

CONSTRUCTIVISM: THE EFFECTS OF THE FLIPPED CLASSROOM  
INSTRUCTIONAL MODEL ON HIGH SCHOOL  
SENIOR AP BIOLOGY STUDENTS

by

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## ABSTRACT

Evaluating the effectiveness of the flipped classroom method of instruction on high school senior AP Biology students was the focus of my action research project. I was interested to see if the flipped classroom would impact my students understanding of the concepts required by the College Board. Additionally, I wanted to see the effects of the flipped classroom on students' higher-order thinking skills and their ability to complete inquiry-based labs. Finally, I wanted to determine the effects of the flipped classroom on my role as an AP Biology teacher.

I chose to move my lectures outside of the classroom and had students watch my pre-recorded lectures accompanied by a PowerPoint presentation for a homework assignment. Two separate Biology units were observed, one included the flipped classroom model and the other was taught using routine teaching strategies and traditional lecture format. Students were also required to participate in an online discussion of the video lectures and were assessed on their understanding of the video content the following class period by a quiz. Students were surveyed prior to the treatment and following the treatment regarding their understanding of the flipped classroom as well as the concepts to be covered during the intervention. A select group of students were interviewed pre and post treatment to glean their ideas about the flipped classroom and its effects.

The majority of student feedback thought the flipped classroom was effective in learning the concepts, increasing student teacher interactions, increasing their higher order thinking skills and helping them complete an inquiry based lab. Data from assessments did not support an increase in understanding in the flipped classroom as opposed to a traditional classroom, however the gap between the two classes of AP Biology students was narrowed by the use of the flipped classroom. Overall the flipped classroom did not appear to have a significant impact on student learning, however, for many students the increase in understanding was encouraging and their reaction positive.

## INTRODUCTION AND BACKGROUND

As an Advanced Placement [AP] Biology teacher, I have struggled with the amount of content and deep level of conceptual understanding my students needed to develop prior to the AP Biology exam in early May. My lectures have tended to focus on quantity not quality and this has led to students struggling with difficult concepts and complex processes. In my attempt to cover as much material as possible, conceptual development and progress was sacrificed, as was the practice of higher-order thinking skills. This has been a problem many AP Biology teachers and the National Research Council have voiced, and it was addressed by the College Board in the updated redesigned curriculum two years ago. The amount of content was reduced, and the new curriculum allowed time for greater focus on inquiry-based labs and higher order thinking skills. These labs required a greater time commitment than gained by the reduction of the quantity of concepts in the redesign. I was concerned incorporating more inquiry-based labs sacrificed needed lecture time. For conceptual development, I found that lecture time was reduced, but needed, in order to efficiently advance basic concepts. One possible solution was to move lectures outside of the school day, and use class time to guide inquiry, increase application of students' higher order thinking skills, and provide practice to develop concepts. This is the idea behind the flipped classroom instructional model, and I was curious whether flipping my classroom would increase comprehension of concepts.

For this action research-based classroom project a flipped classroom is an instructional practice in which the traditional lecture is done outside of class as

homework, and the discussion, processing, and review of the material is done during class. This enables the teacher to be a facilitator of material, and class time can be dedicated to more engaging activities and labs. Inquiry-based labs are guided open-ended investigations in which the student poses the problem or question and then develops the procedure to test a hypothesis with the teacher's guidance. Using a flipped classroom instructional practice was the focus of my capstone project which I implemented into my classroom.

The project focus question was what are the effects of the flipped classroom model of instruction, which included pre-recorded lectures, on-line discussions, and daily quizzes, on student understanding of AP Biology concepts? To support this project I also developed the following subquestions: what are the effects of the flipped classroom instruction model on student-teacher interactions; what are the effects of the flipped classroom model on students' higher-order thinking skills; what are the effects of the flipped classroom model on students' completion of inquiry-based labs; and finally what are the effects of the flipped classroom on my role as an AP Biology teacher? The results of this project will prove useful to AP instructors and their students. Teachers grappling with limited lecture time may choose to convert their classes to the flipped model and students may seek out videos online to reinforce the concepts they are learning in class.

I currently teach AP Biology to seniors at Walpole High School in Walpole, Massachusetts. Walpole is a suburban high school and AP Biology consists of two sections totaling 50 students, classes meet for 68 minutes five times in a seven day cycle for a total of 340 minutes every seven days. All of my students are seniors. I have been

teaching AP Biology for 12 years using a mostly traditional lecture format. Although the AP Biology scores have been consistently strong, the AP Instructional Planning Report (2013) from College Board indicates there is room for improvement.

### CONCEPTUAL FRAMEWORK.

The flipped classroom was developed by Jonathan Bergmann and Aaron Sams in 2008 at Woodland Park High School in Woodland Park Colorado to aid students who had missed classroom lectures (Tucker, 2012). The conceptual framework of this project strives to investigate the effects of a flipped classroom on students' understanding of AP Biology concepts through review of previous classroom implementation of this instructional practice. It further investigates the effect of the flipped classroom on student-teacher interactions, as well as students' higher order thinking skills and their ability to complete inquiry-based labs. Finally, this conceptual framework will examine how the flipped classroom affects my role as an AP Biology teacher. The idea of a flipped classroom is founded in constructivism, and I will begin by explaining how a flipped classroom flows from this approach.

Constructivism is an education perspective in which students build their understanding of concepts through a combination of their existing knowledge and new experiences (Bächtold, 2013). Students who actively participate in their learning are one of the main focuses of science education, according to teachers who held a constructivist belief. Teachers guide the learning in a constructivist setting rather than just imparting knowledge to the students (Feyzioglu, 2012). The flipped classroom model embodies this type of learning by eliminating the traditional lecture from the classroom and

provides students with increased opportunities for active participation. In this way, students can build on their understanding of concepts and apply this knowledge in a supportive setting overseen by their instructor.

In traditional classrooms, teachers most often present concepts and then students are given an assignment based on the instruction to practice at home. The problem identified with this method is when students have questions or do not understand the assignment they need to wait until the next class period to clear misunderstandings. In the flipped classroom model, students spend the time at home watching or listening to the presentation and then work through an activity or assignment during class when the teacher is available for questions and discussion (Goodwin & Miller, 2013). Having the presentation available to students at home, allows them to replay it, stop it to take notes, or bypass those concepts they already understand. The lesson is constructive because it permits students to work through the material at their own pace (Goodwin & Miller, 2013). By removing the lecture from the classroom, teachers are free to meet with individual students one-on-one and assess their learning (Tucker, 2012).

Teachers often assign readings and conceptual reviews to students in order to have them prepare for class. The difference with the flipped classroom is that newer technology serves this purpose and is more engaging (Bergmann & Sams, 2013). When Bergmann and Sams first developed the concept of a flipped classroom, they did so to aid those students who had missed class and needed the instruction. They found the videos and screencasts offered high school Chemistry students, who had been present for the lecture, a chance to review and strengthen concepts they had struggled to master. There

are countless options in the types of technologies teachers can use to present their curriculum. Khan Academy, YouTube EDU, Vimeo, and PBS all offer quality videos that focus on specific content areas. Additionally, teachers can produce their own videos using a variety of software to record both audio and visual information. The use of the technology is one of the motivators to engage students in a high school science class although making sure everyone has access to the material may prove to be a stumbling block for educators (Ash, 2012). Ideally, students would come to class having viewed the material and then use class time to process the information.

This increase in class time, as a result of fewer in-class lectures, allows students and teachers to delve deeper into the content by focusing on problem sets, discussions, small group work, real-world applications, and collaborative learning (Tucker, 2012). More student-focused learning also provides the teacher the means to work individually with students or with small groups and assess their understanding and progress.

To gain a better understanding of how the flipped classroom affects student understanding, I researched articles that concerned teachers who have replaced the traditional lecture with the flipped classroom. At Bryon High School in Byron MN, Troy Faulkner (2014) adopted the flipped classroom model with his entire Math department. Over a period of three years, the school increased the number of students passing the state math test by 50 percent. The increase in the passing rate was attributed to increased student engagement during class time leading to greater student understanding.

The effect of the flipped classroom model on student-teacher interactions was another consideration in this project. In studies done by Moore and Gillett (2014), two

middle school math teachers, the flipped classroom model provided these teachers with increased class time to “engage with problem-solving practices, and get a clearer picture of how time spent working on challenging tasks in class influenced their knowledge and practices as mathematics learners” (p. 424). Moore and Gillett further explained the increase in class time provided more time to work with students individually on “higher cognitive demand tasks” (p. 424); thus, helping to deepen their understanding of the concepts. Moving the lecture outside of class, and homework into school affords teachers the time necessary to tackle higher-order thinking skills and greater opportunities for mastery.

Intrigued by the lure of more effective class time I was interested whether the flipped classroom had any effect on higher-order thinking skills for students. When Bergmann and Sams (2013) first began flipping their classrooms, they discovered instructional videos were valuable in shifting the lower levels of Bloom’s taxonomy out of the class enabling us to spend more class time at the upper end of the taxonomy, with tasks that ask students to apply, analyze, evaluate and create. (p. 18)

In other words, students process the concepts as they view the video and then can develop higher-order thinking skills during class time by a combination of activities and practices designed to challenge them and develop skills.

Since the increase in inquiry-based labs was stipulated by the College Board for AP Biology students (2012), I also wanted to see if a flipped classroom would have any impact on my students’ completion of an inquiry lab. In a study completed with

engineering students at the university level, Mason, Shuman, and Cook (2013) compared a traditional classroom with an inverted, flipped, classroom for 10 weeks. They found that students in the inverted classroom covered more topics during the 10 week period and were able to “solve four open-ended design problems versus one in the traditional classroom” (p. 432). When given the face-to-face instruction or guidance in the inquiry lab, students developed a greater understanding of the concepts (Bergmann & Sams, 2014). These studies indicate the increase in student-teacher interactions, coupled with practiced higher order thinking skills could have a positive effect on my AP Biology students’ ability to complete inquiry based labs.

My final project question involved the role of the teacher in flipped classrooms. In a pilot study done by Greenberg, Medlock, and Stephens (2011), high school algebra students were instructed to watch Khan Academy videos and given teacher support during a five week summer school program. Over the course of the study, the teacher appeared to develop four specific roles: “fostering a class culture of hard work and persistence, monitoring students throughout the period for motivation and learning, personalizing instruction and intervening when data shows that students are struggling, and building personal relationships of trust and caring” (Greenberg et al. p.3). A flipped classroom is a more student-centered environment and the teacher has the opportunity to become more of a facilitator, yet the teacher’s role is vital to student success.

After researching the flipped classroom, it was obvious I would need to prepare to flip my classroom. Teachers have used a variety of methods to change the traditional format in the classroom, such as creating screencasts of PowerPoint presentations for

students to view for homework. Others have assigned specific videos to view on YouTube or Khan Academy and then quizzed students the following day on the concepts covered. Teachers experienced in the flipped classroom method, have furthered the process by implementing a mastery learning practice (Bergmann & Sams, 2012). In this way students demonstrate proficiency on a unit or topic before moving on, allowing students to complete the topics at their own pace. The logistics of maintaining this type of classroom environment can only begin after establishing a flipped classroom system. In addition to prerecorded lectures and learning the software, I also needed to consider why I wanted to flip my classroom (Bergmann & Sams, 2012). Increased student-teacher interactions, developing higher-order thinking skills, an increase in completion of inquiry-based labs and facilitating student learning were my motivations for flipping my classroom.

While the concept of a flipped classroom is fairly recent, actively engaging students to increase their understanding of concepts has always been a goal of educators. From the review of the literature it appears that flipped classrooms may be a viable option in the AP Biology classroom to delve deeper into the concepts and increase students' higher order thinking skills and application of those skills. Switching lectures and direct instruction from the front of the classroom to an intriguing video or screencast will allow the teacher to spend much needed classroom time enabling and empowering student learning.

## METHODOLOGY

Evaluating the effectiveness of the flipped classroom method of instruction was the focus of this action research project. I chose to move my lectures outside of the classroom with the hope that it would increase student's understanding of Evolution, practice higher order thinking skills and develop stronger inquiry skills. Additionally, student-teacher interactions and the effects of a flipped classroom on my role as an AP Biology teacher were investigated. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (Appendix A).

### Participants

Walpole High School is a suburban public school in Walpole, Massachusetts with a population of approximately 1,200 students. Walpole is a predominantly Caucasian upper middle class town, roughly 25 miles southwest of Boston. The students who participated in this capstone project were AP Biology students. All of them were seniors in high school and they were chosen because they were the only students I taught as part of my position as Science department chair. The population of students consisted of 49 students, 23 in one section of the class, and 26 in the second section, 45 students were Caucasian students and 4 were Asian; 35 were female and 14 were male. Every student enrolled in AP Biology was required to complete Honors Biology, Honors Chemistry, and Honors Physics as prerequisites. These students were academically strong and most expressed an interest in science as a potential area of study in college. These students were highly motivated and most played a sport, held an after school job, and regularly

participated in extracurricular activities. The majority of students in the class represented the highest performing students in the graduating class. Incorporating student perspectives and data were an important part of this project.

### Intervention

Two separate Biology units were observed in this capstone project, one included the flipped classroom model and the other was taught using routine teaching strategies. A traditionally taught Genetics unit was administered during both the 2013-2014 and 2014-2015 school years. The treatment unit on Evolution was administered during the 2014-2015 school year. Two units were used to allow for comparison of the intervention. The treatment unit used the flipped classroom model of instruction as the intervention. Both units were taught to AP Biology students at the same high school with similar participant profiles. I chose to compare two separate years of students to allow for the most equity in the project. Comparing different units, such as Ecology and Genetics or Biochemistry to the Evolution unit would prove to be too diverse. Student understanding and success can vary with different topics. The 2013/2014 and 2014/2015 student populations had taken the same prerequisites for AP Biology, they all had similar capabilities and backgrounds and were analogous to one another.

The non-treatment Genetics unit began with a review of Mendelian genetics and the laws of inheritance. Students were required to solve genetic problems including multiple alleles, pedigrees and dihybrid crosses. The chromosomal basis of inheritance was then presented with sex-linkage, linked genes, chromosome mapping and genetic recombination studied sequentially. Calculations of Chi-Square, a statistical process for

determining data accuracy, were introduced and practiced in a virtual fly lab, and alterations of chromosome numbers and human genetic disorders completed the unit. The treatment unit on Evolution began with a study of Charles Darwin and his theory of natural selection. Evidences for evolution were then presented along with genetic variation and the evolution of populations. The Hardy/Weinberg theorem, criteria for determining evolving populations, was covered in detail and calculations of the Hardy/Weinberg equation were included in a simulation of natural selection lab activity. Gene flow, genetic drift and sexual selection were also included in the study of the evolution of populations, and the unit was completed with a study of phylogeny and cladistics. The videos, concepts covered, activities and labs in the Evolution unit were compiled (Table 1).

Table 1  
*Evolution Unit*

Videos	Concepts covered	Activities and Labs
Darwin's Theory of Natural Selection	Darwin's Observations and postulates Natural Selection Resistance to Darwin's Theory	Online Discussion Natural Selection Activity
Evidence for Evolution	Biogeography Homologies Fossils	Online Discussion
Evolution of Populations	Gene Flow Genetic Drift Genetic variation Types of Selection	Online Discussion Types of Selection Activity
Hardy Weinberg Theorem	Calculations of Hardy/Weinberg	Hardy/Weinberg Lab Natural Selection Simulation Lab
Speciation	Allopatric & Sympatric Speciation	Online Discussion

	Post-zygotic barriers Pre-zygotic barriers Gradualism  Punctuated equilibrium Species concept	
Phylogenetics	Cladistics Phylogenetic trees Cladograms	Cladogram Activity Online Discussion Investigating Bears Lab

In the nontreatment unit on Genetics, new concepts and material were presented via a PowerPoint and lecture combination by the teacher at the beginning of class. This information was then reviewed and reinforced through labs and activities done in class and at home both collaboratively and independently. Access to the PowerPoint presentations, after school help and review sheets were provided to assist students in understanding the concepts. Students were encouraged to self-advocate if they needed additional explanations, and student comprehension was assessed through quizzes, lab reports and an end of the unit exam.

During the treatment unit on Evolution, students were assigned a video of the lecture to watch for homework, this included my narration of a PowerPoint presentation done with Camtasia Studio and on one occasion a Paul Anderson video from Bozeman Biology. In addition to watching the video, students were required to log in and participate in an online discussion. The online discussion forum was available through Aspen X<sub>2</sub>, the student and grading database system used by Walpole Public Schools. The questions were formatted to increase higher order thinking skills in students. Each student needed to respond to the discussion question and additionally reply to two of their classmate's postings. Students were given two nights to complete the video and

discussion question. Following this assignment each class began with a short quiz on the video content and students were then given an activity to complete independently or a collaborative lab. The teacher circulated throughout the room, working with individual students or groups of students to clear misconceptions and check for understanding. Some of this instruction was logistical and some was instructional. Laptop computers and Chrome Books were available if students needed to review the lecture. The labs were a mixture of guided and inquiry-based labs requiring students to develop a hypothesis and then test a variable using a student-designed procedure. Students were assessed through daily quizzes, the online discussion forum, one-on-one interactions with the teacher, and written tests and lab reports. These assessments were scattered throughout the unit and also culminated in an end of unit exam.

#### Data Collection Instruments

To collect data for each of the project questions, a triangulation matrix was developed (Table 2). This variety enabled me to obtain data from different perspectives on each of the questions included in the project. Student viewpoints were garnered from interviews and surveys. Student progress and understanding was delineated from assessments, online discussion forums and a postunit culminating assessment. My own perspectives were collected from a reflection journal and an objective perspective was acquired through classroom observations.

Table 2

*Triangulation Matrix*

Focus Questions	Data Source 1	Data Source 2	Data Source 3
<i>Primary Question:</i>			
What are the effects of the flipped classroom model of instruction on students' understanding of AP Biology concepts?	Pre and Postunit student assessments	Preunit and postunit student interviews	Pretreatment and posttreatment student surveys
<i>Subquestions:</i>			
What are the effects of the flipped classroom model on student-teacher interactions?	Colleague observations during both treatment and nontreatment units with prompts	Preunit and postunit student interviews	Pretreatment and posttreatment student surveys
What are the effects of the flipped classroom model on students' higher order thinking skills?	Pre and Postunit student assessments	Online discussion boards	Pretreatment and posttreatment student surveys
What are the effects of the flipped classroom model on students' completion of inquiry-based labs?	Pre and Postunit student assessments	Preunit and Postunit student interviews	Pre and posttreatment student surveys
What are the effects of the flipped classroom model on my role as an AP Biology teacher?	Teacher reflection journal with prompts	Colleague observations with prompts	Pretreatment and posttreatment student surveys

Students were interviewed to glean information for the action research project.

Interview questions were developed to obtain student's understanding of the

Hardy/Weinberg theorem, student-teacher interactions and inquiry-based labs. The

questions were written to find out if students understood what an inquiry-based lab was, how they viewed student-teacher interactions and if they had any knowledge of the Hardy/Weinberg theorem and their perceptions of the flipped classroom process. The list of interview questions is in Appendix B. Student interviews were conducted with six students from my AP Biology class. These students were chosen as they represented two students from each group of high, middle and lower achieving students in the class. The students interviewed included four females and two males, as this was representative of the population in the AP Biology course. Each student was a high school senior and a member of my AP Biology class. Students were interviewed separately after-school in my office, each interview was oral and took approximately five minutes. All of the students were very cooperative and forthcoming with their answers

The student survey, Appendix D, was administered during class to both sections of AP Biology students. They were asked to complete the survey while they worked independently at their desks. All enrolled AP Biology students completed the survey. Survey questions were developed to determine student understanding of the flipped classroom method of instruction and its effects on student-teacher interactions, higher order thinking skills and inquiry based labs.

The results of the interviews and survey are important to the action research project because they provide information regarding student understanding of the flipped classroom and its effect on their learning. To implement the flipped classroom effectively, students have to invest time in attentively watching the videos. By determining their mindset about the importance of the videos, I was able to better prepare

my lessons and provide incentives for watching. Similarly, having an understanding of what students think about inquiry-based labs and their prior experience with them enabled me to more effectively aid them in developing and testing hypotheses. This addressed the subquestion of the effect of the flipped classroom model on students completing inquiry-based labs.

Students participated in an online discussion board during the intervention unit on Evolution. The purpose of this data instrument was to assess their understanding of the concepts presented in the lecture videos and increase higher order thinking skills by asking students to think critically about the concepts. Students were required to log on to the AP Biology page of X<sub>2</sub> after viewing each video and submit a response to the posted question and reply to two other student's posts. Since viewing of the lecture videos was limited to one or two times a week students had more than one night to complete this assessment giving them time to reflect and assess their understanding. The use of this data instrument addressed the subquestion of the effect of the flipped classroom model on students' higher order thinking skills. Student participation was required and recorded as a homework assignment. A list of the posted discussion questions is included in Appendix F.

A teacher journal was used to collect data on the effect of the flipped classroom on student-teacher interactions and my role as an AP Biology teacher. This journal was used periodically to record impressions and reflections on my lessons and teaching. I used a series of prompts to direct my thinking and help me focus on the subquestions.

The journal was completed directly following class to keep my thoughts and impressions current. The prompts used for the teacher reflection journal are in Appendix G.

A final data collection instrument used to address my role as an AP Biology teacher was colleagues' observations. My role at Walpole High school is department chair of the science department; therefore my colleagues were other administration personnel. The English department chair and the principal were asked to observe my classroom. I chose these individuals as they routinely observe teaching and could provide me with practical feedback, they also represented over 40 years of teaching experience, some of which was AP teaching. Each of the observations was unannounced and each observer remained in the classroom for a minimum of 20 minutes. The first observation took place during the Genetics unit or prior to the treatment unit, and again during the Evolution treatment unit. Each of the observers was asked to note pedagogical strategies they observed in the classroom. In addition, a list of questions to insure consistency, were provided to the observers, these are in Appendix H.

#### DATA AND ANALYSIS

The results of the pretreatment student survey indicated more than half, 57.5% of AP Biology students were unfamiliar with the flipped classroom method of instruction prior to the treatment. While no one was very familiar with this method, 27.5% were somewhat familiar and 15% were familiar (N=40). These results were not surprising as I was not aware of any other science teachers in the district using this method of instruction in their classrooms.

The impact of the flipped classroom model of instruction on  
students' understanding of AP Biology concepts

Students were receptive to the flipped classroom and many felt it impacted their understanding of evolution. According to the posttreatment survey, 50% of students stated the flipped classroom increased their understanding of evolution. Additionally, 16% of students indicated the flipped classroom greatly increased their understanding of evolution and 4% felt the treatment only somewhat increased their understanding. Finally, 28.5% of students felt the flipped classroom had no effect on their understanding of evolution (N=42). This is consistent with student responses in the pre and post treatment interviews (N=6). Students were asked what their understanding of the Hardy/Weinberg equation was prior to treatment, four students stated they did not think they had ever heard of it, and three of those four students could not remember using the theorem in any prior science course. There is an obvious, curious discrepancy for one student who stated they did not think they had ever heard of the Hardy/Weinberg equation, yet might have used it in a previous science course. Consequently in the posttreatment interviews 100% of the students could tell me the Hardy/Weinberg equation was used to determine if a population was evolving or not and an equal number felt confident they could complete a word problem involving the equation. Obviously much of the increase in understanding is due to the introduction of the material in any format.

To determine if the flipped classroom was an effective means of instruction I compared the 2013-2014 AP Biology class to the present class in regards to their

performance on the end of unit tests. Both the end of unit test in genetics, which was taught in a traditional format and the evolution unit test, taught with the flipped classroom during the present year only, were compared between the classes. The 2013-2014 AP Biology class had a Mean score of 88.14 with a Standard Deviation of 7.45 on the genetics exam. The 2014-2015 AP Biology class had a Mean score of 79.00 with a Standard Deviation of 10.54 on the pretreatment genetics exam. I also conducted a t-test on these scores. The results of the t-test on the genetics unit showed an extremely statistically significant difference  $t(97) = 4.9899$ ,  $p < 0.0001$  between the two sets of students. Taking into account performance in general and the quality of work submitted throughout the year, this difference did not surprise me. The 2013-2014 AP Biology class had a Mean score of 82.08 with a Standard Deviation of 8.58 on the evolution exam. The 2014-2015 AP Biology class had a Mean score of 75.55 with a Standard Deviation of 11.37 on the posttreatment evolution exam. When I compared the results of the end of unit test in evolution a significant difference appeared in this t-test as well  $t(97) = 3.2291$ ,  $p < 0.0017$ . Clearly the 2013-2014 class was more successful at both of these unit tests than the current year's class. While it does not appear that the impact of the flipped classroom increased or improved student understanding of evolution, the gap between the two groups of students was closer when using the flipped classroom model.

Further investigation of the scores from the two groups of students provided additional evidence on the effect of the flipped classroom in the 2014-2015 AP Biology class. A gain score was calculated using the genetics test as a prescore and the evolution test as a postscore. The 2013-2014 AP Biology class had a Mean score of -1.18 with a

Standard Deviation of 1.54. The 2014-2015 AP Biology class had a Mean score of -0.25 with a Standard Deviation of 0.59. When I compared the gain scores of the two classes an extremely statistically significant difference appeared in this t-test,  $t(97) = 3.9277$ ,  $p < 0.0002$ . Although both of the classes showed a loss between the pre and post scores, the 2014-2015 AP Biology class had a smaller difference than the 2013-2014 AP Biology class. Further contributing to the fact the flipped classroom helped to improve the performance of the 2014-2015 AP Biology students.

The impact of the flipped classroom model  
on student-teacher interactions

The effect of the flipped classroom on student teacher interactions had an interesting outcome and was viewed very differently by both teacher and students. Prior to the treatment 45% of students surveyed indicated the flipped classroom would somewhat increase student teacher interactions while 35% thought the intervention would increase the number of interactions. When asked pretreatment, 67% of the students interviewed stated the number of interactions was good and would like to see an increase if it were to change. However, after the intervention 40% of students surveyed indicated the intervention had no effect on the number of interactions and only 26% chose increased as to the effect of the flipped classroom on the number of student teacher interactions. Interviewed students also mentioned the number of interactions increased but mentioned it was due to the “increased number of activities” and others stated there were not as many interactions as “when we were doing notes.” Yet in the colleague observations both observers counted the number of interactions as increasing

dramatically, from 6 interactions to 18 interactions in a 20 minute interval, between the pretreatment and the posttreatment. From my own observations and impressions I believed I was interacting with students more frequently during the intervention. One reason for the discrepancy between teachers and students might be due to the interactions being one on one and not as obvious to students as answering a question or clarifying a misconception aloud to the whole class.

The impact of the flipped classroom model on  
students' higher order thinking skills

The data was clearer when determining how a flipped classroom affected students' higher order thinking skills. The results of the pretreatment survey had 37.5% of students believing the flipped classroom would increase their use of higher order thinking skills. In fact, only 20% of all students surveyed indicated there would be no effect on higher order thinking skills with the intervention. Yet following the flipped classroom over 66% chose increased and somewhat increased as to the effect on higher order thinking skills. Much of this research question was determined by the online discussion questions listed in appendix F, in which students were asked to process the information contained in the videos.

In the first discussion question students were asked to cite a theory or idea which garnered a response similar to the one Darwin experienced when he published his theory of natural selection. Student's responses included Galileo's heliocentric theory of the solar system, Margaret Sanger's advocacy of birth control and more recently the controversy surrounding the use of vaccinations among other examples. Darwin is a

familiar topic to AP Biology students having covered this material in other science courses, and their responses demonstrated application skills.

A second discussion question asked students to research a population experiencing genetic drift and explain how the evolution of the population was affected by this evolutionary agent. Student responses included the bottleneck of American bison hunted to almost extinction in the 1800's, Huntington's disease in the South Afrikaner population as a result of founder's effect from Dutch settlers, as well as the bottleneck due to hunting of Florida panthers in the early 20<sup>th</sup> century. These responses demonstrated analysis and understanding of the causes of evolution.

A final question on phylogeny was posted asking students to research two organisms, describe where they diverge on a cladogram and why. One student compared tuna and sharks to determine which was more closely related to humans based on characteristics, evolutionary history and classification hierarchy; another compared the platypus to the Aves class to see the distinction between two organisms with similar characteristics. A third student compared sharks and seals to find the differences in their history despite similar habitats. Phylogeny and cladistics are complex topics and students are less familiar with these concepts. Their responses demonstrated evaluation and creativity which are critical thinking and higher order processing skills. As demonstrated in their discussion question responses, students increased their use of these skills throughout the intervention. This same type of rationale was also evident in open response questions included in the end of the unit assessment.

The impact of the flipped classroom model on  
students' completion of inquiry-based labs

Determining the effect of the flipped classroom on completing inquiry based labs proved effective. The majority of surveyed students, 77%, stated the flipped classroom would have no effect to somewhat increased effect on their ability to complete an inquiry based lab. When asked about this same concept in the interviews, I needed to explain what an inquiry based lab was to some students, although half of the students could tell me an inquiry based lab included “solving something ourselves”. Following treatment the number of students stating the intervention had no effect to somewhat increased effect on their ability to complete an inquiry based lab was down to 59% and 28.5% felt it increased their ability. Likewise 100% of interviewed students could correctly describe an inquiry based lab we completed in class.

The scores of the inquiry based lab done in class also reflect the increase in student understanding and ability to complete this type of activity. This inquiry based lab was also used during the 2013-2014 school year without having used the flipped classroom method. A t-test was done to compare the results of both this year's lab scores and last year's. The 2013-2014 AP Biology class had a Mean score of 83.35 with a Standard Deviation of 15.21 on the lab. The 2014-2015 AP Biology class had a Mean score of 78.95 with a Standard Deviation of 11.79 on the lab. The results of  $t(88) = 1.5264, p < 0.1305$  were not statistically significant. In other words the effect of the flipped classroom model was inconclusive in its effects on inquiry based labs. However when looking at an additional lab done in both classes as evidence of the distinction

between the groups, there was a significant difference between the 2013-2014 AP Biology class and the 2014-2015 AP Biology class.

The 2013-2014 AP Biology class had a Mean score of 85.15 with a Standard Deviation of 9.66 on a Gel Electrophoresis lab. The 2014-2015 AP Biology class had a Mean score of 76.48 with a Standard Deviation of 23.33 on the same lab. The results of  $t(94) = 2.3779, p < 0.0194$  were statistically significant indicating the gap between the classes was apparent and the flipped classroom was effective at closing the gap.

The impact of the flipped classroom model on  
my role as an AP Biology teacher

The final research question was to determine if using the flipped classroom model would change my role as an AP Biology teacher. According to the pretreatment survey 35% of students thought there would be no effect in my effectiveness as an AP Biology teacher, while 27% thought the intervention would somewhat increase my effectiveness and 22% indicated there would be an increase. However in the posttreatment survey 48% of students chose increased and 17% chose somewhat increased as to my effectiveness as an AP Biology teacher.

In my teacher journal, I recorded my impressions as being more effective in coordinating and directing students learning, rather than having them rely on my instruction for comprehension of the material. Similarly, the observations done by my colleagues stated my role in the classroom was of a coach as opposed to an instructor. This stipulation was noted by both observers during the intervention of the flipped classroom.

## INTERPRETATION AND CONCLUSIONS

The overall findings of this action research project included successfully using the flipped classroom to provide students with an alternative means of instruction, increasing cooperation and collaboration in the classroom as a result of the flipped classroom and re-defining of my role as an AP Biology teacher as more of a facilitator than instructor.

There are many types of instruction used in classrooms; some are effective and others less effective. Employing the flipped classroom method of instruction provided my students with an effective means of learning information and concepts. In spite of marginal data to support increased understanding of AP Biology concepts, the flipped classroom provided an alternative to the traditional lecture allowing students to explore a new format and strategy in learning. Working with this model, students were able to build upon their existing knowledge to deepen their understanding of science concepts in the constructivists' perspective.

Additionally, the flipped classroom model increased cooperative and collaborative learning by permitting classroom time to be used in more constructive student-centered ways. Eliminating the traditional lecture from the classroom increased active learning by students and provided a supportive environment allowing them to learn from one another. Lab work and group activities encouraged students to apply their knowledge and were done thoroughly and with a greater focus on discussion and consensus. Working together also provided students the opportunity to assess their own knowledge and review or analyze gaps in their understanding.

Finally, my role in the flipped classroom became more of a mentor and facilitator than instructor, helping students determine their understanding of the concepts by active participation not passive listening. This was most evident in the time I spent with students either individually or in small groups. As students worked on activities or labs I was able to move among them to answer questions, remedy misconceptions and challenge thinking. In lieu of looking at the results of an assessment, I was able to evaluate student understanding and comprehension from conversations and dialogues while these activities ensued. This was an important finding as seniors in high school should be capable of increasing their knowledge and understanding without constantly relying on the teacher.

Flipping a classroom is a worthwhile endeavor for educators of all levels to experience in their classrooms. Suggestions for flipping a classroom would include choosing reliable technology to post videos or podcasts and teaching students how a flipped classroom works. This is important for students to feel comfortable with the change in format. It is also essential to provide students enough time to view the videos and review the content during class as well, this serves to aide in assessing understanding and clearing any misconceptions. Also, hold students accountable for the information in the videos, this is crucial for success. Furthermore, be careful of the length of the videos and any additional assignments which may subtract from the effectiveness of a flipped classroom. Finally, realize you cannot rely solely on the video for imparting the information and some students will not respond to this method of instruction.

## VALUE

Teachers are constantly trying to develop methods to reach students and engage them in the learning process. The importance of student teacher interactions cannot be understated in a classroom. This is where the learning happens and a successful educator uses these interactions to gather necessary information on student understanding, learning styles, emotional and social well-being, student perspectives and to strengthen the relationship between student and educator. The flipped classroom is another weapon in the arsenal of instructional methods available for teachers. It provides an increase in variety for the different learning styles found in a classroom. Future uses of the flipped classroom may include alternating units with more traditional practices throughout the year to maintain interest, motivation and differentiation for students. Adopting a mastery learning process in the classroom is another option for the flipped classroom. In this scenario, students would pace themselves using videos, online quizzes and assessments to learn and master the concepts. Although this type of a classroom would require individual technology to be provided or at least available to each student. Students would also have to be instructed on how the flipped classroom works and assured this alternative method was valuable.

One of the concerns students voiced prior to beginning the flipped classroom was a reluctance to alter the established practices in the classroom. Several students were comfortable with current methods and did not want to change what was familiar mid-year. Alternatively, some students were very receptive to the flipped classroom and the opportunity to review, re-visit and replay lectures until they were comfortable with the

material. In one specific incidence a lower performing student stated she “loved it” when referring to the flipped classroom. She shared how she used the videos to listen, take notes, replay and exam the concepts. As a result, she scored higher on the evolution exam than any other exam all year. For this student, the flipped classroom provided the additional reinforcement needed to succeed. This action research project showed me the flipped classroom can enable students with different learning styles the opportunity to do well when traditional methods have been less successful.

Action research is a necessary part of reflective teaching and professional growth. Using the process of action research can inform and help educators determine if best practices are truly best. As a veteran teacher, collecting data and using the data to inform my practice as an educator should be a necessary part of my profession. Assessing student understanding and comprehension is the first step in reflective teaching, using the information to improve, advance or remedy my instructional methods brings the process full circle to determine which methods of instruction are most effective for a given audience.

REFERENCES CITED

- Ash, K. (2012). Educators view 'flipped' model with a more critical eye. *Education Week*, 32(2), S6-S7.
- AP Biology Course Description (2012, Fall). AP central. Retrieved March 22, 2014, from [http://media.collegeboard.com/digitalServices/pdf/ap/IN120084785\\_BiologyCED\\_Effective\\_Fall\\_2012\\_Revised\\_lkd.pdf](http://media.collegeboard.com/digitalServices/pdf/ap/IN120084785_BiologyCED_Effective_Fall_2012_Revised_lkd.pdf)
- AP Instructional Planning Report. (2013, June 28). AP central. Retrieved February 27, 2014, from <https://apscore.collegeboard.org/scores/>
- Bächtold, M., (2013). What do students “construct” according to constructivism in science education? *Research in Science Education*, 43, 2477–2496. doi: 10.1007/s11165-013-9369-7
- Bergmann, J., & Sams, A. (2012). Why you should flip your classroom. *Flip your classroom reach every student in every class every day*. Eugene, OR: International Society for Technology in Education
- Bergmann, J., & Sams, A. (2013). Flip your students' learning. *Educational Leadership*, 70(6), 16-20.
- Bergmann, J., & Sams, A. (2014). Flipping for mastery. *Educational Leadership*, 71(4), 24-29.
- Faulkner, T. (n.d.). Flipped Classroom - Byron High School Mathematics Department. *Flipped classroom - Byron High School mathematics department*. Retrieved February 27, 2014, from <https://sites.google.com/a/byron.k12.mn.us/byron-high-school-mathematics-department/flipped-classroom>
- Feyzioglu, E. (2012). Science teachers' beliefs as barriers to implementation of constructivist-based education reform. *Journal of Baltic Science Education*, 11(4), 302-317.
- Goodwin, B., & Miller, K. (2013). Evidence on flipped classrooms is still coming in. *Educational Leadership*, 70(6), 78-80.
- Greenberg, B., Medlock, L. & Stephens, D. (2011). Blend my learning: lessons from a blended learning pilot. Oakland, CA; Envision Schools, Google, & Stanford University D. School. Retrieved February 28, 2014, from <http://blendmylearning.files.wordpress.com/2011/12/lessons-learned-from-a-blended-learning-pilot4.pdf>

- Mason, G., Shuman, T., & Cook, K. (2013). Comparing the effectiveness of an inverted classroom to a traditional classroom in an upper-division engineering course. *IEEE Transactions on Education*, 56(4), 430-435.
- Moore, A., Gillett, M., & Steele, M. (2014). Fostering student engagement with the flip. *The Mathematics Teacher*, 107(6), 420-425.
- Tucker, B. (2012). The Flipped Classroom, Online instruction at home frees class time for learning. *Education Next*, 12.1(Winter), 82-83.

APPENDICES

APPENDIX A  
IRB EXEMPTION



**INSTITUTIONAL REVIEW BOARD**  
**For the Protection of Human Subjects**  
**FWA 00000165**

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**MEMORANDUM**

**TO:** Maryellen O'Malley and John Graves  
**FROM:** Mark Quinn, Chair *Mark Quinn CJ*  
**DATE:** November 18, 2014  
**RE:** "Constructivism: The Effects of the Flipped Classroom Instructional Model on High School Senior AP Biology Students" [MOM111814-EX]

The above research, described in your submission of November 18, 2014, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

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

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

APPENDIX B

STUDENT INTERVIEW QUESTIONS PRETREATMENT

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

1. What is your current understanding of the Hardy/Weinberg equation?
2. Have you used the Hardy/Weinberg equation in other science courses? Explain.
3. What do you think about the number of student/teacher interactions? Would you like to see it change and if so how?
4. What do you think of when I say inquiry-based labs?
5. If you were asked to develop an inquiry based lab on the Hardy/Weinberg theorem what would your response be? Explain.

APPENDIX C

STUDENT INTERVIEW QUESTIONS POSTTREATMENT

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

1. What is your understanding of the Hardy/Weinberg theorem now? Explain.
2. Would you be able to successfully complete a word problem involving the Hardy/Weinberg equation? Explain.
3. Do you feel that the number of student-teacher interactions has changes? If so, what do you think accounts for the change?
4. Can you describe how an inquiry based lab works and provide an example of one you have completed?
5. How has your understanding of the Hardy/Weinberg theorem changed since doing inquiry based labs? Explain.

APPENDIX D  
STUDENT SURVEY PRETREATMENT

## AP Biology Students:

Please complete this survey. Answer each question and provide as much information as possible where appropriate. It is important to be honest in your answers as they will help me develop and plan future AP Biology lessons. You may remain anonymous if you wish. Thank you for helping me with this project and for your time. Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

1. How familiar are you with a flipped classroom?

1 Very familiar    2 Familiar    3 Somewhat familiar    4 Unfamiliar

*If you are unfamiliar with a flipped classroom please read the following, otherwise continue on to question 2.*

A flipped classroom is an instructional practice in which the traditional lecture is done outside of class as homework, and the discussion, processing, and review of the material is done during class.

2. Do you think a flipped classroom will increase student-teacher interactions in the classroom? Explain why or why not.

1 Greatly increase    2 Increase    3 Somewhat increase    4 No effect

3. Do you think flipped classroom will increase your use of higher order thinking skills? Explain why or why not.

1 Greatly increase    2 Increase    3 Somewhat increase    4 No effect

4. Do you think the flipped classroom will increase your ability to complete an inquiry based lab activity? Explain why or why not.

1 Greatly increase    2 Increase    3 Somewhat increase    4 No effect

5. Do you think a flipped classroom will increase my effectiveness as an AP Biology teacher? Explain why or why not.

1 Greatly increase    2 Increase    3 Somewhat increase    4 No effect

APPENDIX E  
STUDENT SURVEY POSTTREATMENT

## AP Biology Students:

Please complete this survey. Answer each question and provide as much information as possible where appropriate. It is important to be honest in your answers as they will help me develop and plan future AP Biology lessons. You may remain anonymous if you wish. Thank you for helping me with this project and for your time. Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

1. Do you think the flipped classroom increased your understanding of Evolution?

1 Greatly increased      2 Increased      3 Somewhat increased      4 No effect

2. Do you think the flipped classroom increased interactions between the student and the teacher during the Evolution unit? Explain why or why not.

1 Greatly increased      2 Increased      3 Somewhat increased      4 No Effect

3. Do you think the flipped classroom increased your use of higher order thinking skills during the Evolution unit? Explain why or why not.

1 Greatly increased      2 Increased      3 Somewhat increased      4 No Effect

4. Do you think the flipped classroom increased your ability to complete an inquiry-based lab activity during the Evolution unit? Explain why or why not.

1 Greatly increased      2 Increased      3 Somewhat increased      4 No Effect

5. Do you think the flipped classroom increased my effectiveness as an AP Biology teacher? Explain why or why not.

1 Greatly increased      2 Increased      3 Somewhat increased      4 No Effect

APPENDIX F  
DISCUSSION BOARD QUESTIONS

AP Biology Students:

Respond to the following discussion question. Read classmates responses and respond to at least two different student's posts.

Video #1: Darwin had a difficult time publishing his theory because he knew there would be resistance and negative reactions to his conclusions. Can you think of other discoveries, theories or ideas that triggered resistance or negative reactions either recently or in the past? What type of reaction was generated and how do you think that compares to Darwin's?

Video # 2: The video discuss several evidences for evolution and how they contribute to Darwin's theory. Which one would you say is the most compelling and why?

Video # 3: Cheetahs provide an excellent example of the bottle neck effect in genetic drift. Research another population which demonstrates one of the evolutionary agents that is discussed in the video. Explain the population and how the evolutionary agent affected the evolution of that population.

Video # 4: The video discusses a number of pre-reproductive barriers and post reproductive barriers. Which ones do you think have had the most significance or impact on speciation and why?

Video #5: The video discussed how organisms are classified and how cladograms and phylogenetic trees are used. Research two organisms, one mammal and one other animal and describe where they diverge. One possible hint is to look at the classification hierarchy of the organisms. Explain what you find and why you choose those two organisms.

APPENDIX G  
TEACHER JOURNAL PROMPTS

The following questions were used to guide reflections in a daily journal:

1. What was the objective for today's lesson?
2. What percent of class time did you spend directing the entire class? Was this instructional, explanatory or logistical? Explain.
3. What percent of class time were students working independently or in a collaborative setting?
4. How many students did you have one-on-one interactions with during the period?
5. How many interactions did you have with individual groups of students?
6. How would you categorize questions from the students that were posed to you, instructional, explanatory or logistical? Provide an example.

APPENDIX H

QUESTIONS FOR COLLEAGUE'S OBSERVATIONS

Observers:

Please focus your attention to the following strategies while observing my class.

1. Were you able to determine the objective for today's lesson?
  
2. What percent of the observation did I spend directing the entire class? Was this instructional, explanatory or logistical? Explain.
  
3. What percent of the observation were students working independently or in a collaborative setting?
  
4. How many students did you observe having one-on-one interactions with me during the period?
  
5. How many interactions did you observe me having with individual groups of students?
  
6. How would you categorize my role in the classroom? Instructor, coach, mentor, logistical coordinator? Please provide an example.