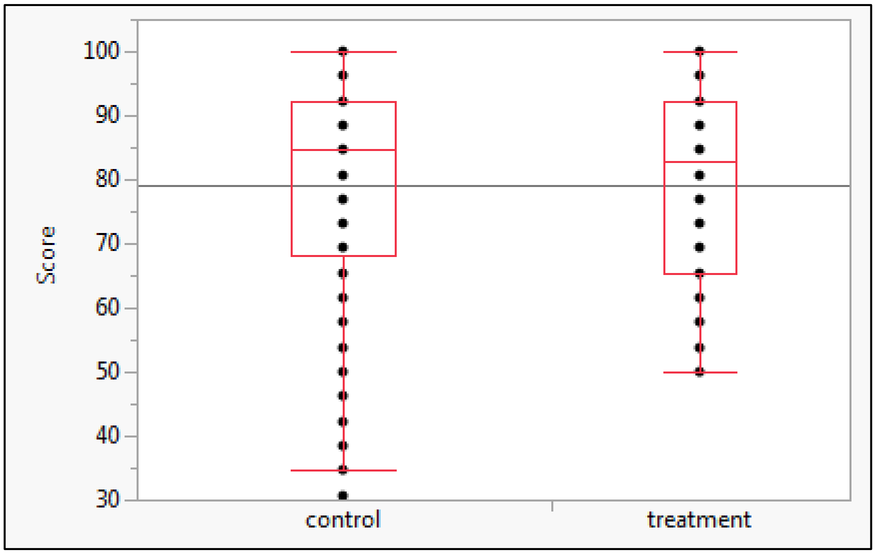

Figure 4: Unit 2 Test

The p-value from the ANOVA test for the unit 2 test results was 0.7204 with α=0.05. The SMD effect size was found to be .0509. Both the p-value and the effect size show that there was no statistically or practically significant difference in student mean scores for the Unit 2 test.

4.2.3 Unit 3 Test

The mean score for the control group's Unit 3 test was 65.82 with a standard deviation of 19.09. The mean score for the treatment's Unit 3 test scores was 67.56 with a standard deviation of 18.09. Figure 5 represents the distribution of scores.

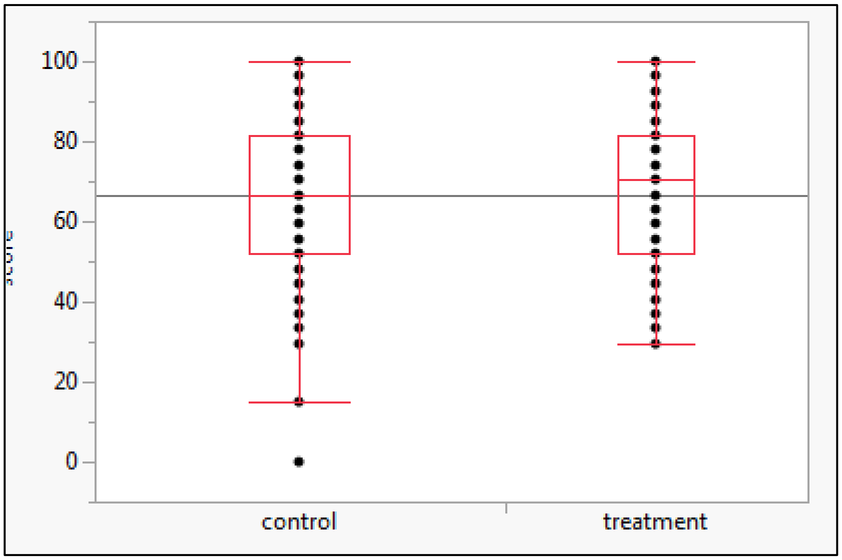

Figure 5: Unit 3 Test

The p-value from the ANOVA for the Unit 3 test was 0.5100. The SMD effect size was found to be 0.0935. The difference in student mean scores for the Unit 3 test was not statistically or practically significant.

4.2.4 Summary of Findings for Research Question #1

The first research question of this study addressed whether students in a flipped classroom can perform on end-of-unit tests better than students using a traditional approach. Data was collected on the students for the first three units of the school year (approximately the first quarter of school) in their Physics with Technology class at Lone Peak High School.

All three end-of-unit tests were compared using ANOVA to control for the increased probability of an alpha error due to multiple tests being conducted. Mean unit test scores were also compared using SMD effect sizes to determine any practical significance. It was found that none of the three end-of-unit tests had any statistically or practically significant difference in means. Although the mean test scores show that there was an overall trend of decreasing test scores, each unit test cannot be compared to the others. Each unit's test covers different topics and had different levels of difficulty.

4.3 Findings Regarding Research Question #2

The second research question asked if student attitudes towards their physics class and their learning style would be statistically or practically different. At the end of the experiment, a survey was given to each student. The survey questions are detailed in Appendix A.1. Because of the nature of the responses, only the first 11 of the 14 questions use the Likert scale and can be numerically analyzed to test for statistical significance. The computed means, standard deviations, and p-values are summarized in Table 2. The larger the SMD effect size, the more practically significant the difference in means. Positive effect sizes represent a more positive survey response to the question by the treatment group. Negative effect sizes represent a more positive response for the survey question by the control group.

For the first nine questions, the following five-point scale was used: a score of 1 was a strong negative association towards the question, a 3 was neutral, and a 5 was a strong positive association towards the question. Question #10 was also scaled between 1 and 5: a response of 1 would indicate that the physics class is extremely easy, a 3 would indicate that the class might be challenging, but it is as challenging as they would have expected for a physics class, and a response of 5 would represent that the class is extremely difficult. For question #11, a response of 1 would represent very little time, 3 is as much time as they would expect for a physics class, and 5 would represent that it takes up most of their free time. There were also three free response questions for students to freely express their feelings and opinions in their own words. From Table 1, question 1 has a small practically significant difference in means with an SMD effect size of 0.259, but it was not statistically significant with a p-value of .0798. Question 9 is statistically significant with a p-value of 0.0131 and a moderate amount of practical significance with an effect size of 0.366. No other survey questions were statistically or practically significant.

Table 2: Survey Responses

Question	Mean (Control)	Mean (Treatment)	Standard Deviation (Control)	Standard Deviation (Treatment)	P-value	SMD Effect Size
1. Overall, I enjoy going to school.	3.472	3.695	0.8908	0.8268	0.0798	0.259
2. I enjoy my physics class.	3.203	3.28	1.074	1.103	0.6301	0.070
3. I feel like I understand the physics content taught in this class.	3.38	3.476	1.213	1.135	0.5794	0.081
4. I like the way physics is taught in my class.	3.352	3.427	1.071	1.267	0.6593	0.063
5. I feel like I do well on my assignments in physics.	3.565	3.39	1.087	1.194	0.2949	-0.153
6. I feel like I do well on my tests in physics.	3.333	3.28	1.26	1.289	0.7771	-0.041
7. I can see that I am improving in my knowledge of physics.	3.806	3.817	1.089	1.017	0.9443	0.010
8. I know where to get help if I get stuck on a physics assignment.	4.009	4.073	1.164	1.131	0.7048	0.055
9. B-day: How much do you think the Flipped classroom has helped you learn? A day: How much do you think the flipped classroom WOULD help you to learn physics?	2.778	3.219	1.2177	1.187	0.0131	0.366
10. How difficult is your physics class?	3.333	3.195	0.8424	0.9615	0.3029	-0.152
11. How much time do you spend out of class on physics work?	2.907	3.024	0.08033	0.0922	0.3400	0.138

Questions 12-13 were open-ended questions to only the students who were in the flipped class to get feedback regarding the flipped classroom. Question 12 asked for the things they liked about the flipped classroom. There were a wide variety of responses with some of them not being pertinent to the research, so they were excluded. Student responses were (number of students that expressed similar comments, if any, are in parentheses):

"I like that we do homework in class where (the instructor) is there to help." (22)

"If I needed to look back on something I had learned, I was able to do that easier." (12)

"It gives me an opportunity to learn how to learn on my own." (2)

"What I liked most about the flipped classroom was the fact that we could basically sit home in our pj's and watch videos about physics and take notes. I also liked the fact that we do/take quizzes at home."

"I liked doing homework examples in class when everyone already had a decent understanding of it because it helped to solidify the information. It was nice because we had time to ask questions and use the information in examples rather than using the entire class period to learn the material." (3)

"Class time was more fun and engaging." (2)

"I liked that we were able to learn the same amount of material as other classes in a fifteen minute video instead of an hour long lecture. The flipped classroom was undoubtedly more time efficient. Also I always seem to learn better when I can review the material over and over and rewind videos, whereas in a lecture if you miss what the teacher says you can't rewind them. In addition I retained more information watching videos and taking quizzes than listening to lectures because the quizzes forced us to review the information and actually know the information presented in the video."

Question #13 asked what drawbacks there were to the flipped classroom style. Like Question #12, the responses were varied, and many responses didn't actually answer the question that was asked, or brought up negative attitudes towards other aspects of school that are irrelevant to the research, so they were excluded. Relevant ideas that were brought up were (number of similar responses, if any, are in parentheses):

"Not being able to ask questions to the video." (10)

"It was hard doing one flipped classroom and having all of my other classes be the regular. It really threw me off." (3)

"I felt like I couldn't learn as well this way" (4)

"I didn't like doing the OHW in class." (2)

"I don't really like watching videos to explain what I'm learning. I like it better to do it during class, that way when we are learning something new we can ask questions and understand the concept better before doing it on our own." (9)

There was also one topic that came up, but contradicted itself. Some students expressed the desire to spend more time in class reviewing the material since they didn't understand the video very well. Others expressed frustration that the class discussion took up too much time and we were just covering the exact same stuff they already learned from the video. Recommendations for potential ideas on how to alleviate this problem are addressed in the section on recommendations for further research.

Question #14 on the survey asked all students what other comments they had regarding the physics class and the flipped classroom. Most of the comments echoed the comments already mentioned for questions 12 and 13. Of all the responses, one stood out to the researchers as insightful and not already expressed in some way from the previous questions' responses:

"I think that normal class room and a flipped class room will yield the same results…because it truly depends on the students own work ethic and self-control. You could alter the class room as much as you would like but when it comes down to it, it really just depends on the students own integrity."

4.3.1 Summary of Findings for Research Question #2

At the end of the experiment, a survey was given to students in both the treatment and control groups to investigate any potential difference in students' perceptions toward their classroom environment. It was found that only one survey question showed any statistically significant difference in means: #9-How much did the students believe that the flipped classroom did/would help them learn. The students in the flipped classroom responded with a mean of 3.219, which corresponds to a slightly positive association towards learning in the flipped classroom. The students in the traditional class responded with a mean of 2.778, which corresponds with a slightly negative association towards learning in the flipped classroom.

5 CONCLUSIONS AND RECOMMENDATIONS

Advances in media technology over the last decade have made it much easier for teachers to flip the classroom by having students view video lectures before class and then perform their homework with the teacher as part of their classroom activities. Despite the current popularity of this teaching approach, there has been comparatively little empirical research conducted to determine its effectiveness in teaching high school students. The purpose of this research was to investigate (a) the effectiveness of using the flipped classroom in a high school physics with technology class and (b) identify students' attitudes towards the flipped classroom. In this chapter, the conclusions are organized by research question with recommendations on further research discussed at the end of the chapter.

5.1 Summary Relevant to Research Question #1

The first research question in this study addressed whether students in a "flipped" high school physics class can perform better on end-of-unit tests than students in a traditional class based on guided inquiry methods of instruction. Data was collected on the students for the first three units of the school year (approximately the first quarter of school) in their Physics with Technology class at Lone Peak High School.

Cumulative high school GPA's were recorded for each student and the FCI was administered to each student to compare baseline knowledge prior to beginning their physics course. Since both the Average GPA's and mean score on the FCI showed no statistical or practical significance, it was concluded that the baseline between both groups was close enough to not cause a statistically significant bias in the end-of-unit test scores. Therefore, any difference in means found in the end-of-unit tests was caused by the method of instruction.

The difference in means for the Unit 1 end-of-unit test was found to be neither statistically nor practically significant. Unit 1 is considered to be mostly a review unit of math skills students learned their previous year in their math class. There is some new content covered, but it is relatively little compared to the amount of material being reviewed. Although there might have been a difference in means from the style of instruction received while reviewing the content, it was not expected since the content should be familiar to the students already.

Unit 2 and 3 were an introduction to analyzing and describing constant velocity and constant acceleration motion. This topic has not been taught in depth previously in the students' other science classes. The difference in means on the unit 2 and 3 end-of-unit test was found to be neither statistically nor practically significant.

It is conclusive that in situations like the one in this experiment, students in the flipped physics class performed equally well as students in the traditional inquiry-based class. The traditional method of instruction in the experiment was based on guided inquiry methods, which has been shown to be an effective method of instruction, especially in science classes. (Barthlow 2014) Students began the unit with hands-on learning opportunities with a lab that demonstrates the major concepts being studied in the unit. Students were guided through the lab and discovered the scientific principles on their own. Students in the flipped classroom performed the same experiments, demos, and lessons, but received instruction before class with video lectures. Since they had already learned much of the material at home, the in-class activities became more confirmation-based learning (students perform activities that confirm their knowledge), rather than inquiry-based learning (where students discover concepts on their own). Since students in the flipped classroom performed equally well, on average, on their end-of-unit exams as the traditional students, it can be concluded that the flipped classroom is equally effective as guided inquiry for high school physics classes. This finding is especially impressive as there were several major limiting factors that occurred in the flipped classroom that are described below.

A major issue that came to light during this research study was the frequency in which the students were watching the assigned videos before class. The instructor reported that students frequently came to class unprepared by not having watched the videos ahead of time. The instructor made as many arrangements and accommodations as possible to encourage and remind students to watch the videos before coming to class. Announcements were given vocally to the class each day, as well as written on the whiteboard for all the students to see and listed on the calendar on the class website.

Students were given an online quiz to complete immediately after watching each video. The quizzes were designed to be video specific, in which the content on the quiz would be relatively easy for students who watched the video, but difficult for students to just randomly guess if they did not watch the video. Since there was no built in technological mechanism available to the instructor to keep track of which students watched the videos, the quiz scores that accompanied the videos were used to track which students watched the videos. Each day at the beginning of class, the quiz scores were recorded for that class period. There were a few incidents where students explained to the instructor that they had watched the video, but for some reason (whether technical problems or just forgetting) did not complete the quiz. However, these incidents were few and had little statistical impact on the outcome of the analysis. By looking at the quiz scores, it was determined that on average, 68% of the students came to class having already watched the videos before class. However, it was not possible to tell if and how many videos were watched late, and the number of times they were watched. To further investigate the frequency that videos were watched on time, watched late, and/or watched repeatedly, students received an anonymous three question follow-up survey. The three questions were:

1. How often did you watch the videos on time?
2. How often did you watch each of the videos in total (both on time and late combined)?
3. How often did you re-watch each of the videos?

The three questions were based on a five-point Likert scale: a score of five on the survey would represent all or almost all of the videos, a four would be approximately 2/3 to ¾ of the videos, three would be approximately half of the videos, two would be approximately ¼ to 1/3, and a score of one would be none or almost none of the videos.

Table 3: Frequency that Videos Were Watched

Survey Question	Mean Response
1. How often did you watch the videos on time?	4.03
2. How often did you watch each of the videos in total, (both on time and late combined)	4.59
3. How often did you re-watch the videos?	2.4

It was found that for Question #1, the students reported that they had watched the videos on time with a mean response of 4.03 out of 5. Since a score of four corresponds to a 2/3-3/4 ratio of videos watched, their self-reported answers coincide with the results found from looking at the quiz scores with 68% watching the videos ahead of time. This is similar to the findings of Gaughan who found 72% of students came to class prepared on average each day (Gaughan, 2014). Of the 80 students who responded to the follow-up survey, 30 (37.5%) said they watched all or nearly all of the videos on time, 31 students (38.75%) reported that they watched 2/3-3/4 of the videos on time, 13 Students (16.25%) of the students watched half of the videos on time, and the remaining 7.5% of students watched none, or nearly none of the videos on time.

Students responded to Question #2 (i.e., watched videos on time and late) with a mean response of 4.59. Of the 80 survey responses, 71% responded with a five, showing that 71% of the students did watch all or nearly all of the videos at some point during the unit being studied. Another 21% of the students responded with a four, which corresponds to those students having watched 2/3 to ¾ of the videos. Only two students (2.5%) responded that they watched none or nearly none of the videos at all.

Students responded to Question #3 (i.e., frequency of re-watching the videos) with a mean response of 2.4. The majority of students reported that they rarely re-watched videos (28.75% responded with a one, and 30% responded with a two). 18 students (22.5%) responded that they re-watched approximately half of the videos, eight (10%) responded that they re-watched between 2/3 and ¾ of the videos, and seven (8.75%) of the students re-watched all or nearly all of the videos.

If on any given day, only 68% of the students watched the video the night before, this poses two major questions that teachers of the flipped classroom need to be aware of: What are they going to do in their lesson plans to accommodate the 32% of the students that are not prepared for that lesson? And what are they going to do to motivate the approximately quarter of the students who regularly show up unprepared? To answer to the latter question, it is important to understand the students' motives for not watching the videos before class.

At the conclusion of the experiment, students were interviewed face-to-face in focus groups so that the interviewer could ask probing questions regarding the flipped classroom as well as ask follow-up questions to any responses the students gave. The treatment group was split into three separate focus groups and the same question was asked to each group, although follow-up questions varied from group to group depending on students' responses.

Students were asked what limiting factors played a role in preventing them from watching the videos before class began. The interview was designed to leave the question open ended so students could respond with their specific situation, rather than feel like their answer had to fit into one of the "multiple choice" type answers. Because it was more open ended, there was little quantifiable data to help determine how many students struggled with each of the provided responses. However, the interviewer took notes during the three focus groups' interviews to compare answers between the three groups.

The first comment made in each of the three focus groups was that they simply forgot to watch the videos. Although a specific count of the number of students who agreed with that comment was not recorded, the interviewer noted that many students either nodded silently in agreement, or vocally addressed similar comments. Based on the reactions and comments made regarding the limiting factors of watching videos on time, it is believed by the interviewer that this was the most common problem among the students. In each of the three focus groups, the follow-up question to the comment on forgetting to watch the videos was whether homework in general is hard to remember, or if watching videos specifically was harder to remember than doing a "regular" homework assignment. A few students replied that the videos were harder to remember than "regular" homework. The students claimed that since watching videos was so easy to do, they did not worry about it, and therefore forget to do it when they get home. However, even though a few students believed the videos were specifically more difficult to remember, a majority of students who said they sometimes forgot to watch the videos said that homework in general is hard to remember to do. The big drawback they find with the flipped classroom is that with a more traditional paper homework assignment, if they forget to do it, they can work on it in a different class the next day before turning it in to the assigned class. Since the flipped classroom's homework was to watch videos, it was more prohibitive to do those during other classes than a traditional homework assignment.

Another common topic in each of the three focus groups was that there were occasionally technical issues that prevented them from watching the video on time. The term "technical issues" in the context of the interview consisted of two main issues: Non-functioning computers and unavailable computers. Non-functioning technical issues involved computers that had crashed or had Internet connection problems. Unavailable computers meant that the students had access to a computer, but it was unavailable due to siblings also working on homework, or their computer filters blocked YouTube, where the video was hosted.

The rest of the comments were similar to excuses for not doing any type of homework assignment. Several students freely admitted to "being lazy" and just not wanting to do their homework, even though they knew they had homework due. Other students reported that they simply did not have time to watch videos at home because of extensive extra-curricular activities and work schedules. When asked if that was a problem unique to the flipped classroom or if it occurs with all homework, the students responded it is a common problem. However, since the flipped classroom is so technology dependent, the lack of accessible technology while "on-the-go" compounds the problem of having a lack of time. For example, a paper assignment can be taken with them while out-and-about, but the flipped homework requires them to be at their computer taking notes while watching the video, which is harder to do while "on-the-go" (although it was admitted by the students they do not necessarily take the traditional homework with them, but at least the flipped homework made it virtually impossible for them to try to take it with them). These comments from students partially confirm Nielson's cautions that students, especially K-12 students, are unmotivated to do homework (Nielson, 2012).

In two of the three focus groups, the conversation lead the interviewer to ask a follow-up question about how many students still prefer the flipped classroom method in their physics class, despite the complications they faced with the videos. Approximately 80% raised their hand to signify they would prefer to continue with the flipped classroom for their physics class. No claims can be made regarding whether students would prefer this method for all of their classes as it was asked only if they would like to continue using the method in their physics class.

From the focus group interviews, it was concluded by the interviewer that a majority of the problems surrounding the issue of not watching the videos on time are not unique to the flipped classroom, but are encountered independently of which type of homework is given. This leads the researchers to believe that this issue is most likely not easily fixed by making small changes in how the flipped classroom is implemented by the instructor, but is a serious issue that will most likely occur regardless of how carefully an instructor implements the flipped classroom. However, this is an area that needs to be investigated and more research is recommended on methods to increase the quantity of students watching videos before class.

Some of the responses from the students suggest that videos were not watched because the students didn't fully appreciate their importance. Anecdotal evidence from the instructor's perception of classroom conversation shows that students watch the videos once they realize they need the information to get past the next hurdle (e.g. the next homework problem, test preparation, etc.). Over the last few years, the instructor in this experiment had provided occasional "homework help" videos throughout the school year that were not required viewing for the class, but provide help for homework problems and test preparation. These videos are often seen as extremely helpful, and students have historically never complained about the presence of those videos. This could be because the video is "just-in-time" where students understand why they need the video to help them. However, students who are required to watch videos before understanding why it is being watched and what they need from the video are less likely to pay close attention, or watch it at all. Therefore it appears that whether student watch videos or not is conditioned on the need for information in the video. Further comments are made in the section on recommendations for further research.

The researcher found it interesting that despite only 68% of students on average watching the videos each day, the students in the flipped classroom still performed equally well on their end-of-unit tests. The researcher suspects that increased levels of participation in watching videos on time would help to increase the flipped students mean scores. The researcher believes that the flipped classroom is a viable method of instruction and despite the complications of motivating students to proactively watch the videos on time, it shows promise in helping students to learn effectively.

5.2 Summary Relevant to Research Question #2

Research question #2 related to the student's attitudes towards learning in the flipped classroom. At the end of the experiment, a survey was given to each student to compare the attitudes and feelings of the students in the flipped class vs the students in the traditional class. The survey questions are detailed in Appendix A.1. 11 of the 14 questions used a five-point Likert scale and were analyzed to find any difference in attitudes between the two different groups. It was found that only one question showed any statistically significant difference in means.

Question #9 on the survey was worded differently for both groups. It asked the students in the flipped classroom how much they think the flipped class helped them to learn, and asked the control group how much the students thought it would have helped them. The average response from the flipped class was 3.219, which showed a slightly positive response towards the flipped classroom helping students learn. The control groups mean response was only a 2.778, which shows they have a slightly negative association with learning in the flipped classroom. With a p-value of .0131 there is evidence to suggest that the difference in means is statistically significant.

This difference in means was interesting to the class instructor as students and parents expressed a lot of interest in the flipped classroom when the experiment was first presented. It is uncertain what the attitudes were of the students before the experiment began since no data was collected on their attitudes at the beginning of the experiment. It is possible that overall, the students were not excited for the flipped classroom, and only a small minority that did like the idea was vocal and expressed their enthusiasm. Another possibility is that the students in the control group at the beginning of the experiment really liked the idea of the flipped classroom as their vocal comments suggest, but learned to enjoy the traditional method of instruction more as time progressed. More research is recommended to investigate how students' attitudes change over time between different methods of instruction.

The researchers were surprised to find so many survey questions have no statistically or practically significant difference in means. Most questions on the survey were directed toward the physics classroom specifically to see if the different teaching styles changed the way they viewed the topic of physics in school, which showed no statistical difference in means. However, there is evidence to suggest that the mean response on questions specifically regarding which method of instruction they preferred did have a statistical difference in means. It appears that while students may prefer one teaching style over another, the style of instruction did not actually affect their view on the topic being covered in class. This suggests that changing the style of instruction to a flipped method will not influence whether or not the students like the subject matter more.

5.3 Instructor's Perceptions of the Flipped Classroom

Although not part of the original research questions, the instructor's perceptions of the flipped classroom are an invaluable resource to other teachers contemplating a switch to a flipped classroom. The instructor's comments and perception of the flipped class is included here to assist other teachers in their decision.

It is not believed that the flipped classroom is the "silver bullet" to fix all of the problems that educators face in their classroom. It is another tool to be used as part of their overall instructional strategy. The simple act of flipping the classroom will not likely change how students learn or change the student's attitudes towards education. However, if used properly and in conjunction with a variety of other instructional methods, it can be an invaluable resource for many students who struggle with traditional education.

While the study does not show a statistically significant difference in mean exam scores or survey responses, the instructor feels there is a difference in the relationships with the two groups. The instructor feels a closer connection with students in the flipped classroom, most likely due to the fact that the instructor has more one-on-one time with each student during class time. Students in the flipped classroom appear more willing to open up about specific problems they face and come for additional help.

One aspect of the flipped classroom that is challenging is providing ample material for students. Most instructors (including the instructor in this research) have limited experience creating multi-media presentations. The shortest videos took approximately 2-3 hours to create, including the time it took to organize and plan the lesson, recording time, and editing time. Some of the longer videos (mostly the "on-the-street style and "real-life" examples videos) took several days to create. Many of the shorter videos already had PowerPoint® slides created from previous years' lessons. It is suspected that new teachers who are starting their flipped classroom from ground-up may spend significantly more time creating videos. Some may argue that it is time that is only spent once as videos could be reused each year, which is true. However, the instructor in this experiment found that as experience was gained in creating the videos, he spent more time re-recording and editing some of the previous year's videos.

Another difficult part of the flipped classroom is insuring a high quality of instruction in each video. It is difficult to gauge beforehand how well a video will be received by the students and how well they will learn from that video. This problem may be alleviated with experience and looking for open and honest feedback from students about the quality of the videos and suggestions for improvements.

5.4 Recommendations for Further Research

The experiment was performed at a public high school in Highland, UT where the demographics are primarily affluent with strong support from parents. Our results cannot be extrapolated to the general population since the demographic is so homogeneous. Further research should be performed on different demographics of socioeconomic status to see what effects the flipped classroom has on different socioeconomic backgrounds.

Most of the videos were screen captures of PowerPoint® presentations with the instructor's voice providing the narration. These PowerPoint® presentations have been used for several years (with occasional modifications each year) by a few different Physics teachers at Lone peak High School who collaborate together each week. This provides at least a small amount of face validity to the quality of the videos, but there was no formal method of evaluating the quality of the videos. Further research should be done on video quality, i.e., what effect the quality has on student learning, as well as what makes videos more or less efficient so teachers can provide high quality videos to their students.

The largest struggle the instructor had with the students during the research was to get them to watch the videos before class. It was common for between ¼ and ½ of the students to show up to class without having watched the videos before class. It is unknown what effect this had on the data. Further research should also be done to find methods that effectively encourage students to watch their videos before class, as well as research on how much each video watched correlates to an increase in their test scores.

A possible solution to the last recommendation is to provide videos to be watched "just-in-time" with students' needs. These "just-in-time" videos would be watched by students as they encounter specific problems they cannot overcome on their own. These types of videos are often provided by teachers who record themselves solving problems form their homework and assignments so that students can receive help while working on their assignments at home. Further research is recommended on the effectiveness of using videos as "just-in-time" methods of instruction to help students learn. It would be interesting to see if there would be any statistically significant difference in mean test scores between two groups that receive equal instruction in class, but one group is made aware of the optional help from the video at home.

At the beginning of the experiment, the vocal majority of the students were in favor of the flipped classroom, but no data was collected to see what the total responses were. The researchers found that there was very little statistically significantly different between the attitudes of both groups at the end of the experiment, but it is uncertain if there was any difference in opinions before the experiment began and if students' attitudes changed during the experiment. Further research should be done to monitor students' attitudes about the method of instruction as time progressed to see if their attitudes changed in any way.

Students commented that either the classroom discussions were either too long and just repeated concepts already covered in the videos, or the discussions were too short and students continued to struggle on the concepts. Students that learn more quickly found the videos to be adequate, but the students who are slower struggled with the video. They can rewind and watch it again, but even then, some students stayed confused as the explanation given just didn't make sense to them. One recommendation would be to provide multiple resources for students to learn the concept, rather than one 10-15 minute video. In that way, slower students have more opportunities to learn the material in a variety of methods without making the faster students feel like they are required to spend as long as the slower students. Further research could be conducted to find how much of an effect it would have on students' scores and attitudes when various resources are provided for each topic.

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APPENDIX A.

A.1 Survey

The 14 question end-of-experiment survey was given to each student to compare feelings and attitudes towards the physics classroom and the method of instruction they received. For the first 8 questions, a 5 point Likert scale was used where a score of 1 was Strongly Disagree, 3 was Neutral, and 5 was Strongly Agree.

1. Overall, I enjoy going to school.
2. I enjoy my physics class.
3. I feel like I understand the physics content taught in this class.
4. I like the way physics is taught in my class.
5. I feel like I do well on my assignments in physics.
6. I feel like I do well on my tests in physics.
7. I can see that I am improving in my knowledge of physics.
8. I know where to get help if I get stuck on a physics assignment.

Questions 9 through 11 were more specifically directed to the flipped classroom. They were also a 5 point Likert scale. 12-14 were free response questions.

9. B-day: How much do you think the Flipped classroom has helped you learn? (A day: How much do you think the flipped classroom WOULD help you to learn physics?)

10. How difficult is your physics class? (a score of "1" is considered very easy, "3" would be considered to be a challenging class, but acceptably challenging, and "5" would be considered extremely difficult)
11. How much time do you spend out of class on physics work? (A score of "1" would be considered very little or no time at all; "2" would be some time, but not as much as you would have expected for a physics class;"3" would be considered to be as much as you would expect for a physics class; a score of "4" would represent that you spend more time than you expected out of class for a physics class, but it does not consume all of your free time; and a "5" is way more than you would expect for a physics class and it takes up most or all of your free time.)
12. For B day: What did you like the most about the flipped classroom?
13. For B day: What did you like the least about the flipped classroom?
14. Are there any other comments you would like to share that relate to the flipped class? Both A day students and B day students are encouraged to answer.