

THE IMPACT OF THE FLIPPED CLASSROOM ON LEARNING AND PROBLEM
SOLVING OF NINTH GRADE BIOLOGY STUDENTS

by

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DEDICATION

I would like to dedicate this project and paper to my students, both past and present. They are the ones who drive me to constantly improve my teaching methods. I desire to give them a passion for lifelong learning about the natural world around them, a passion for understanding, and passion for investigating. It is to them I dedicate my pursuit of more creative ways to inspire them to greater learning and enjoyment in the process.

I would also like to dedicate this endeavor to Professor Nancy Burritt. She has shown me the power of encouragement and her support has spurred me on to complete what I have started in this master's program even in the face of difficult life situations which would have otherwise caused me to quit. Her example has inspired me to be a better person as well as a better educator and to never give up no matter the difficulties.

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ABSTRACT

The students in my biology classes, like most students in today's world, struggle with problem solving skills and learning difficult biological concepts such as cell biology and genetics. Their prior educational learning experience has been teacher centered with lectures and note taking, then memorizing facts from their notes to pass a test. More classroom time is needed for application, group activities, and development of problem solving abilities. The problem with achieving that is the lack of time in a 53 minute class period to teach concepts and then apply those concepts to problem solving.

This project investigates the effects of changing the traditional method of lecture and note taking during class to using online instructional resources at home for homework. This will free up class time for more question and answer time, application, group activities and collaboration as well as problem solving exercises. This approach has been termed the "flipped" classroom method. The students were assigned weekly online resources such as animations and video lectures for homework along with associated written work. During class time, the students were engaged in various activities where they applied what they hopefully learned the night before. Time was allotted for question and answer sessions, clarification, and when needed individual help from me.

Data collection during this project included pre and post treatment student surveys, pre and post treatment unit tests, student self-evaluations following activities. In addition, the students completed post treatment anonymous written feedback. Six students were interviewed both before and after the treatment was implemented.

The pre and post treatment formal unit assessments showed significant gains over all in learning and problem solving. However, that is to be expected with or without the flipped classroom because the concepts covered during the project were new to the students. The pre test scores were very low due to lack of prior knowledge and the post test scores were higher after the students were exposed to the concepts for six weeks each unit. The resulting qualitative data suggested that the flipped classroom approach improved student attitude significantly even though their attitudes were already good and also improved student engagement during class. Students appreciated having more time to ask questions and more time with me if needed. They also appreciated the collaborative group projects and felt they learned more with the help of their peers. Even though the data showed the students had a slight preference for the traditional classroom because that is what they have always had, they overwhelmingly preferred a combination of the two teaching methods. After the project was completed, many students asked if I would continue giving them internet resources because it helped them learn so much better.

INTRODUCTION AND BACKGROUND

There is a distinct void in the transfer of knowledge and problem solving skills at Glenwood School. Most students, including the high achievers, rely on memorizing facts to pass a test rather than attempting to gain understanding and knowledge. As a result these students struggle with applying scientific concepts toward problem solving and they see no “real life” value in what they learn. Glenwood is a small private college preparatory school, starting with two year old pre-kindergarten and going through 12th grade, in the outer suburbs of Smiths Station, Alabama. The total number of the student body population ranges from year to year between 450 – 600 students. The majority of students, 70%, are Caucasian and from middle class families where both parents work. Additional ethnic groups attending Glenwood School are 20% African America, 5% Latino, and 5% Asian. Last year the graduation rate was 100% with 100% acceptance to a college or university where they had received a scholarship of some kind. This is a typical graduating class at Glenwood. Students are very involved in school activities, clubs, and athletics and the parents are just as involved as their children. I have taught middle and high school life sciences at Glenwood for the past 20 years along with a sixth grade laboratory skills class.

Although my current teaching methods include “real life” scenarios during lecture and class discussion, periodic instructional videos, and lab activities (most of which are “cookbook” style), teaching is centered in lectures and student note taking. The students also complete directed reading assignments, answer section and chapter assessment questions for homework or classwork, and the following day there is an opening question on the board to be completed before class formally begins. Typically, the majority of students lack the

ability to apply what they learn to problem solving. The pre-treatment survey question “when it comes to applying what you have learned in biology to reasoning and critical thinking to solve a problem, how would you rate your ability”, 52% felt they were sometimes good at applying what they learned and 37 % felt they had a difficult time with application. Only 15% felt very confident with application to problem solving ($N=45$). I do not think there is enough time devoted to hands on application of the concepts being learned and problem solving activities in my biology classes. This could be due to the fact that I feel driven by curriculum requirements and find myself too focused on getting through the required materials rather than helping students with their learning, application, and problem solving skills. This violates my values as a teacher because I believe the most needed skills for student success in school and in life are problem solving and higher order thinking skills. In order to better teach my students problem solving and higher order thinking, they need to spend more time during class in the practice of these skills. To allow more time during class to do this, I am incorporating the teaching method called “flipping the classroom”. Watching online video resources at home, while class time is spent doing “homework”, engaging in group problem solving, having one on one time with the teacher, and finding answers to questions has been termed “flipping” the classroom. Students will make use of various online resources, such as video tutorials and animations online, as homework assignments, which will free class time for application, group activities, and problem solving.

We live in a technology-infused information age. Our students live a life immersed in a technological environment using cell phones, computers, smart phones, etc. These young people rely upon technology for information as well as entertainment. In a pre-

treatment survey the students were asked how much total time they spend on the internet each day. A total of 22 of the 43 responded they spend more than 60 minutes daily on the internet, 9 spend between 41 and 60 minutes daily, and 11 spend between 21-40 minutes. Only one student out of 43 stated they spend no time daily on the internet. When asked if they already used the internet to help them understand biology, 55.8% said sometimes and 12% said yes. These are the tools they are interested in and the medium they are familiar with for gaining information and understanding. The same tools are what we as teachers should be using to engage our students rather than outdated practices that are teacher centered and shaped in an era lacking today's current technology. When asked in the pre-treatment survey if they would like to use the internet at home to help them understand biology, 20 of the 53 respondents said yes, 11 said no, 14 said maybe, and 7 said they did not know. In most of today's classrooms, students must leave behind their preferred technology for learning to use the traditional learning practices of their parents and grandparents. Prensky (2008) sums it up with "compared with students' technology-infused lives outside of school, the traditional classroom is a somber place".

Focus Question

In order to better help my biology students learn difficult concepts and develop problem solving skills, I will conduct classroom research using the flipped classroom model. My focus question is: What are the effects of flipping the classroom on learning and problem solving in ninth grade biology students? Additional secondary questions are: What is the impact of flipping the classroom on student engagement and attitude during class time? In what ways will flipping the classroom impact student preference for instructional methods.

CONCEPTUAL FRAMEWORK

Engaging and motivating today's student is a challenge. The world of a modern day student is one of continual connectivity whether it is through the use of smartphones, computers, or other electronic devices, all of which provide access to the internet. I rarely see a student outside of the classroom without them being 100% consumed with something on their cell phones. The educational use of these tools has the potential to prepare, engage and motivate students in a student-centered process (Shea & Sherer, 2011). Students should have the opportunity to access online lectures and supporting materials in order to enhance learning outside the classroom. Furthermore, online video lectures and multimedia instruction outside of class will allow the instructor more time for class discussion, answering questions, interactive activities, and application of knowledge during class (Brecht & Ogilby, 2008).

Educators are increasing the use of computer technology and discovering new methods for delivering instruction as a result of this student preference for online delivery (Jensen, 2011). Many universities are making online instruction available to their students with positive student opinion (Brecht et al., 2008; Foertsch, Moses, Strikwerda, & Litzkow, 2002; Jones-Wilson, 2005a; Kishi, Kucsera, & Traphagan, 2010; Parson, Reddy, Wood, & Senior, 2009; Shyu, 2000). This generation of students has been using technology throughout most of their lives and they expect their educational experiences to include online access of information. The educational process of delivering knowledge needs to catch up (Shea et al., 2011).

Reforms in science education are ongoing due to low levels of achievement, literacy, and test scores. The need for enhanced instruction and alternatives to the traditional textbook driven, teacher centered classroom are evident. The “old school” ways of reading, taking notes, and memorizing to pass a test are being replaced by the 21st century classroom. In order to help students learn to use knowledge to solve problems and establish higher order thinking skills, a variety of delivery methods are warranted (Chan, Doran, Lenhardt, & Tamir, 2002). Education can go from producing “armchair scholars” who lack understanding yet achieve high grades to students who have gained the ability to use knowledge productively (Westera, 2011). This is achieved by providing students with an authentically rich and meaningful learning environment.

Educators are being driven toward exemplary practices by research findings as well as informed guidelines from the National Science Education Standards. These standards reinforce science as a process for learning skills through inquiry based learning (Chan et al., 2002). For the classroom teacher this is no easy task. Time and resource restrictions tend to limit active learning when the instruction is based on reading, lecture, notes, and memorization of facts. The use of online video delivery for lectures, animations, and other supporting materials at home will free classroom time for active learning which is vital for understanding scientific concepts and practices. The use and practice of scientific inquiry and thinking through problem solving activities allows students to gain greater insight into scientific practices and discovery (Chan et al., 2002). Sungur and Tekkaya (2006), in *Effects of Problem-Based Learning and Traditional Instruction on Self-Regulated Learning*, stated that the students who practiced problem based learning methods showed improvement in use

of learning strategies, scored higher in intrinsic goal orientation, and gained a greater tendency to apply prior knowledge to new problems. All students in the study of the effects of problem based learning by Chia & Chin (2004a) indicated a greater degree of learning and an increased understanding for real life application of what was learned. Veritable learning requires authentic instruction and experiences in the classroom such as problem based learning, inquiry based learning, and lab experimentation. The problem for most teachers using traditional methods of instruction is there is not enough time.

Internet access rises above the restrictive nature of the classroom and allows interaction across boundaries of space and time (Westera, 2011). The instant availability, ease of use, and 24 hour access of online video lectures and course materials enhances student learning (Parson et al., 2009). Numerous studies have indicated that online video lectures helped students better understand course materials and increased their ability to learn (Brecht et al., 2008; Foertsch et al., 2002; Parson et al., 2009; Shyu, 2000). The use of visual enhancements such as graphs, animations, pictures, and charts helps most students learn better (Chan et al, 2002) and internet instruction can provide these features. Students also are helped by the ability to control the pace of the videos, re-watch segments for further understanding, and replay as needed for review (Brecht et al., 2008; Dupont & Holbrook, 2011).

Numerous studies have been completed to determine if using the flipped classroom method enhances student attitude, engagement, learning, and performance (Brecht et al., 2008; Chiu & Lee, 2009; Foertsch et al., 2002; Jensen, 2011; Jones-Wilson, 2005a; Shyu, 2000). The results have been mixed. Jensen found a slight effect on performance, a decrease

in attendance for those with online video access, and an actual decline in motivation. He points out that a variety of online resources and delivery of materials should be included to obtain greater student performance and motivation. In contrast, Brecht found improvement in performance of weaker students with a 71.9% reduced failure rate compared to students without video access or in class application through problem solving activities. Jones-Wilson indicated the class was more productive, which resulted in more time to teach larger amounts of material than before the treatment. She deduced this was a result of less time needed for review. Exam scores improved with an increase in scores above the 60th percentile, decrease in the scores below the 40th percentile, and doubling of student scores above the 70th percentile after the treatment (Jones-Wilson, 2005a). These findings were also supported in the study of Chiu & Lee who reported their results indicated the lectures followed by hands-on labs have a greater positive outcome in student learning than traditional lecture only methods.

Although the above findings support the importance and effectiveness of “flipping” the classroom in improving student motivation, learning, and performance, there are issues involved that teachers planning to implement this method should be aware of and plan for accordingly. First, as pointed out by Chiu et al, (2009), unless there are controls and guidance for video use outside the classroom, students may not benefit as much as they do with in-class lectures and labs. Just as students choose not to do their homework for traditional classes, students may not watch the online videos. Possible motivation for watching the homework videos (besides making them interesting and relevant) could be guided questions to answer, or other types of assignments that require the student to

demonstrate that they did watch the video. Secondly, students who are weak in the subject matter may not gain understanding of complex concepts through watching the video although Brecht (2008) found weaker students improved their test scores through this method and the rate of failures was decreased by 71.9%. In order to help students who do not understand the information presented in the video, the beginning of class could be dedicated to answering questions and having class discussions. The beauty of the “flipped” classroom is that it allows more time during class for teacher-student interaction. As stated by Brecht, the reduced rate of failures could be directly related to the time in class for application in solving problems. Thirdly, there is an increased demand for the teacher’s time in setting up the online instruction in addition to the classroom activities.

Recent studies reveal that although students prefer online course materials and resources, they view it as a supplement and not a substitute for in class lecture (Parson et al., 2009). It will take time to shift how educators and students alike view the concept of “flipping” the classroom. The majority of study findings indicate there is a positive effect on student engagement, learning, and performance. Additionally, students indicated a more positive attitude toward what they were learning (Chiu et al., 2009; Foertsch et al., 2002; Parson et al., 2009; Shyu, 2000). Foertsch et al., stated 75% of students thought they were better able to understand the online lectures and that increased their ability to learn. While studying the effects of anchored instruction, Shyu found this type of instruction gave the students a more highly motivational environment which resulted in a higher level of problem solving skills among the students regardless of their prior skill level. Although there can be an issue with students not watching the videos, Brecht et al., (2008) found a significant

number of students reporting that they used the videos. For this strategy of using video lectures outside of class to enable class time to be converted to active learning and be effective, students must accept and use the videos (Brecht et al., 2008). They can view the online resources wherever they have internet access and at the pace best suited to their learning style. Video lectures and animations are targeted and focused, allowing for in depth study of specific topics. Class time is changed from teacher centered to student centered application that “aggressively challenges and moves forward the students’ understanding of and skill in working with the course material” (Brecht et al., 2008). Video instruction online coupled with in class activities may transform teaching and learning in a, (much needed), fundamental way (Kishi et al., 2010).

METHODOLOGY

In light of the fact that the lives of our modern day students revolve around the use of the Internet to gain information, to investigate, and to relate to the world, my intervention does as well. This classroom research project implements the use of the flipped classroom in order to determine the impact on student learning, engagement, attitude, preference for instructional method, and problem solving skills.

Participants

This study was carried out in two of my ninth grade general biology classes during the third grading period, spring of 2016. This biology course is a required science course for ninth grade at Glenwood School and usually the students entering this course have little experience with reasoning and critical thinking in science. Their experience with science has been largely memorization of facts to pass tests. As a result of this prior learning approach, they struggled in my classes, especially at the beginning as they learned to use scientific

information in problem solving. The 53 minute classes met back to back in the mid-morning. There was a mixture of dedicated students who were serious about learning, those who did not care, and those somewhere in between. The total number of students was 48, comprised of 25 girls and 23 boys. The diversity of ethnicity was typical of our small private school with four African American males and the remainder being Caucasian students. Group 1 biology class was a smaller class with 20 total students whereas Group 2 had 28 students. Group 1 as a whole was less dedicated to learning than Group 2, which has been known at Glenwood as a group that strives for high grades but not necessarily for learning. Both groups memorized facts in order to do well on tests. In Group 2 there was a female student who has visual impairment and cerebral palsy. This student used a tablet computer to take notes and periodically took pictures of images I displayed on the Smartboard.

The content for these classes during the classroom research project was a unit on cells and a unit on genetics. These topics and the concepts associated with them seem to be difficult for students to grasp. Having the students utilize various online instructional resources as homework allowed additional time in class for clearing up misconceptions, for application, and more time for teacher-student guidance. There were two interventions in order to apply the flipped classroom model research to each group. One group had the intervention applied and the other group served as a comparison. In the next unit, the groups were swapped.

Intervention

This intervention began in early January and continued throughout the grading period which is nine weeks but due to various interruptions during the grading period, the research

ended up taking twelve weeks. Toward the end of the prior semester the students were introduced to the concept of the flipped classroom including how to use the internet to access the course resources and lectures at home while having traditional lectures and note taking during class. This was initiated in order to have the students ready for the intervention at the beginning of the next semester. The computer lab at the school was made available before and after school for those students unable to access the online resources at home.

Since I wanted both groups of students to experience the flipped classroom treatment, I decided to implement the use of the flipped classroom in one class, Group 1, while continuing to use the traditional classroom method with Group 2, for the unit on cells. During the unit on genetics, I reversed the treatment groups. Group 1 followed the traditional format while Group 2 experienced the flipped classroom. Using this approach allowed me to have a control group for comparing the impact of the flipped classroom and also have the treatment applied to both classes.

The treatment began with the unit on cells for students in Group 1. These students watched the online lecture/resource, when assigned, as homework, which was once or twice each week. Links to the online resources were provided on the class webpage and also sent to each student in an email. In order to insure the students actually watched the Internet resource, they were assigned to either take notes while watching, answer guided questions provided in the email, or complete a web quest when assigned. They were asked to email these written assignments back to me the night of the online assignment. During the treatment, at the beginning of each class there was a question and answer period followed by a class discussion. The remainder of the class time was spent in an activity/lab/problem-

solving assignment either with a partner, within a group, or individually. The majority of interactive activities were group based. Group 2 class continued with a traditional lecture format, written homework assignments, and an occasional activity. This unit lasted for six weeks which was longer than planned due to several unexpected school closings and spring sporting events requiring many students to miss classes for five days.

Following the unit on cells, Group 2 became the flipped classroom as they studied the unit on genetics. Group 1 began the same unit but with traditional lecture format, written homework assignments, and occasional activities. The implementation of the flipped classroom for Group 2 followed the same procedure as Group 1 had followed the unit before. This included watching online resources at home, taking notes or answering guided questions, and emailing these written assignments to me. The class period began with a question and answer session, class discussion, and the remainder of the class period consisted of an activity/lab/problem-solving assignment which was usually group based.

Data Collection

Before the students began accessing the internet for lectures and other resources, both groups completed a pre-treatment survey to report among other things how often they use the internet, what their confidence level was in applying biology concepts to solve problems, and what their level of attention and engagement was during class (Appendix B). Additionally, survey questions asked their thoughts about flipping the classroom, using internet lectures, and if they think it would enhance their learning to have more time in class for activities. Students from each class were selected for pre-treatment interviews based on their first

semester grades, 2 high achievers, 2 average achievers, and 2 below average achievers.

(Appendix D)

To begin each unit, students from both classes took a pre-unit assessment which measured prior knowledge and problem solving ability (Appendix A). Upon the completion of in class activities, each treatment group completed a self-evaluation rubric to measure learning, effectiveness of the online resource, degree of engagement, and attitude of the students (Appendix C). Time was dedicated at the beginning of class to give the students an opportunity to ask questions and give verbal and anonymous written feedback on their experiences. Following the completion of each unit the students completed a post unit assessment, intended to measure any increase in learning and problem solving skills (Appendix A). In addition, after the treatment the students in each group were asked to anonymously write their thoughts about the flipped classroom including positive feedback, negative feedback, and any recommendation for future implementation of the flipped classroom format.

When the treatment period was at an end, the students were asked to complete a post-treatment survey which included questions asking in what ways the flipped classroom impacted their ability to learn and problem solve, their level of engagement and attitude during class, and how they would compare the flipped classroom model to that of the traditional model. (Appendix B). The same select group of students who participated in the pre-treatment interviews was also interviewed for the post-treatment student interview (Appendix D).

Table 1
Data Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3
<i>Primary Question:</i> What are the effects of flipping the classroom on learning and problem solving skills of ninth grade Biology students?	Pre and post unit assessments measuring prior knowledge, problem solving skills, and growth of each	Self-evaluation rubric following class activities/labs measuring the impact of online resources on learning and problem solving skills	Pre and post treatment surveys and interviews
<i>Secondary Questions:</i> 1. What is the impact of flipping the classroom on student engagement and attitude during class time?	Pre and post treatment student surveys and interviews measuring student attitude and engagement	Self-evaluation rubric measuring the impact of flipped classroom format on attitude and engagement	Student written reflections and feedback
2. In what ways will flipping the classroom impact student preference for instructional methods?	Pre and post treatment student interviews measuring student classroom model preference	Pre and post treatment student surveys measuring student perception of most effective learning environment	Student written reflections and feedback

DATA AND ANALYSIS

The flipped classroom had a positive effect on learning and problem solving as was demonstrated in the comparison of the scores in the pre and post treatment unit tests. (*Figures 1-4*). Analysis of the cells unit treatment group (group 1, $N=20$) indicated an overall increase when evaluating the pre-test versus post test results (*Figure 1*). There was an

increase of 66.9% in the mean score, 22.7% increase when comparing the highest score of both tests, and a 160% increase of the lowest score from both tests. Breakdown of the interquartile range (middle fifty percentile) demonstrated a 75.2% increase in test scores.

Analysis of the cells unit non-treatment group ($N=28$) indicated an overall increase in scores when comparing the pre-test and post-test (*Figure 2*). There was an increase of 83.1% in the mean score, 32.0% increase in the highest score of each test, and a 114.2% increase in the lowest score. Comparison of the interquartile range revealed an increase of 75.2%, the same as the treatment group.

Comparison of the treatment and non-treatment groups exhibited an overall increase in both groups from the pre and post-test. The standard deviation for the treatment group (group 1) pre-test was 12.3 and 12.5 post-test. The non-treatment group (group 2) pre-test standard deviation was 10.8, and post-test standard deviation of 14.3. The non-treatment group standard deviation difference showed a greater variation in the range of scores.

Post-test analysis showed an increase of 20.8% increase for the upper 25th percentile and 20.7% increase for the lower 25th percentile in the non-treatment group. The interquartile range post-test comparison exhibited a 15.8% increase in scores also for the non-treatment group.

Analysis of the genetics unit treatment group (group 2, $N=27$) indicated an overall increase when evaluating the pre-test versus post test results (*Figure 3*). There was an increase of 37.9% in the mean score, 15.3% increase when comparing the highest score of both tests, and a 56.2% increase of the lowest score from both tests. The pre-test interquartile range average was 38.9 and post-test average is 65.88. Breakdown of the

interquartile range (middle fifty percentile) demonstrated a 69.4% increase in test scores from the pre-test to post test.

Analysis of the genetics unit non-treatment group (group 1, $N=20$) also indicated an overall increase in scores when comparing the pre-test and post-test (*Figure 4*). There was an increase of 50.0% in the mean score, 51.9% increase in the highest score of each test, and a 56.7% increase in the lowest score. The pre-test interquartile range average was 55.5 and post-test average is 61.6. Comparison of the interquartile range revealed an increase of 11.0%.

Comparison of the treatment and non-treatment groups exhibited an overall increase in both groups from the pre and post-test. The standard deviation for the treatment group pre test (group 2) is 13.4 and 11.7 for the post-test which showed a smaller amount of variability in the scores on the post test. The non-treatment group (group 1) pre-test standard deviation was 10.3 and 12.0 for the post test.

Post test analysis showed an increase of 54% for the upper 25th percentile and 85.8% increase for the lower 25th percentile in the treatment group. The interquartile range post test comparison exhibited a 6.8% increase in scores also for the treatment group.

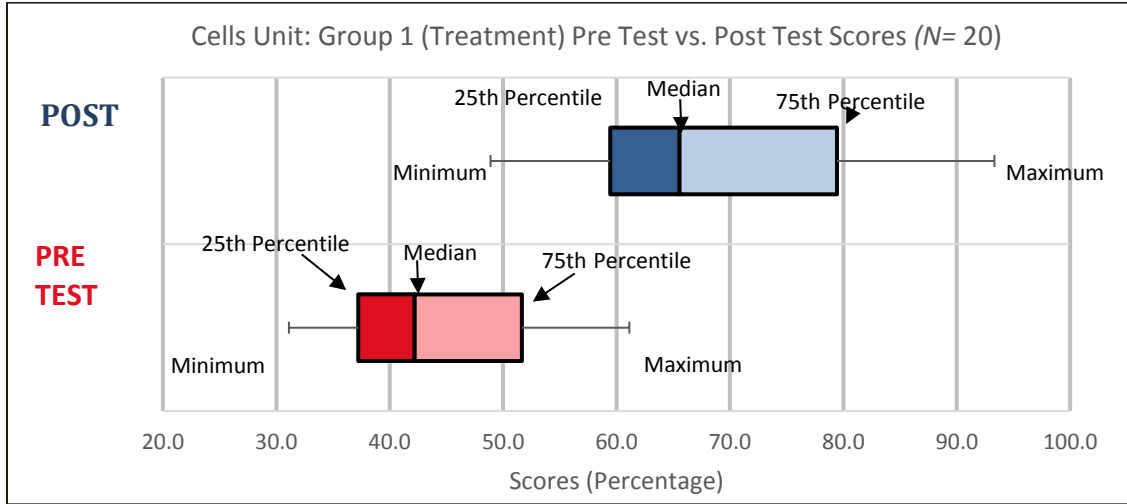


Figure 1. Cells Unit Group 1.

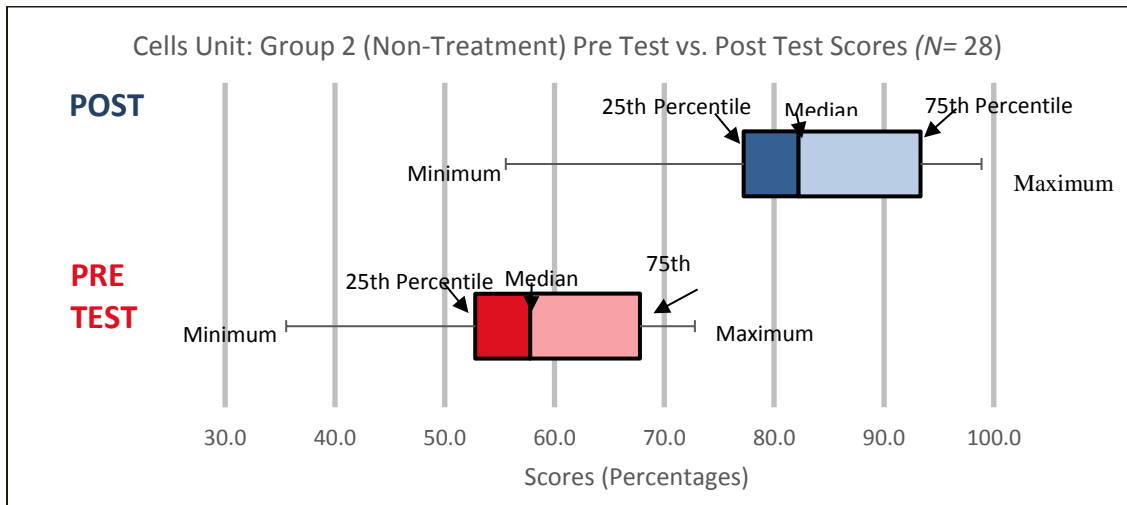


Figure 2. Cells Unit Group 2.

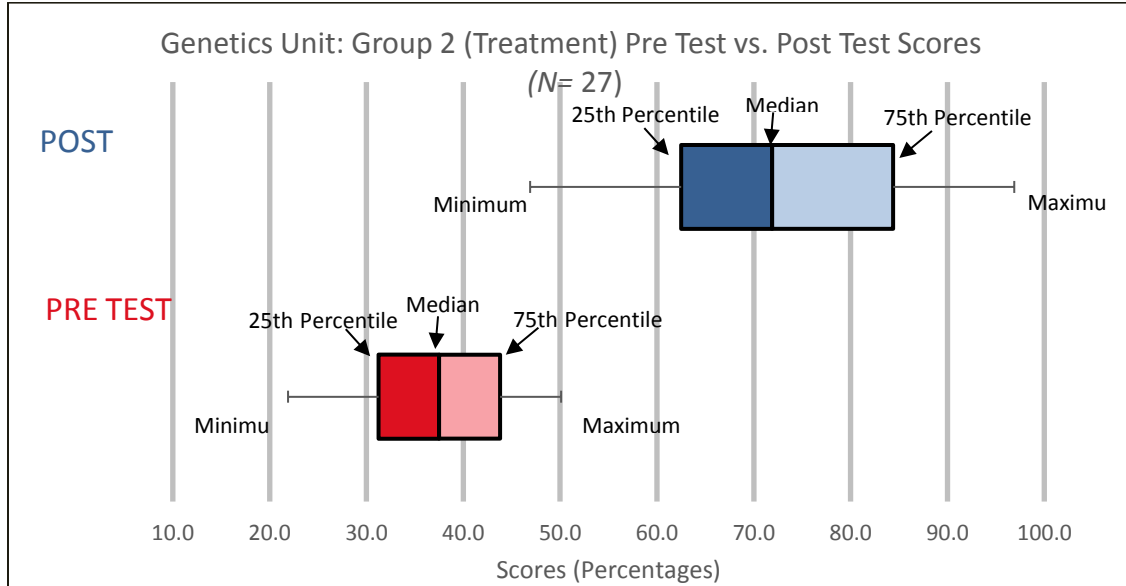


Figure 3. Genetics Unit Group 2.

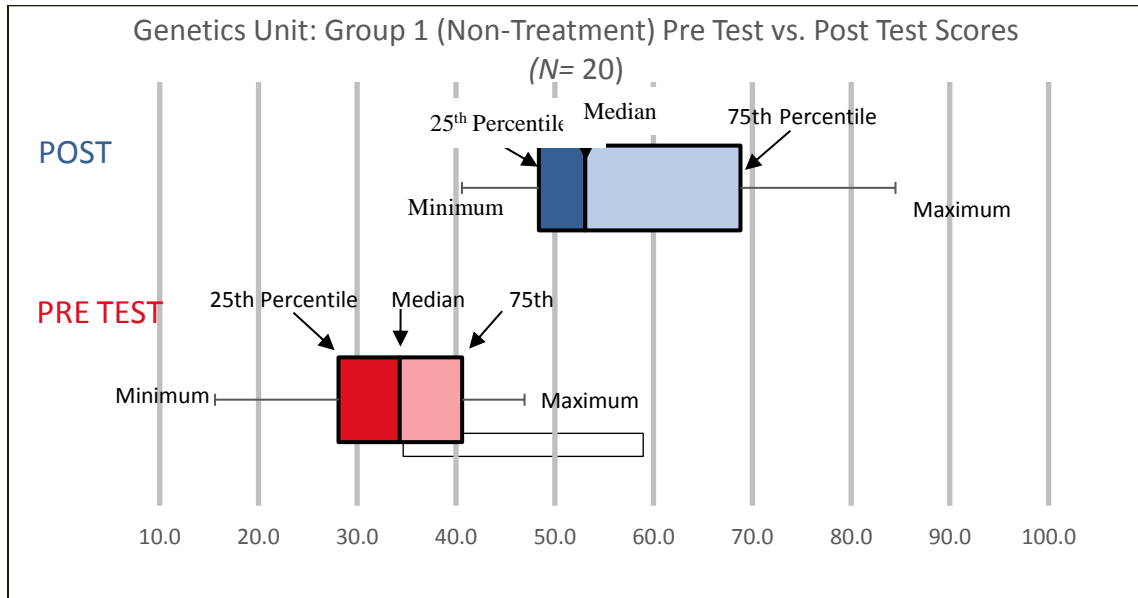


Figure 4. Genetics Unit Group 1.

The flipped classroom increased the problem solving skills of the students in both groups. When asked in the post treatment survey whether the flipped classroom format helped them have better problem solving abilities, 61% responded with “yes” (N=45).

Additionally, of 43 responses when asked to rate their improvement in problem solving from the flipped classroom, 33% rated their improvement with a 3, 28% rated their improvement with a 4, and 19% rated with a 5 on a Likert rating scale with 1 being least and 5 being greatest improvement. (*Figure 5*). In a pre-treatment survey question asking students to rate their ability in applying what they learn in biology to solve a problem, only 15% felt confident in their problem solving skills and 52% felt they were “sometimes good at applying what I have learned to solve a problem”. When asked in the post treatment survey if watching online resources and having in class activities better helped with understanding of biology concepts than traditional methods, 53% of students responded they had more confidence in their understanding of biology concepts, 27% said they have better understanding with the traditional methods, and 20% responded they could not tell any difference. When rating their improvement in understand of biology concepts during the flipped classroom, on a Likert scale of 1-5 with 1 being least and 5 being greatest, 26% chose a 2, 21% chose a 3, 37% chose a 4, and 14% chose a 5 ($N=45$).

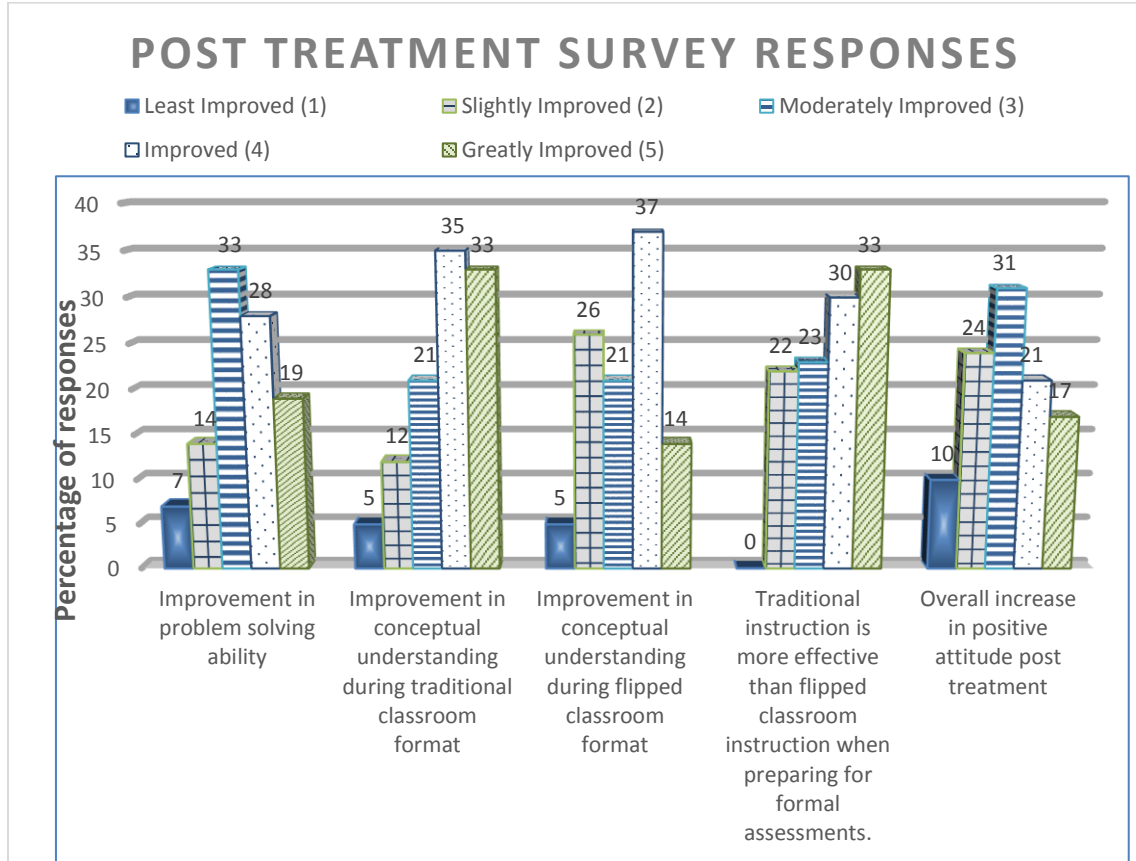


Figure 5. Student post treatment survey responses, ($N=45$).

Conversely, student post treatment surveys ($N=45$) revealed that students in both groups agreed the traditional classroom was more effective in preparing them for quizzes and tests. On a Likert rating scale of 1 to 5, with 1 being least effective and 5 being the most effective, 23% rated the effectiveness of the traditional method with a 3, 30% with a 4, and 33% with a 5. Comparing that to whether watching the video lectures prepared them for quizzes and tests, 62% said “sometimes” and 34% said “yes” watching the online video lectures did prepare them. When asked if the flipped classroom method helped the student learn more than the traditional method, 22 students responded with a “yes” and 23 students responded with “no” ($N=45$).

Utilizing online resources as homework helped the students in both groups to understand the topics being covered during class activities and helped them complete the classwork. In self-evaluation, (Likert scale rating of 1-4, 1 being strongly disagree and 4 being strongly agree) 82% of the students in Group 1 ($N=20$) gave a 4 rating for the helpfulness of watching the online resource to their conceptual understanding. 59% of Group 2 ($N=28$) gave a rating of 4 and 37% a rating of 3. When rating whether the online assignment helped with completing the classwork, 64% of Group 1 and 73 % of Group 2 gave a rating of 4, strongly agree.

Throughout this school year, the attitude of the students in each group had been overall a positive one. The students seemed to genuinely enjoy being in class most days and from my observations looked forward to coming to class. Most of the students come to learn although the common 9th grade student issues such as talkativeness and periodic lack of attention can be a struggle to control at times. Of the 52 student responses to the pre-treatment survey question “Which of the following describes your attitude during biology class?”, 62% chose the answer “I love biology class because I am learning so much each day.”, 15% said “I love biology class but don’t feel like I am learning much each day, 6% said “I dread going to biology class because it is boring and I am not interested, 0% said I hate biology class, and 17% answered “I have no opinion about biology class.” (Appendix B).

The flipped classroom experience increased the positive attitude of the students toward biology class. The responses to the post treatment survey question “On a scale of 1 to 5, with 1 being the least and 5 being the greatest, rate improvement in your attitude toward

being in biology class from the flipped classroom format.” (*Figure 5*) indicated an overall improvement in attitude during treatment since 31% of responses were a 3 moderately improved, 21% chose a 4 improved, and 17% chose a 5 greatly improved ($N=45$). 24% indicated they slightly improved. In contrast, of the 48 responses to the post treatment survey question “How did the flipped classroom effect your attitude toward biology class?”, 40% chose the answer “I felt frustrated by flipped classroom format.”, 37.2% answered “I was more excited to be in class.”, and 33% felt no difference in attitude about biology class.

Student self-evaluations were taken after group activities during the treatment periods for both groups. A Likert Scale was used in these evaluations with ratings of *strongly disagree*, *disagree*, *agree*, and *strongly agree*, each rated 1-4 respectively (Appendix C) . 64% of students in Group 1 ($N=20$) and 67% in Group 2 ($N=28$) strongly agreed that “online assignment helped in the attitude toward the class work and how much we participate”. 69% in Group 1 and 65% in Group 2 strongly agreed that having more time for question and answer with the teacher contributed to their success during class activities. A high percentage, 77% in Group 1 and 84% in Group 2, felt they were cooperating and helping each other during the same class activities.

Student interviews ($N=6$) supported what was revealed in the surveys and the self-evaluations overall concerning student attitude and engagement. When asked what they liked and disliked about the flipped classroom, a student from Group 1 replied “I like that we have more hands on and I learn more by doing it. Not just memorizing but learning.” A student from Group 2 said “I like class (flipped) but at home we have to do more. It is like a catch 22, more at home to do but better in class experience. (I like) flipped because it makes

class more fun. I get more excited about coming to class.” Another from Group 2 said “Regular (traditional) is kind of boring. Wish we could do this in some other classes like history.” In response to that student, another said “In history we just take notes, flashcards, etc. here we do group activities, stuff like that and working with other people really helps.” In contrast, one student in Group 1, who (based upon my observations) struggled with her attitude throughout the treatment said “The questions and answers (during class) helped me more than the videos did. I really like having notes. Watching things it is harder for me to watch it over and over and over again to learn it.”

At the end of the treatment, students were asked to give anonymous written feedback. They included both positive and negative feedback as well as suggestions for improving their flipped classroom experience. Examples of the most common negative feedback comments were: “I can’t focus on the video when I have question to do with it.” “I have a hard time remembering stuff about the video.” “I am struggling to remember to watch the video at home and answer your email questions when I do it helps me though. I liked copying the notes from the board a little more.” “I would like a big worksheet where you hand it out and it has questions from the video.” “Didn’t like having to check my email.” “Honestly it doesn’t help me pay attention more in class. I like to write things down b/c (sic) that is how I learned to study.” “I honestly hate flipped classroom. I was not able to pay more attention, I got distracted. I got stressed a lot. I like taking notes with you.”

Examples of the most common positive feedback comments were: “The videos are awesome ideas and really help me to understand the lessons and helped me solve questions I had. Some of the examples and cartoons they show is (sic) the main reason I can remember half

the things that we go over.” “I think that this really works because I am better at stuff when I get to do things hands on.” “Seeing the point of view of others helps me learn better.” “More time to talk about weak points throughout the class.” “I think I learned about the same but I liked it more because we had more time in class to talk about it.” “More in depth understanding.” “I just didn’t like that we didn’t have written notes off of the board. But I like that we are doing more hands on things.” “I liked that we could work together more.” “Class is more fun and easier.” “I like the flipped classroom. I pay attention. I actually understand.” “Know some people better by getting in groups, made me like biology better.” “Things have been easier to understand.” Biology students at Glenwood prefer a combination of the traditional and flipped classroom method for instruction. (*Figure 6*) In anonymous feedback from Group 1 ($N=19$), 1 student preferred the flipped classroom, 4 preferred the traditional classroom, and 14 students requested a combination of the two. Feedback from Group 2 ($N=26$) had similar results with 5 stating a preference for the flipped classroom, 9 preferring the traditional and 12 who would like to have a combination of the two.

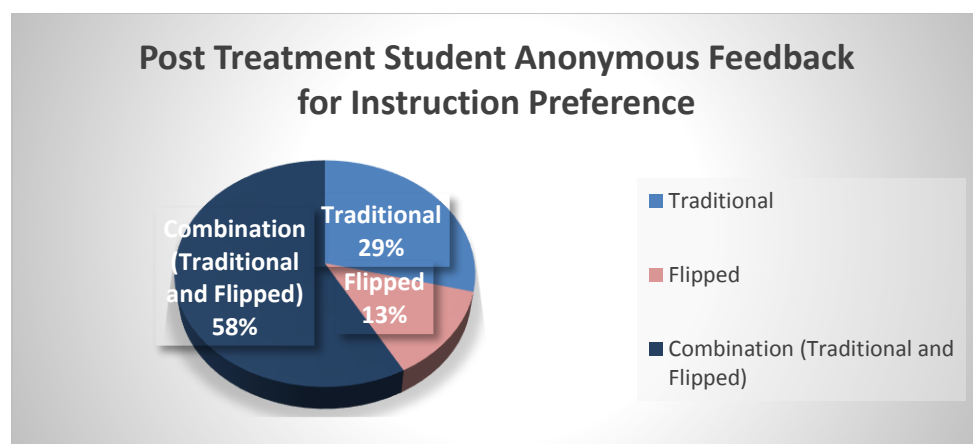


Figure 6. Post treatment anonymous feedback to the question “Which classroom instructional method do you prefer?”

Student interviews brought a mixed response in student preference. One student stated “I like having notes also and going in the book, going through things with you. I also like the flipped cause (sic) we got to ask more questions and got to go through things together. I also like having videos. They helped me and I think helped a lot of other people. I still go back to the flipped classroom stuff even after we finished (the treatment).”. Of the students who were interviewed, 100% ($N=6$) of those students agreed they would prefer a combination of the two learning approaches. One asked if watching the videos could be optional so those who learned from them would have them available. During the treatment, many students requested that I share the power point presentations with them via Google Docs so they would have the notes but still be able to have the increased number of group activities during class. During class discussions, the majority of both groups agreed they would prefer having a mixture of flipped and traditional learning approaches. In post treatment survey results, when given only the traditional or flipped as choices, the students slightly prefer the traditional classroom. Of the 45 responses, 23 students, 54.8%, prefer the traditional whereas 20 students, 47.6%, prefer the flipped classroom approach. There were 2 students who did not like either way of learning. In another survey question, 65% of the student responses said they would rather have the flipped classroom because there is more time for labs and activities during class.

Those students who preferred the traditional classroom voiced their opinion frequently throughout the treatment and after. They overwhelmingly preferred taking notes in class and having those notes to study by. One student said “I like taking the notes from the

board better cause (sic) you explain it so well.” Another said “I like it when we got notes from you cause (sic) I know what I should write down.”

INTERPRETATION AND CONCLUSION

The flipped classroom research and resulting data suggest there is significant potential to increase student learning, problem solving skills, engagement, and attitude through the use of online instructional resources and more in class active learning. The students realized there had been an improvement in their problem solving ability as well as an improvement in their understanding of biology concepts. Although the student perceived improvement in understanding from the treatment as compared to the traditional instruction was not significant, it was nonetheless an improvement. Thirty seven percent felt their understanding had improved during the flipped classroom and 14% had greatly improved. However, 33% felt their understanding greatly improved during the traditional instruction and 35% improved. Even though these data seem to contradict each other, overall the students felt there was improvement from the flipped classroom. This was encouraging to me because during my years of teaching, the unit on cells and the unit on genetics are the most difficult of all the concepts for my students to understand. Students did rate the traditional instruction method above that of the flipped method in preparing them for formal assessments. I believe that is due to the way they have learned to learn through lecture and note taking. Not having the in class lectures and not taking notes from lecture made them feel like they were not learning when the pre and post treatment unit tests indicate that they were in fact learning.

Data from the pre and post treatment unit tests show the student's knowledge increased along with an increase in problem solving ability. Although this increase is to be expected in both groups with or without the treatment, there were greater positive gains in scores on the post test for the treatment groups in each unit when compared to the non-treatment group. It was encouraging to see the greatest gains were for those with the lowest pre test scores. Those are the students who generally do not listen in class, do not complete homework regularly, and do not study for formal assessments. As a result their test scores throughout the school year have been very low. These post test scores suggest the flipped classroom had a positive impact on the learning of the lowest achievers in my biology classes.

Data from post treatment survey questions, self-evaluations, and interviews support an increase in student engagement during class coupled with improved attitude which could have been the cause of an over-all increase in learning. From my observations, students learn better when they are engaged and excited about what they are learning. Freeing class time for more group learning and collaboration brought an excitement to be in class and an improved level of performance. In many of the typically low achievers, scores on assessments rose beyond their normal previous scores and there was a higher rate of homework assignment completion. The rate of homework completion for Group 1 rose from 70% completion to 90% during the treatment. Two of the students never remembered to watch the videos so they never completed the written assignments however these two students typically did not turn in assignments before or after the treatment.

Typical comments from both groups were that working with other students and getting their input helped with their understanding and problem solving. In addition, many students voiced their appreciation for beginning class with unlimited question and answer time. The students in both groups felt they gained more understanding and were able to have a greater degree of learning the difficult concepts we were studying due to time allowed for questions, clarification, and personal instruction time with me during activities.

From my perspective, there was a higher degree of excitement and enthusiasm from the students. Student attitude, although already very good, improved. That made me more excited about using the flipped method. Data showed an overall increase in positive attitude which is significant to me since the attitude was positive during class before the treatment began. The students appreciated working together, helping each other understand, and having more input from me throughout the treatment. Most students enjoyed the flipped classroom experience and all of the students interviewed asked to continue the flipped method and asked me to share my notes with them via Google Drive so we could continue having more in class activities.

There was growth in all areas even for those students who did not like the flipped classroom experience. Although over all the students preferred the traditional method of instruction, 29%, over the flipped method, 13%, the qualitative data collected during this research study indicate a student preference for combining the use of these methods, 58%. There were daily requests for both approaches throughout the treatment period. During their previous years of schooling, the students at Glenwood have been trained to take notes and then memorize those notes to take a test. The flipped classroom method of learning was a

challenge to their “normal” way of learning and many of them were frustrated with the new approach. In the beginning of the treatment, the high achievers were the most vocal in their disapproval of the flipped classroom. They are also the ones most diligent in taking thorough notes and memorizing those notes. They wanted notes and felt they could not learn the difficult concepts without them. As the treatment progressed and these students adjusted, the post treatment survey data along with the feedback and interviews show they began to realize the positive difference the flipped classroom was making in their learning and problem solving ability.

In light of the data support for improvement in attitude and engagement as well as problem solving ability and learning, the use of the flipped classroom method had a positive effect in these areas. Any improvement, although small, in learning such difficult concepts as those in genetics and cell biology suggests a positive impact. For student attitude to improve during (treatment) these units, when in previous years typical comments from students would be “I hate learning about cells. I just can’t understand it. It is too hard for me. I will be glad when this is over.”, it suggests to me a very positive impact from the flipped classroom methods. However, I consider my study to be incomplete. For this study and its results to have greater validity and for the impact of the flipped classroom to be demonstrated more fully, more time needs to be spent in researching this method. A 12 week period of the flipped classroom is not enough to provide the best and most valid data. I would like to begin the school year using this teaching method rather than beginning in the middle of the school year when students have settled in to learning the way they are most accustomed to which is in class lecture and taking notes. It was difficult for them to adjust but once they did,

they enjoyed it, yet they still preferred the traditional instruction. Additionally, I would like to include periodic short quizzes leading up to the unit exams to help students and to help me evaluate their level of understanding along the way, before taking such a big exam.

Misconceptions and lack of understanding can be addressed early that way, helping students have a better performance on formal evaluations and a better experience.

VALUE

The most significant impact and value gained from this project is the realization that biology can be exciting and difficult concepts can be learned. Students at Glenwood School have gained an even more positive attitude toward biology class and learning biological concepts in general. They have also realized they can actually learn without memorizing notes. My goal in doing this research project in my classes was multifaceted. I desire for my students to gain the ability to think critically, to take what they learn and use it to solve a problem. I also desire to have more time in class dedicated to problem solving activities, to the practice of application of biological concepts. I want to offer more one on one time with my students to strengthen their confidence in their ability to learn and to think critically. I decided to try the flipped classroom because it seemed to offer the avenue to achieve these goals, utilizing the tool that is already constantly in the hands of my students, the cellphone and its internet access.

There were numerous valuable outcomes from this project. One unexpected development was the modern day student does not want to use email to communicate with their teacher. I was emailing the video links as well as the written assignments that went along with them to each student. Also, the links and assignments were posted on our class

Engrade page. In turn, they were to email the completed written work back to me before midnight. They did not like this. Some said they would forget to check email because they never use it and many complained about emailing the assignment back to me. This was surprising to me since email is what I use to communicate. Some students suggested I use Snapchat or Instagram as a way of communicating. If I plan to use the flipped classroom in the future (which I do), according to my students, I need to find a more popular way of communicating it to them. One that is easier for them to access.

An amazing and rewarding development resulting from the treatment was the confidence gained by low achievers when they were working in collaborative groups. One student who had struggled with understanding anything no matter how simple began to show significant improvement. Before the treatment, he told me he just could not understand biology no matter how hard he tried or how much he studied. When he began to gain understanding and improve in grades, he attributed that to what he was learning from his peers in group work. His mother, with whom I had met several times about his grades, emailed me to tell me how pleased she was with his improvement in grades and in his confidence in biology. He went from being a low “C” student to a high “B” student and ended the semester with a high “B” average. He is representative of many of the students in both groups.

Yet another amazing and significant occurrence was the request of many of the groups to come in during my planning period, their physical educational period, so they could continue to work together and help each other with understanding. Because they did not have lectures during class and did not have notes from class to study, they decided it

would be a good thing to work together outside of class. This was a result of their realization that they can learn without notes and they can do it through helping each other, sharing understanding and solving problems together. They had such excitement in doing this even though it was outside of the class period.

The students also came to the realization that the internet is not just for socialization, free music, and news but it can be used to help them find answers and to help them understand difficult concepts. Many of my students told me they were still using the online resources I had given them and continued to ask me for more. Now they are learning to search out their own resources because they have seen the value in it and the ease of accessing it with their phones.

For me, the most valuable part of this research process was including my students and their thoughts in my decision making. Getting their perspective on how they learn, how they want to learn, and what impacts them most positively changes not only my thinking but also my approach to their learning. After all, they are the main stakeholders in this thing we call education. The way they learn is changing, has changed, and will continue to change. As educators, not only must we change with them, but we must listen to them, get their feedback, try incorporating the strategies they suggest helps them the most, and see what impact it has on their confidence and learning.

My goals in doing this project have been realized however I think this is just the beginning of a long journey for me. A continual journey of reflection and evaluation of my teaching methods, my evaluation methods, and my approach to education in general. I have changed more toward my teaching methods in the last year than in all of my 21 years in

education. It is as if I am starting over as a newbie and the future is brighter than I thought it could be at this point. Rather than staying frustrated with apathetic students, I am excited about finding new and more creative ways to excite, inspire, and challenge my students. It may sound trite and “corny” but the best is yet to come for me and for my students.

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APPENDICES

APPENDIX A

PRE AND POST TREATMENT UNIT ASSESSMENTS

Biology Cells pre and post-test, 2016
(Levine, J. & Miller, K., 2010)

Multiple Choice

Identify the choice that best completes the statement or answers the question.

- _____ 1. Who used a compound microscope to see chambers within cork and named them “cells”?
- Anton van Leeuwenhoek
 - Robert Hooke
 - Matthias Schleiden
 - Rudolf Virchow
- _____ 2. Looking at a cell under a microscope, you note that it is a prokaryote. How do you know?
- The cell lacks cytoplasm.
 - The cell lacks a cell membrane.
 - The cell lacks a nucleus.
 - The cell lacks genetic material.
- _____ 3. Which of the following is a function of the nucleus?
- stores DNA
 - stores sugars
 - builds proteins
 - packages proteins
- _____ 4. Which of the following is a function of the cytoskeleton?
- helps a cell keep its shape
 - contains DNA
 - surrounds the cell
 - helps make proteins
- _____ 5. Which structure makes proteins using coded instructions that come from the nucleus?
- Golgi apparatus
 - Mitochondrion
 - Vacuole
 - Ribosome
- _____ 6. Which organelle would you expect to find in plant cells but not animal cells?
- Mitochondrion
 - Ribosome
 - Chloroplast
 - smooth endoplasmic reticulum
- _____ 7. The primary function of the cell wall is to
- support and protect the cell.
 - store DNA.
 - direct the activities of the cell.
 - help the cell move.
- _____ 8. You will NOT find a cell wall in which of these kinds of organisms?
- Plants
 - Animals
 - Fungi
 - Bacteria

- ___ 9. Which of the following is a function of the cell membrane?
- breaks down lipids, carbohydrates, and proteins from foods
 - stores water, salt, proteins, and carbohydrates
 - keeps the cell wall in place
 - regulates the movement of materials into and out of the cell
- ___ 10. Diffusion occurs because
- molecules are attracted to one another.
 - molecules constantly move and collide with each other.
 - cellular energy forces molecules to collide with each other.
 - cellular energy pumps molecules across the cell membrane.
- ___ 11. An animal cell that is surrounded by fresh water will burst because the osmotic pressure causes
- water to move into the cell.
 - water to move out of the cell.
 - solutes to move into the cell.
 - solutes to move out of the cell.

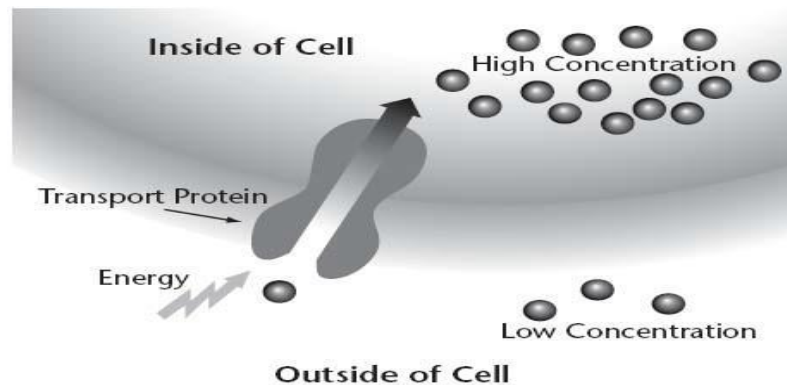


Figure 7-4

- ___ 12. Which means of particle transport is shown in Figure 7-4 above?
- Diffusion
 - Osmosis
 - facilitated diffusion
 - active transport

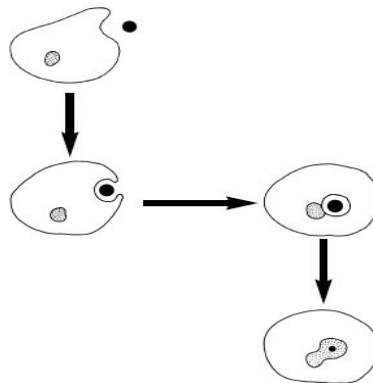


Figure 7–5

- _____ 13. Which means of particle transport is shown in Figure 7–5 above?
- Endocytosis
 - Exocytosis
 - facilitated diffusion
 - protein pump
- _____ 14. Which of the following organisms makes its own food using light energy from the sun?
- Mushroom
 - Amoeba
 - Leopard
 - oak tree
- _____ 15. What happens during photosynthesis?
- Heterotrophs consume ATP.
 - Heterotrophs produce ATP.
 - Autotrophs consume carbohydrates.
 - Autotrophs produce carbohydrates.
- _____ 16. Plants gather energy with light-absorbing molecules called
- pigments.
 - thylakoids.
 - chloroplasts.
 - glucose.
- _____ 17. Most plants appear green because chlorophyll
- absorbs green light.
 - absorbs violet light.
 - does not absorb green light.
 - does not absorb violet light.
- _____ 18. What happens when chlorophyll is struck by sunlight?
- The electrons in the chlorophyll molecule become energized.
 - The chlorophyll molecule is broken into two parts.
 - A chemical reaction turns chlorophyll into high energy carbohydrates.
 - Energy from fat molecules is released.
- _____ 19. A student is collecting the gas given off from a plant in bright sunlight at a temperature of 27°C. The gas being collected is probably
- oxygen.
 - carbon dioxide.
 - ATP.
 - glucose.
- _____ 20. Photosynthesis uses sunlight to convert water and carbon dioxide into
- oxygen and carbon.
 - high-energy sugars and proteins.
 - ATP and oxygen.
 - oxygen and high-energy sugars.

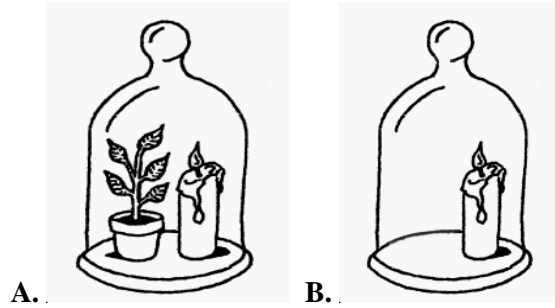


Figure 8-4

- ___ 21. In Figure 8-4, why might the candle in jar A burn longer than the candle in jar B?
- Carbon dioxide produced by the plant allows the candle to burn longer.
 - Chlorophyll produced by the plant allows the candle to burn longer.
 - Glucose produced by the plant allows the candle to burn longer.
 - Oxygen produced by the plant allows the candle to burn longer.
- ___ 22. If carbon dioxide is completely removed from a plant's environment, what would you expect to happen to the plant's production of high-energy sugars?
- More sugars will be produced.
 - No sugars will be produced.
 - The same number of sugars will be produced but without carbon dioxide.
 - Fewer sugars will be produced at first, but then the plant will recover.

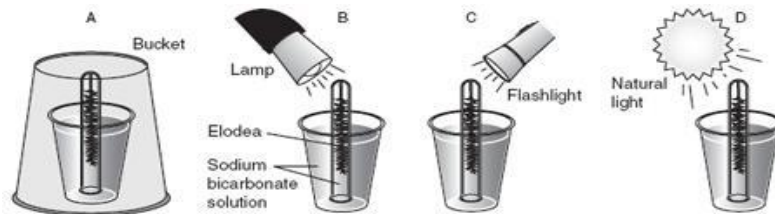


Figure 8-5

- ___ 23. In which experimental setup shown above would you expect the *Elodea* plant inside the test tube to produce the LEAST amount of oxygen?
- A
 - B
 - C
 - D
- ___ 24. How do organisms get the energy they need?
- by burning food molecules and releasing their energy as heat
 - by breathing oxygen into the lungs and combining it with carbon dioxide
 - by breaking down food molecules gradually and capturing their chemical energy
 - by using the sun's energy to break down food molecules and form chemicals

- ___ 25. Which of the following is one of the ways that cellular respiration and photosynthesis are opposite processes?
- Photosynthesis releases energy, and cellular respiration stores energy.
 - Photosynthesis removes carbon dioxide from the atmosphere, and cellular respiration puts it back.
 - Photosynthesis removes oxygen from the atmosphere, and cellular respiration puts it back.
 - Photosynthesis consumes glucose, and cellular respiration produces glucose.
- ___ 26. Photosynthesis is to chloroplasts as cellular respiration is to
- chloroplasts.
 - cytoplasm.
 - mitochondria.
 - nuclei.
- ___ 27. The products of photosynthesis are the
- products of cellular respiration.
 - reactants of cellular respiration.
 - products of glycolysis.
 - reactants of fermentation.
- ___ 28. Which of the following is a correct statement about the events of the cell cycle?
- Little happens during the G_1 and G_2 phases.
 - DNA replicates during cytokinesis.
 - The M phase is usually the longest phase.
 - Interphase consists of the G_1 , S, and G_2 phases.
- ___ 29. Which of the following represents the phases of mitosis in their proper sequence?
- prophase, metaphase, anaphase, telophase
 - interphase, prophase, metaphase, anaphase, telophase
 - interphase, prophase, metaphase, telophase
 - prophase, anaphase, metaphase, telophase
- ___ 30. Cancer is a disorder in which some cells have lost the ability to control their
- size.
 - spindle fibers.
 - growth rate.
 - surface area.
- ___ 31. Why are stem cells important?
- They have specialized DNA.
 - They are incapable of becoming cancer cells.
 - They have the potential to undergo cell division.
 - They have the potential to develop into other cell types.

Science Skills

A student put together two different experimental setups as shown below. The plants were in a sunny window.

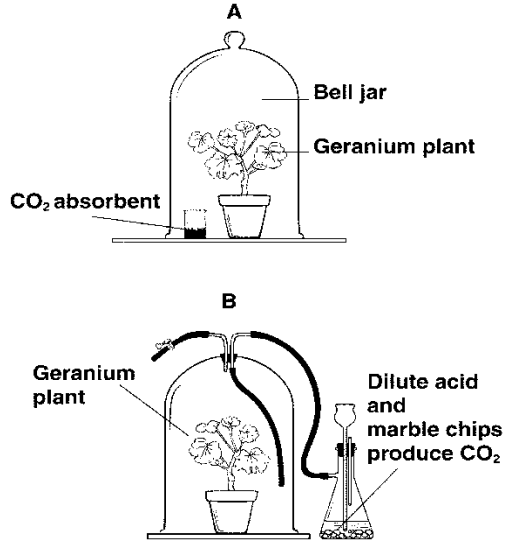


Figure 8–11

1. **Design an Experiment** Look at Figure 8–11. What factor is the student varying?
2. **Control Variables** Suggest an appropriate control for the experiment shown in Figure 8–11.
3. **Predict** In Figure 8–11, assume that the student placed Plant A in indirect sunlight for two days. How would the rate of photosynthesis of this plant compare with that of a plant grown under normal conditions?
4. **Predict** In Figure 8–11, assume that the student placed Plant B in indirect sunlight for two days. How would the rate of photosynthesis of this plant compare with that of a plant grown under normal conditions?

A scientist set up a respiration chamber as shown below. She placed a mouse in flask B. Into flasks A, C, and D, she poured distilled water mixed with the acid-base indicator phenolphthalein. In the presence of CO₂, phenolphthalein turns from pink to clear. She allowed the mouse to stay in the chamber for about an hour.

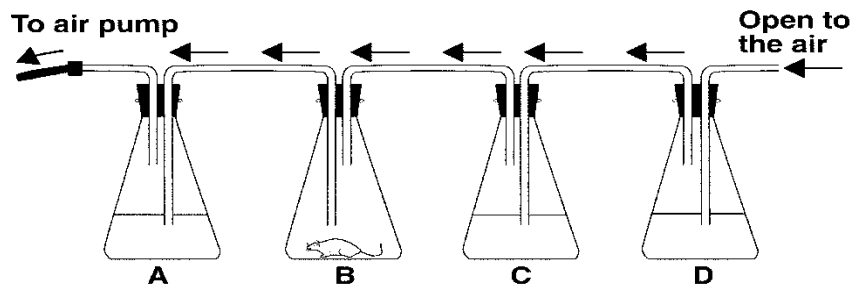


Figure 9–7

5. **Infer** Write the equation for cellular respiration. Based on this equation and the setup shown in Figure 9–7, what substance(s) would you expect the mouse in flask B to give off?

6. **Interpret Visuals** What will the mouse require to carry out cellular respiration? Look at the flasks in Figure 9–7. Describe the flow of materials through the flasks. Will the mouse receive fresh air so that it can survive?
7. **Interpret Visuals** Based on Figure 9–7, how will the scientist be able to detect whether the mouse is carrying out cellular respiration

Biology genetics test, 2016, pre and post treatment
(Levine, et al., 2010)

Multiple Choice

Identify the choice that best completes the statement or answers the question.

- ___ 1. The different forms of a gene are called
 a. traits.
 b. pollinations.
 c. alleles.
 d. hybrids.
- ___ 2. A tall plant (TT) is crossed with a short plant (tt). If the tall F_1 pea plants are allowed to self-pollinate,
 a. the offspring will be of medium height.
 b. all of the offspring will be tall.
 c. all of the offspring will be short.
 d. the offspring can be tall or short.
- ___ 3. When you flip a coin, what is the probability that it will come up tails?
 a. 1
 b. $\frac{1}{2}$
 c. $\frac{1}{4}$
 d. $\frac{1}{8}$
- ___ 4. A heterozygous tall pea plant is crossed with a short plant. The probability that an F_1 plant will be tall is
 a. 25%.
 b. 50%.
 c. 75%.
 d. 100%.
- ___ 5. Organisms that have two identical alleles for a particular trait are said to be
 a. hybrid.
 b. homozygous.
 c. heterozygous.
 d. dominant.

		Tt	
		T	t
TT	T	TT	Tt
	T	TT	Tt

$T = Tall$

$t = \textit{Short}$

Figure 11–1

- ___ 6. In the Punnett square shown in Figure 11–1, which of the following is true about the offspring resulting from the cross?
- About half are expected to be short.
 - All are expected to be short.
 - About three fourths are expected to be tall.
 - All are expected to be tall.

		<i>RRYy</i>			
		<i>RY</i>	<i>Ry</i>	<i>RY</i>	<i>Ry</i>
<i>RrYy</i>	<i>RY</i>	<i>RRYY</i>	<i>RRYy</i>	<i>RRYY</i>	<i>RRYy</i>
	<i>Ry</i>	<i>RRYy</i>	<i>RRyy</i>	<i>RrYy</i>	<i>RRyy</i>
	<i>rY</i>	<i>RrYY</i>	<i>RrYy</i>	<i>RrYY</i>	<i>RrYy</i>
	<i>Ry</i>	<i>RrYy</i>	<i>Rryy</i>	<i>RrYy</i>	<i>Rryy</i>

Figure 11–3

- ___ 7. Use Figure 11–3 to answer the following question. If a pea plant that is heterozygous for round, yellow peas (*RrYy*) is crossed with a pea plant that is homozygous for round peas but heterozygous for yellow peas (*RRYy*), how many different phenotypes are their offspring expected to show?
- 2
 - 4
 - 8
 - 16
- ___ 8. A male and female bison that are both heterozygous for normal skin pigmentation (*Aa*) produce an albino offspring (*aa*). Which of Mendel's principles explain(s) why the offspring is albino?
- dominance only
 - independent assortment only
 - dominance and segregation
 - segregation only
- ___ 9. A breed of chicken shows codominance for feather color. One allele codes for black feathers, another codes for white feathers. The feathers of heterozygous chickens of this breed will be
- black.
 - white.
 - gray.
 - speckled.
- ___ 10. In rabbits, there are four different versions of the gene for coat color. What pattern of inheritance is this?
- incomplete dominance.
 - polygenic inheritance.
 - codominance.
 - multiple alleles.
- ___ 11. Variation in human skin color is an example of
- incomplete dominance.
 - codominance.
 - polygenic traits.

- d. multiple alleles.
- ___ 12. What determines the color of western white butterflies?
- genes alone.
 - the environment alone
 - temperature and genes
 - exposure to sunlight and genes
- ___ 13. Which of the following supports the claim that the environment can affect genetic traits?
- Oak trees get taller as they grow.
 - Hydrangea flower color varies with soil pH.
 - Dandelion plants are self pollinating.
 - Pinion trees bear cones every other year.
- ___ 14. The arctic fox is blue-gray in the summer and white in the winter. What most likely influence(s) this change?
- genes and the environment
 - dominant alleles
 - the environment alone
 - codominant alleles
- ___ 15. If an organism's diploid number is 12, its haploid number is
- 12.
 - 6.
 - 24.
 - 3.

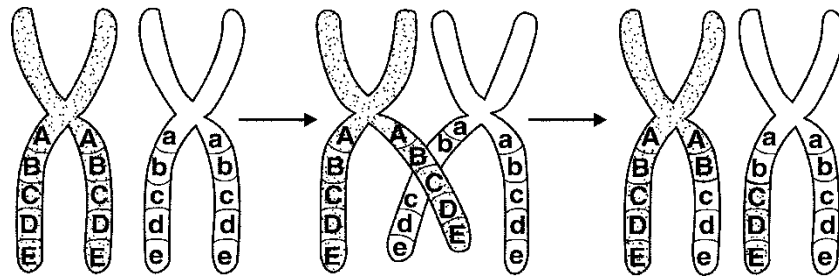


Figure 11-4

- ___ 16. What is shown in Figure 11-4?
- independent assortment
 - anaphase I of meiosis
 - crossing-over
 - Replication
- ___ 17. Linked genes
- are never separated.
 - assort independently.
 - are on the same chromosome.
 - are always recessive.

Gene Map of Chromosome 2 of the Fruit Fly

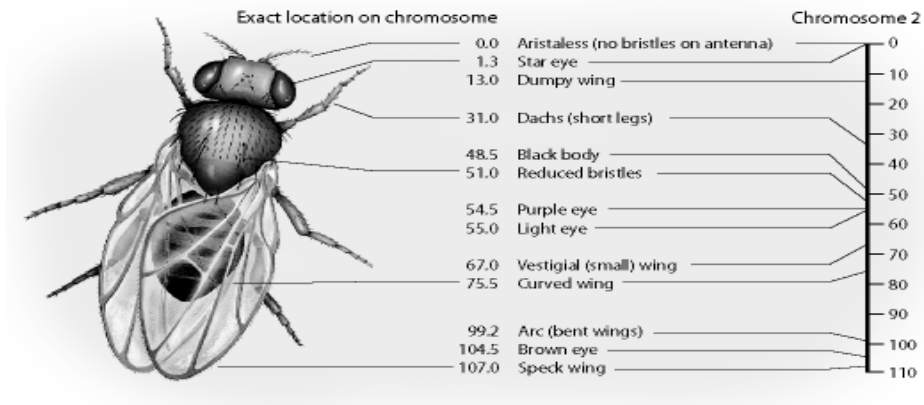


Figure 11-5

- ___ 18. Which trait is most likely linked to having a curved wing in the fruit fly in Figure 11-5?
- dumpy wing
 - vestigial wing
 - arc (bent wings)
 - speck wing
- ___ 19. Gene maps are based on
- the frequencies of crossing-over.
 - independent assortment.
 - genetic diversity.
 - the number of genes in a cell.
- ___ 20. The farther apart two genes are located on a chromosome, the
- less likely they are to be inherited together.
 - more likely they are to be linked.
 - less likely they are to assort independently.
 - less likely they are to be separated by crossing over.

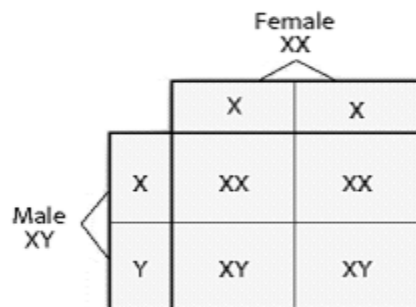


Figure 14-1

- ___ 21. According to Figure 14-1, what is the approximate probability that a human offspring will be female?
- 10%

- b. 25%
- c. 50%
- d. 75%
- _____ 22. How many chromosomes are shown in a normal human karyotype?
- a. 2
- b. 23
- c. 44
- d. 46
- _____ 23. Sex-linked genes are located on
- a. the autosomal chromosomes.
- b. the X chromosome only.
- c. the Y chromosome only.
- d. both the X chromosome and the Y chromosome.
- _____ 24. Which of the following statements is true?
- a. Females cannot have hemophilia.
- b. A colorblind girl's father must be colorblind.
- c. A sex-linked allele cannot be dominant.
- d. A colorblind boy's father must be colorblind.

Blood Types	
Blood Type	Combination of Alleles
A	$I^A I^A$ or $I^A i$
B	$I^B I^B$ or $I^B i$
AB	$I^A I^B$
O	ii

Figure 14–2

- _____ 25. If a man with blood type A and a woman with blood type B produce an offspring, what might be the offspring's blood type?
- a. AB or O
- b. A, B, or O
- c. A, B, AB, or O
- d. AB only

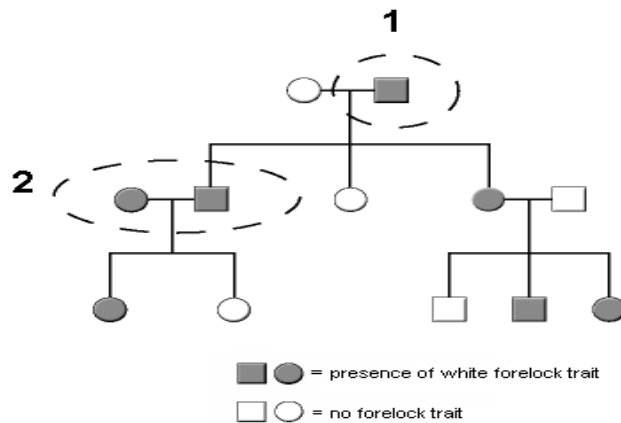


Figure 14–3

- ___ 26. Examine the pedigree in Figure 14–3. The allele for the presence of a white forelock is dominant. What is the probability of the couple labeled 2 of having a child with a white forelock?
- 25%
 - 50%
 - 75%
 - 100%
- ___ 27. Examine the pedigree in Figure 14–3. The allele for the presence of a white forelock is dominant. Therefore, we can tell from the chart that in the couple labeled 2
- the male is heterozygous and the female is homozygous.
 - the male is homozygous and the female is heterozygous.
 - the male is homozygous and the female is homozygous.
 - the male is heterozygous and the female is heterozygous.
- ___ 28. Which of the following is caused by a dominant allele?
- Huntington’s disease
 - Colorblindness
 - cystic fibrosis
 - sickle-cell disease
- ___ 29. Which of the following diseases and conditions does not appear until late in a person’s life?
- cystic fibrosis
 - sickle cell disease
 - Colorblindness
 - Huntington disease
- ___ 30. Sickle cell disease is caused by a
- change in one allele.
 - change in the size of a chromosome.
 - change in two proteins.
 - change in the number of chromosomes in a cell.
- ___ 31. In cystic fibrosis, a change in a single gene causes the protein called CFTR to
- become less soluble.
 - fold improperly.
 - destroy the cell membrane.
 - transport sodium ions.

- _____ 32. People who are heterozygous for sickle cell disease are generally healthy because they
- are resistant to many different diseases.
 - have some normal hemoglobin in their red blood cells.
 - are not affected by the gene until they are elderly.
 - produce more hemoglobin than they need.
- _____ 33. Which of the following combinations of sex chromosomes represents a female?
- XY
 - XXY
 - XXXY
 - XX

APPENDIX B

PRE AND POST TREATMENT STUDENT SURVEYS

Glenwood School
Biology student learning, engagement, and attitudes survey I

This survey is completely voluntary and your responses will not affect your grade or standing with the teacher in any way. If you choose to take this survey, please choose each answer to the best of your knowledge. Put a check in the box in front of the answer which applies to you.

I learn best by

- listening
- writing
- reading
- doing activities
- watching videos
- a combination of these

In biology class, which describes how you learn best

- taking notes from teacher lecture
- listening to teacher lecture
- reading assignments and doing written homework
- doing activities and/or labs during class
- I don't learn in biology class
- watching videos in class

Do you have internet access at home or on your cell phone?

- Yes
- No
- Sometimes

Do you think watching internet lectures or videos at home could help you understand and learn biology lessons?

- Yes
- No
- I am not sure

Do you think it could help you learn biology better if there was more time in class to ask questions, do activities, labs, and written work?

- Yes
- No

- Maybe
- Don't know

How much total time do you spend on the internet every day either on your cell phone or on a computer?

- 1-20 minutes
- 21-40 minutes
- 41-60 minutes
- More than 60 minutes
- I don't spend any time on the internet.

Do you learn from participating in group activities and labs?

- Yes
- No
- Sometimes
- Depends on who is in my group
- I don't like group activities and labs

Do teacher lectures keep your attention during biology class?

- Yes
- Sometimes
- No
- I have a hard time staying awake during lectures in biology class.
- Only when it is about something I am interested in.

When it comes to understanding concepts taught in biology, which of the following applies to you?

- I can easily understand biology concepts.
- I have to study a little bit to understand biology concepts.
- I have to study a lot to understand biology concepts.
- Biology is too hard so I don't even try.
- I need extra help from the teacher to help me understand biology concepts.

Which of the following describes your attitude during biology class?

- I love biology class because I am learning so much each day.
- I love biology class but don't feel like I am learning much each day.
- I dread going to biology class because it is boring and I am not interested.

- I hate biology class.
- I have no opinion about biology class.

Which of the following best describes your average attention and engagement level during biology class?

- 100% of the time I am engaged and attentive during class
- 75% of the time I am attentive and engaged during class
- 50% of the time I am attentive and engaged during class.
- 25% of the time I am attentive and engaged during biology class.
- Less than 25% of the time I am attentive and engaged during biology class.
- I am never attentive and engaged during biology class.

Which of the following best describes the teacher's attitude during biology class?

- Mrs. Wright is always excited and positive when teaching biology class.
- Mrs. Wright usually is excited and positive when teaching biology class.
- Mrs. Wright is bored and frustrated when teaching biology class.
- Mrs. Wright does not enjoy teaching biology class.
- Mrs. Wright hates teaching biology class.

When it comes to applying what you have learned in biology to solve a problem, how would you rate your ability?

- I am very good at applying what I learn to solve a problem.
- Sometimes I am good at applying what I have learned to solve a problem.
- I have a hard time applying what I learn to solve a problem
- I cannot apply what I learn to solve a problem.
- I do not understand biology so I don't learn anything to solve a problem with.

Glenwood School
Student post treatment learning, attitude, and engagement survey

This survey is completely voluntary and your responses will not affect your grade or standing with the teacher in any way. If you choose to take this survey, please choose each answer to the best of your knowledge. Put a check in the box in front of the answer which applies to you.

Which teaching method do you prefer?

- Flipped classroom format with watching online resources and in class activities over traditional classroom of lecture and written homework.
- I prefer traditional classroom format with lecture and written homework over the flipped classroom format.
- I don't like either way of learning.

Which classroom format helped you learn most effectively?

- Flipped classroom
- Traditional classroom
- Neither

Did the flipped classroom allow for more time to ask questions of the teacher?

- Yes
- No
- There was no difference from the usual.

Did the flipped classroom format allow for more activities, labs, and group activities?

- Yes
- No
- There was no difference from the usual.

How did the flipped classroom affect your attitude toward biology class.

- I was more excited to be in class.
- I felt no difference about being in class.
- I felt frustrated by flipped classroom format.
- I have no opinion about the flipped classroom format.

How many times did you watch each online assignment?

- 1 time
- 2 times

- More than 2 times
- I never watched the assigned resources.

Did watching online lectures and videos help prepare you for in class activities and labs?

- Yes
- Sometimes
- No
- I didn't watch the videos.

Did watching online video lectures help prepare you for quizzes and tests?

- Yes
- Sometimes
- No
- I didn't watch the videos.

Do you agree with the following statement? The flipped classroom format helped me learn more than the traditional format.

- Yes
- No

On a scale of 1 to 4, with 1 being the least and 4 being the greatest, rate your improvement in problem solving from the flipped classroom format.

- 1
- 2
- 3
- 4

On a scale of 1 to 4, with 1 being the least and 4 being the greatest, rate your improvement in understanding of biology concepts from the flipped classroom format.

- 1
- 2
- 3
- 4

On a scale of 1 to 4, with 1 being the least and 4 being the greatest, rate your improvement in your attitude toward being in biology class from the flipped classroom format.

- 1

- 2
- 3
- 4

On a scale of 1 to 4, with 1 being the least and 4 being the greatest, rate your teacher's improvement in attitude during biology class from the flipped classroom format.

- 1
- 2
- 3
- 4

On a scale of 1 to 4, with 1 being the least and 4 being the greatest, rate your ability to focus in class from the flipped classroom format.

- 1
- 2
- 3
- 4

On a scale of 1 to 4, with 1 being least and 4 being the greatest, rate the ability of online lectures and videos to help you learn biology concepts.

- 1
- 2
- 3
- 4

On a scale of 1 to 4, with 1 being the least and 4 being the greatest, rate the effectiveness of the traditional classroom format with lecture and note taking to help you learn biology concepts.

- 1
- 2
- 3
- 4

On a scale of 1 to 4, with 1 being the least and 4 being the greatest, rate the effectiveness of the traditional classroom format with lecture and note taking to help prepare you for quizzes and test.

- 1
- 2

- 3
- 4

APPENDIX C
STUDENT SELF EVALUATION

Self-Evaluation Form

Your name _____ Date _____

The first column says "Yourself" and is reserved for your evaluation of yourself. In the rows under your name, indicate the extent to which you agree with the "Evaluation Criteria" statement in the first column on the left, using a scale of 1-4 (1=strongly disagree; 2=disagree; 3=agree; 4=strongly agree). Total the numbers in each column at the bottom.

Evaluation Criteria	Yourself
Prepared for class and group work by watching online resources beforehand	
Watching the online assignment helped complete the classwork	
Watching the online assignment helped understand the topic and information during class	
Online assignment helped in the attitude toward the class work and how much we participate	
Cooperates and helps others during the classwork/activity/lab/project	
Having more time for Q&A during class contributes to the success of the classwork/activity/lab/project	
TOTALS	

APPENDIX D

STUDENT PRE AND POST INTERVIEW QUESTIONS

Student Interview Questions

1. What are your thoughts about the traditional classroom model? What do you like and dislike about it?
2. What are your thoughts about the flipped classroom model? What do you like and dislike about it?
3. Which classroom model do you enjoy most and why?
4. Which classroom model do you think helped you learn most and why?
5. In what ways was my attitude during class affected by the flipped classroom model?