USING REAL-WORLD APPLICATIONS TO ENHANCE LEARNING IN A HIGH SCHOOL BIOLOGY CLASSROOM

by

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

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2014

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Christina Anne Scott

April 30, 2014

DEDICATION

There are many people I would like to thank. First, thank you to my colleagues. Your wisdom, your guidance and your willingness to go above and beyond for your students has been an amazing example for this newbie.

To the Knibbe, Scott and Anderson family, especially my sister Liz, and my friends, especially Meranda, thank you for believing in me, for not being mad because I abandoned you, and for being great shoulders to cry and yes, whine on. I miss you and I can't wait to spend time with you again! Thank you for your prayers and for being proud of me, it means the world to me.

To the people part of this process: Walt, thank you for encouraging me and guiding me through this process, you are an amazing teacher; Moon, thanks for your insight and shuffling; Ettie, I am so grateful for all you have taught me about life; René, I wouldn't be a teacher if it weren't for you, thank you for seeing what you did.

To my children, 'RaeRae' and 'Buddy', I love you. I cannot tell you how wonderful you have been throughout my process of school and pursuing my dream. Thank you for your hugs, thank you for your 'Don't worry moms', and for being willing to allow me this time. I hope I made you half as proud as I am of you.

Last, to my husband Frank. I never could have done this without you. You have taken up the slack in every part of our lives. You have given me strength when I didn't have any. You have given me wisdom each time I have needed it and in each instance, I felt blessed. Most of all, thank you for being a great dad to our kids and for your patience, kindness and for loving me, you have healed my heart.

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ABSTRACT

In this investigation, real world applications were used to enhance the academic success and motivation of students in a high school biology class. During the process, student surveys, assignments and assessments were used as measuring tools. Teacher motivation was also evaluated throughout the process. In the end, the use of real world applications had encouraging impacts on students' academic success and both teacher and students noted an increase in motivation.

INTRODUCTION AND BACKGROUND

I have completed my fifth year of teaching biology at Glacier Peak High School which is located in Snohomish, Washington. Glacier Peak High School was established in 2008 and it is one of two high schools in the city of Snohomish. According to the registrar, Glacier Peak has 1,691 students and the approximate ethnicity of the school is 89% Caucasian, 5% Hispanic, 4% Asian, 2% African American, and 1% Native American (personal communication, September 30, 2013). With the average median home price being $478,000 which is higher compared to neighboring areas, Glacier Peak tends to serve students from upper middle class families (Trulia, 2013). Overall, Glacier Peak is a school with strong academic and social integrity, it has dedicated sports, music and art programs, and students and staff are actively encouraged and motivated to perform at the highest levels.

I began my teaching career during the 2008-2009 school year and at that time, students participated in the Washington Assessment of Student Learning (WASL) which was given from 1997 to 2009. The WASL was replaced by the High School Proficiency Exam (HSPE) in 2010. The main difference between the WASL and HSPE was the removal of the extended response questions. This allowed students to show they are able to solve the problems, while not being scored on their writing ability. The WASL and HSPE were given as the primary assessment test and the science portion included topics from earth science, physical science, and biology. Due to the large quantity of scientific topics included on these exams, significant class time was spent reviewing these topics to prepare students for the tests. However, the efficacy of using these tests to measure student achievement was limited because students did not need to pass the WASL and

HSPE in order to graduate; as a result, many students did not take the tests very seriously, or even chose to opt out of the test.

The situation changed dramatically during the 2010-2011 school year for several reasons. First, the science standards changed significantly and the WASL/HSPE was replaced with the Biology End Of Course (EOC) exam. The new biology standards no longer included physical and earth science, allowing teachers time to focus on the biology / life standards. In addition to the change in standards and testing, a passing grade on the Biology EOC was made a graduation requirement beginning in the 2012-2013 school year which increased the pressure to teach the new standards well.

When the change to high stakes testing began, I set a goal to communicate why science is central to my students' lives. I wanted to link what they are learning about in biology class, to topics that occur in their day to day lives and which can impact them in various ways. The concepts of science can be challenging as students struggle with vocabulary, the complexity of the processes, the need for multilevel thinking, and the application of classroom concepts to real world biological problems. However, when fundamental scientific concepts are understood, they can unify science disciplines and provide students with powerful ideas to help them understand the natural world. I believe that as students take part in active learning through the use of real-world situations, students will build ownership of the ideas being taught and use this to scaffold their learning.

In order to test this idea, my first objective was to identify content areas where student achievement typically fell short of my instructional goals. I reflected on my past years of teaching and spent time looking over my students test scores. From these

reflections, I noted that students consistently struggle with the following cell process units: DNA structure and replication, transformation, photosynthesis, cellular respiration and protein synthesis. As I pondered what instructional changes I could bring to these units, I thought of how case studies can be used to connect scientific concepts to the real-world. As an example, the current rise of antibiotic resistant bacterial can only be properly understood through the lens of evolution. Topics like this one, that are discussed by the media and which will present real challenges in my students' future, have the potential to engage student interest and motivate them to build the conceptual framework necessary to understand the issues. By connecting difficult concepts with real-world problems, it is my hope to motivate students toward building a deeper understanding.

This leads me to my primary research question: "What are the effects of real-world applications on student learning in a high school biology class?" Within this question, I plan to explore the following three sub questions. The first sub question was, "In what ways do real-world applications impact motivation in high school biology?" The second sub question was, "What impact has planning, researching and teaching biology using real-world applications affected my professional development as a teacher?" The third and final sub question was, "What are the effects of real-world applications on students' ability to reflect on their own understanding?" Overall, my goals for my AR project were to help students make scientific connections to their world, to increase their motivation for learning, and to inspire a greater interest in science.

The students that were part of my Action Research (AR) project included students with a wide variety of motivations: advanced freshman looking to continue in math and

sciences in order to prepare for college, students who have routinely struggled in school, as well as students who were looking to complete their final science requirement. During the 2013-2014 school year I taught two sections of biology; in 5th period I had 31 students with ten females and 21 males. In 6th period I had 30 students with 18 females and 12 males. Biology is primarily offered as a sophomore class but the district allows advanced freshmen to take this class, and in 5th period I had nine freshmen, and in 6th period I had 12 freshmen. Also to note are the students on Individual Education Plans (IEP) and 504s. In 5th period I had two students on an IEP and in 6th period I had one student on an IEP, and two on a 504. In each of the units we have studied this year there was a collaborative effort to teach biology as a system, as a network, and as an informational science.

It is of upmost importance that I surrounded myself with a team of people to give me guidance and criticism throughout this process. Walt Woolbaugh, Ed.D. is my project advisor, he is a MSSE faculty member and he has been my instructor while writing my capstone. René Fester Kratz is my science reader and is a Biology Instructor at Everett Community College. She holds a Ph.D. in Botany, she was my professor for Cellular Biology and Microbiology and a huge reason I am a teacher today. Kerensa Moon is a fellow science teacher who has a BS in General Science and Geological Sciences and her MS in Geophysics from Mississippi State University. She currently teaches Physics, AP Physics and Biology and has expertise in teaching in regards to real-world situations. Ettie Goldy is my proofreader/editor. Mrs. Goldy has her BA in Early Childhood Education from LeTourneau University and has been a pre-school teacher and director for over 30 years.

Last to address is the way I shared my results. The science department at Glacier Peak High School is collaborative, and we work to teach many of the same units near to the same timeline. Thus, I shared my results frequently with my science colleagues. I also shared information with the Special Education Department as I work directly with my students on IEP's. Since my principal James Dean is currently my evaluator, I shared the process with him on a routine basis. Jim is a former science teacher, and he has given me strong feedback and I was lucky that that continued. Finally, I shared the results with my students and I found that it was empowering for all of us.

CONCEPTUAL FRAMEWORK

The following conceptual framework consists of evidence for real-world applications used as a pedagogical tool. I will first address a theoretical basis which will discuss methods of experiential learning. Second, I will address research methodologies which include data collection and data analysis. Finally I will concentrate on articles which share insight from educators who have used techniques similar to my AR project.

Teaching methods using real-world applications can also be associated with other methods such as inquiry based science, issue based learning, and experiential learning. Although the titles may be different, each of these teaching methods bring learning opportunities to students that are realistic, thought-provoking, engaging, instructional and applicable to students lives. Simply stated, experiential learning emphasizes the central role that that experience plays in the learning process. Lewis and Williams (1994) suggest that the 20th century has seen a change from formal, abstract education to one that is more experienced-based. In classrooms that practice experiential learning, students engage in activities like role play, games, and study analysis; of these, case studies in

particular requires students to process real-life scenarios which can be analyzed along with course material (Lewis & Williams, 1994). According to Lewis and Williams, “Educators are being held accountable for what learners know and are able to do. The pressure for accountability has caused educators to design competency-based measures of learning and experiential techniques for assessing learner outcomes” (1994, p. 6).

A leading author of experiential learning concept was John Dewey (1938). He gave emphasis to the importance of a relationship between experience and education. Dewey believed that education conveys culture, provides other interpretations of the world, and allows students to explore these interpretations through their own experiences. “The educational end and the ultimate test of the value of what is learned is its use and application in carrying on and improving the common life of all” (Dewey, 1934/1964, p. 11). Dewey understood the importance that experience plays as part of learning and the process of education.

David Kolb was also an influential author in regards to experiential learning. Experiential learning is defined as, "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience" (1984, p. 41). According to Kolb, experiential learning is a four stage learning cycle. The first stage is concrete experience where the learner actively experiences an activity such as a lab session or field work. The second stage is reflective observation when the learner intentionally reflects back on that experience. The third stage is abstract conceptualization where the learner endeavors to conceptualize a theory or model of what is observed. The fourth stage is active experimentation where the learner is trying to plan how to test a model or theory or plan for a future experience

(Kolb, 1984). He believed that all four stages of the cycle must be worked through, but the learner may begin at any part of the cycle and as part of this process, "learning is described as a process whereby concepts are derived from and continuously modified by experience" (Kolb, 1984, p. 36).

The use of problem-solving case studies as a teaching method has been shown to have positive influences on student understanding of scientific concepts (Herreid, 2007). A case study includes an engaging or controversial story, usually a dilemma with a real-world connection that requires a basic understanding of scientific principles. The use of case studies can build context for scientific concepts and lead to an interest for science. As part of the learning from this process, students participate in experiential learning as they problem solve, evaluate scenarios, and see a process of science connected to their world.

Rybarczyk, Baines, McVey, Thompson, & Wilkins (2007) used a case study as an active learning tool to teach cellular respiration, a topic that is typically regarded as a difficult topic for students to learn due to its complexity. The case study follows a four year old girl who died from rotenone poisoning after washing her dog with flea dip. As part of the scenario, students brainstorm the cause of death, analyze data from an autopsy report, and assimilate information regarding cellular respiration to determine how the poison interacts with mitochondria.

The goal for the researchers was to note whether there was a difference in assessments for students that used the case study (+CS) (*N=94)* compared to those who did not (-CS) (*N=63)*); also to note whether the misconception that cellular respiration is synonymous with breathing and whether students used higher order thinking skills. Their

methodology included pre- and post-tests and surveys. In the end, their investigation supported the fact that, “case based approached in learning science is an effective approach for students to learn biological processes in relevant, real-world contexts and results in significant learning outcomes” (Rybarczyk et al, 2007, p 186). The students were not the only benefactors of this process as instructors also provided positive feedback including statements such as, “the case is a good way to get students to analyze data and highlight the important parts of cellular respiration” (Rybarczyk et al, 2007, p 186).

According to McLaughlin (2010), it is imperative for science education to move beyond the textbook in order to give students high impact learning. Specific to McLaughlin’s belief is paring students directly with research either virtually or physically in order to develop true scientific understanding. In her study, this was accomplished by completing learning modules in selected biomes, daily journaling similar to field journals used by scientists, completing an in depth field study in areas such as Costa Rica, as well as pre and post assignments and assessments. The author believes that student interest is increased by hands on learning and the consideration of local and global issues which require students to demonstrate their ability to convey relationships that extend beyond the academic walls. If students are engaged as researchers, they could become the driving force in the data collection and analysis that is fundamental to learning science; this is especially true if students themselves develop the research methods.

Lenz and Wilcox (2012) believe the classroom easily lends itself towards teaching science in ways that encourage students to analyze and discuss personal, societal, and global issues that can be linked to science concepts. As part of this type of activity,

students evaluate scientific evidence, practice using evidence to support an argument on scientific evidence, and explore how science and society interact. The authors identified five criteria that are important to an issue oriented classroom: discussion, student collaboration, application of evidence, identification of trade-offs and assessment.

The advantages of using a real-world method of teaching are many. These include student engagement as well as helping to contextualize science as students incorporate societal, cultural, environmental, political and ethical issues (as cited in Zeidler, Walker, Ackett & Simmons, 2005). In order to choose issues which will work, well, Lenz and Wilcox (2012) suggested that topics meet the following criteria: be appropriate to the grade level, be amenable to the application of relevant scientific evidence, be engaging to a diverse group of learners, be complex enough to foster debate and discussions, and be an overarching topic that can be integrated throughout a unit. Examples of topics that meet these criteria include the use of genetically modified foods, emerging infectious diseases, the increase in antibiotic resistance, and the decrease in biodiversity that results from closing of wildlife preserves. The more we as teachers make connections between scientific principles, data, analysis, and processes, to real-world relatable issues, the more students will benefit.

METHODOLOGY

Instrumentation

My AR project was conducted from January 23, 2014 through March 27, 2014. During the process new curriculum was supplemented with previously used curriculum, all of which aligns with Washington State standards. 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). This project included a variety of qualitative and quantitative data collection in order to obtain a comprehensive assessment of implementing real-world applications into high school biology and is displayed below in Table 1.

Table 1
Data Collection Matrix

Research Questions	**Data Source #1** *Baseline*	**Data Source # 2** *Treatment*	**Data Source # 3** *Treatment*	**Data Source # 4** *Treatment*
Primary Question: "What are the effects of real-world applications on student learning in a high school biology class?"	Student Survey Teacher reflection field notes and journaling Student assignments and post unit summative assessment	Student Survey Teacher reflection field notes and journaling Student assignments and post unit summative assessment	Student Survey Teacher reflection field notes and journaling Student interviews Student assignments and post unit summative assessment	Student Survey Teacher reflection field notes and journaling Student interviews Student assignments and post unit summative assessment
Secondary Question: In what ways do real-world applications impact student motivation in high school biology?	Student Survey Teacher reflection field notes and journaling Student assignments and post unit summative assessment	Student Survey Teacher reflection field notes and journaling Student assignments and post unit summative assessment	Student Survey Teacher reflection field notes and journaling Student interviews Student assignments and post unit summative assessment	Student Survey Teacher reflection field notes and journaling Student interviews Student assignments and post unit summative assessment
Secondary Question: "What impact has planning, researching and teaching biology using real-world applications affect my professional development as a teacher?"	Post-treatment Student Survey Teacher reflection field notes and journaling	Student Survey Teacher reflection field notes and journaling	Student Survey Teacher reflection field notes and journaling Student interviews	Student Survey Teacher reflection field notes and journaling Student interviews
Secondary	Student Survey	Student Survey	Student Survey	Student Survey

Question: "What are the effects of real-world applications on students' ability to reflect on their own understanding?"	Teacher reflection field notes and journaling Student assignments and post unit summative assessment	Teacher reflection field notes and journaling Student assignments and post unit summative assessment	Teacher reflection field notes and journaling Student interviews Student assignments and post unit summative assessment	Teacher reflection field notes and journaling Student interviews Student assignments and post unit summative assessment

In order to determine whether the effects of real-world applications influenced student learning and motivation, the following data was collected and triangulated. Data was obtained through a variety of instruments in order to compare the effects of student learning and motivation, as well as teacher motivation. This data was used via multiple data sources in order to compare it to each research question, as well as to cross reference within each treatment and between treatments in order to help insure validity and reliability. Data collection included student generated artifacts / science notebooks, formative assessments, summative assessments, student interviews and surveys as well as teacher journaling. The collection of data for my AR project included: class data including all students, as well interviews of two freshman females, two freshman males, two sophomore females and two sophomore males and all IEP students.

As to the units, I began with a baseline unit followed with three treatment units, with each unit becoming progressively more difficult. The baseline unit began with a student survey which was organized into four parts: relevance of science, students' motivation to learn, the importance of teacher input and improvement of the student as a learner. See the student survey in Appendix B. The baseline unit included a variety of formative assessment tools, teacher journaling and field notes, and ended with a

summative assessment and post unit survey. See Appendix C for lesson plan and the post unit survey.

In treatment units one, two and three, pre and post student surveys were completed to measure student confidence, motivation and whether students could apply their learning to real world situations. See Appendices D, E, and F for lesson plans and surveys. Also to note, formative assessments, teacher journaling and field notes remained consistent throughout each unit.

At the completion of treatment unit one, a Classroom Assessment Technique (CAT) was conducted in order to determine what the students muddiest point was. See Appendix G for the CAT. Treatment unit two included student interviews with IEP students in order to determine what students found most difficult in regards to photosynthesis and cellular respiration, as well as what would have helped them to improve their learning. See Appendix H for interview questions. Treatment unit three included student interviews which asked students to rank the treatment units in regards to difficulty, what was important to learn, what they like to learn more about, and whether they could apply their learning to the real world. See Appendix I for interview questions.

Treatment

Baseline Unit: DNA Structure and Replication

The baseline unit consisted of DNA structure and replication. The students were given a review of DNA which had been previously introduced during the macromolecule unit in November 2013. Subsequent to the review, the students learned about the structure and function using lecture notes, bookwork, vocabulary, and a DNA extraction lab. DNA replication was introduced using lecture notes, a coloring worksheet and a

DNA replication activity using candy. In each of these assignments, no new curriculum was introduced.

Treatment Unit One: Transformation

Three summers ago I was fortunate to be able to participate in the Science Education Partnership at the Fred Hutchinson Cancer Research Center where I was matched with a researcher and spent three weeks working with that researcher. A benefit of completing this program is the use of kits at no cost. One of the kits I have used in the past is the bacterial transformation kit that facilitates the insertion of the pBLU plasmid DNA into *E.coli.* Prior to the treatment, I used my original curriculum as I have found it to be effective. This curriculum included writing a short story, learning vocabulary, taking lecture notes, being introduced to bacteria, and practicing with micropipettors. After these activities, students completed the lab and wrote a formal lab report which was used as a summative assessment.

As part of the treatment for this unit, students were introduced to engineered microbes via an article jigsaw activity. The microbes they read about included a strain of photosynthetic cyanobacteria used in research to develop biofuels (American Society for Microbiology, 2013), *E.coli* used to remove mercury from waste sites (Griggs, 2011), and microbes used in bioremediation of oil spills (Biello, 2010). Following the jigsaw activity, the students watched a short documentary regarding the BP Oil spill.

Treatment Unit Two: Photosynthesis and Cellular Respiration

The second treatment unit included a combination of the processes of photosynthesis and cellular respiration. Prior to the treatment, I used my original curriculum as I have found it to be effective. The unit began with a lecture addressing the

inputs and outputs of both processes and continued with an art project referencing the same. Photosynthesis was studied first and included a lecture/foldable, an introduction to chemical energy and an inquiry-based lab. The learning goal for this lab was to check for student understanding of both the process of photosynthesis and the scientific method. The students practiced their understanding of experimental design by testing the effect of four variables on the rate of photosynthesis. The students completed a poster and presented their experiment and data to the class. The unit of cellular respiration was taught using bookwork, lecture/foldable and a lab. See Appendix E for lesson materials and surveys. A summative assessment completed this portion of the unit with the students making a foldable comparing photosynthesis and cellular respiration. See Appendix J for summative assessment.

The treatment for this unit was completed after the summative assessment. First, a short review was followed by a discussion with the area of focus being the previously taught topics of trophic levels, the carbon cycle and global climate change. In regards to trophic levels, the discussion referenced what would occur to the secondary producers and above if the rate of photosynthesis decreased. Carbon dioxide was addressed as both an input into photosynthesis as well as an output of cellular respiration. The balance of the carbon cycle and the impact of carbon dioxide in the atmosphere on global climate change were also considered. Following this discussion the students completed a case study based on cellular respiration described previously in my conceptual framework. The case study follows a four year old girl who died from rotenone poisoning after washing her dog with flea dip. As part of the scenario, students brainstorm the cause of death, analyze data from an autopsy report, and assimilate information regarding cellular

respiration to determine how the poison interacts with mitochondria (Rybarczyk et al, 2007, p 186).

Treatment Unit Three: Protein Synthesis

The third and final treatment took place during the protein synthesis unit. Prior to the treatment, I used my original curriculum as I have found it to be effective. Proteins were introduced as part of the macromolecule unit and students were given a short review of proteins. Protein synthesis was introduced with lecture notes followed with bookwork, vocabulary, video clips and a coloring worksheet. After this the student were instructed regarding the use of an amino acid wheel and a practice worksheet tying all the pieces together. The students then completed a lab where students decode DNA and followed a recipe to make Rice Krispy treats.

I began the treatment with a lecture and notes showing the structures of proteins, a reference to transformation, an introduction to the protein hemoglobin including its function in the body, and a description of how people with diabetes do not correctly produce or use their insulin protein. The students then decoded normal DNA and DNA with one amino acid change (its primary structure) and were shown how the single change makes the difference between the allele for normal hemoglobin versus the one for sickle cell anemia. A discussion followed. Finally, a lecture was used to introduce students to the process of using recombinant DNA technology to make human insulin within bacterial cells.

The final assignment I gave for each treatment unit was a concept map so that I could evaluate the students' ability to reflect on their learning. Concept maps are practical ways for students to think about the connections between science terms, then

organize these terms in a way they can visualize the relationships between them. This is an assignment I have never done as they intimidate me, but I thought it was important for students to challenge their thoughts about science concepts, connect these concepts together, and then reflect on their learning. See Appendix K for concept map assignment.

DATA ANALYSIS

Data analysis began with a baseline survey with four main elements I was questioning: students' motivation to learn, importance of student learning, relevance of science in their lives, and the importance of teacher input. The survey was analyzed looking at the mode for each question and categorization and results are shown in the table below.

The results of the baseline survey indicated the mode for student motivation varied. In regards to doing their best and completing assignments, the mode demonstrated agreement. In reference to being motivated by labs, the mode showed the students strongly agreed. Also as part of the motivation category was students' belief they are good at science and this mode indicated they were undecided.

Next to address are the items which referenced the relevance of science. Both the mode regarding learning new and interesting things, as well as whether science was useful, indicated that the students were undecided about the importance of science to their lives.

Three items on the baseline survey addressed the contribution of students and the teacher to their learning. In general, students had a negative view of their learning gains and the importance of understanding science, with the mode equivalent between undecided and disagree. In contrast, the mode on items regarding teacher input indicates

a comparable pattern in both items showing students agree they get enough help and feedback.

Table 2
5th and 6th Period Baseline Survey Results (N=61)

Rating	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
Item 1: Always try to do best in school (motivation)					
N	15	19	15	5	7
Item 2: Good at science (motivation)					
N	6	13	20	13	9
Item 3: Learning new and interesting things (relevance)					
N	11	18	19	9	4
Item 4: Completing an assignment (motivation)					
N	17	23	11	7	3
Item 5: Get enough help (teacher)					
N	16	23	16	4	2
Item 6: Get enough feedback (teacher)					
N	11	19	17	9	5
Item 7: Science is useful (relevance)					
N	11	10	20	12	8
Item 8: Motivated by labs (motivation)					
N	21	20	10	6	4
Item 9: Improving as a science student (student learning)					
N	9	8	19	19	6

Students' comments on items two and six helped to give further insight into their views. Their responses to item two, which addressed whether they are good at science, included "Because my parents and teachers in the past tell me I'm a natural at science." Similarly, "I like this stuff and I like this class." On the other hand, student replies also included, "I'm good at chemistry and physics. I'm not good at biology." Likewise, "I just don't think I get science." Item six referred to whether they receive enough feedback

and their responses included, “I think teachers could tell us what we did wrong or what we could have done better. So I guess no.” Another response was, “If I don’t get something I ask and get answers, but if I don’t ask, I don’t always know.” Overall the results of this survey were close to what I expected and was comparable to the teacher journaling done during this time.

Following the completion of the baseline unit, and prior to the summative assessment, the students completed a post survey. As part of this survey I chose to give students three choices for their answers (agree, undecided, disagree) compared to the usual five, but this trend was not continued for the rest of the surveys as students questioned where the other categories were. The results of the survey are shown in Figure 1.

The survey results showed 66.5% of students agreed they were confident in their knowledge of DNA (*N*=61*)*. Comparatively, 22% were undecided in their comprehension and 11.5% of students disagreed stating they were not confident in their understanding of DNA. The second question addressed the students’ motivation to learn DNA structure and this question revealed that 66.5% of students were motivated to learn the structure of DNA. This left the 14.5% students who were undecided in their motivation followed by the 19% which were not motivated to learn of DNA structure. Following this was the question regarding motivation to learn about DNA replication and 62.5% agreed they were motivated. Also to note were the 17.5% of students which felt undecided in their motivation, and the 20% which stated they disagreed that they were motivated to learn replication. The last two categories referred to the students who struggled with the content during the replication unit. Last to address are the students’

responses to whether they can apply their learning to real world situations and in this 57% of students agreed they could. This leaves the 32% of students which were undecided and the 11% of students which disagreed they could make real world applications.

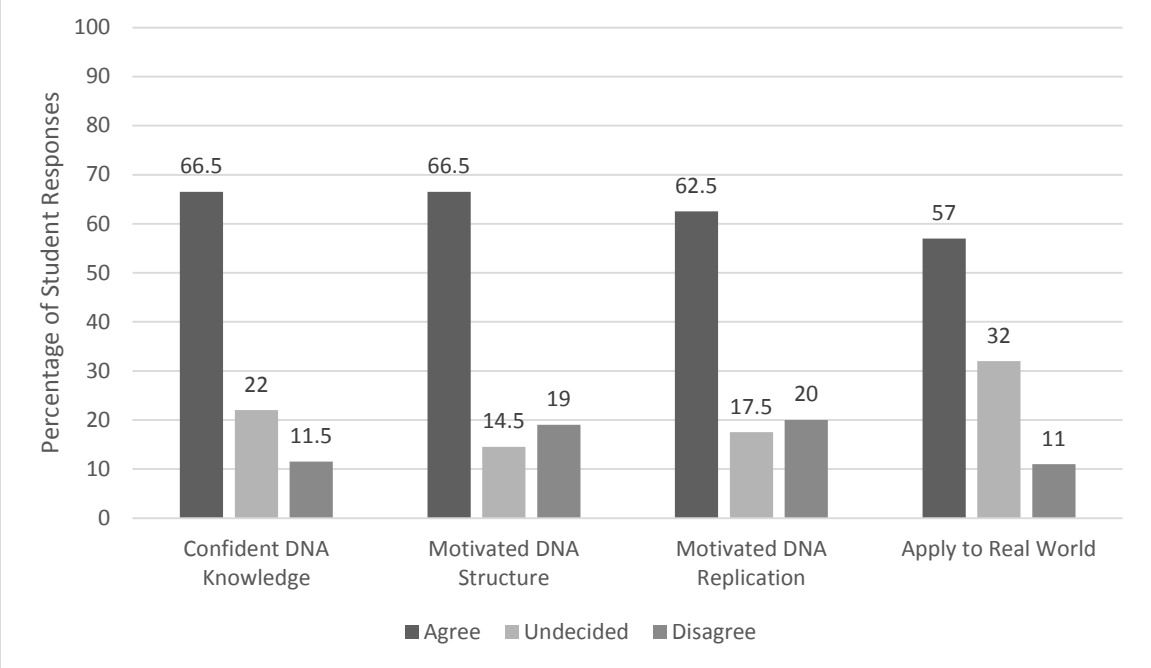

Figure 1: 5th and 6th Period Percentage of Student Response to Post Baseline Unit Survey, *(N*=61*).*

Only a few students, six out of 61, wrote replies to the question regarding what motivated students to learn new concepts in DNA. One student replied, “Being able to understand how things work.” Another response was, “Getting a good grade.” An additional student stated, “Mrs. Scott and her happy attitude.” There were a few students who replied with specifics such as, “I think that DNA has alot of cool stuff we can learn and I hope we learn more.”

The results of the baseline unit survey were generally as I expected. Since the unit on macromolecules was completed recently compared to the baseline unit, students came into the unit with knowledge of DNA. The students were engaged in the process of learning, including asking many questions as part of the process, thus showing their motivation. Though real world connections were not addressed specifically, they were a part of classroom conversations, questions and answers. Also, the lab the students completed was an important visual application of the structure and replication of DNA which I believe played a significant part in their confidence and motivation.

Treatment Unit One: Transformation

Treatment unit one began and ended with a Likert survey that is shown in Figure 2. Results of the survey showed students felt they improved in their confidence, motivation and their ability to apply their learning to the real world in comparing pre and post unit surveys. Initially their overall confidence and motivation was low, and increased by the end of the unit, but the range remained about mid-level with numbers ranging from 3.4 in confidence to 3.2 in motivation. Early in the unit I had hoped the post treatment survey would demonstrate a higher level of confidence, motivation and application to the real world. Instead, the ending statistics were consistent with teacher journaling I had noted during the unit. The unit was begun during the Reading and Writing HSPE testing, and though class times were extended, the students seemed fatigued due to the testing. I had written in my journal, “The students seem worn out” and “The students said they were exhausted and were ready to go home.”

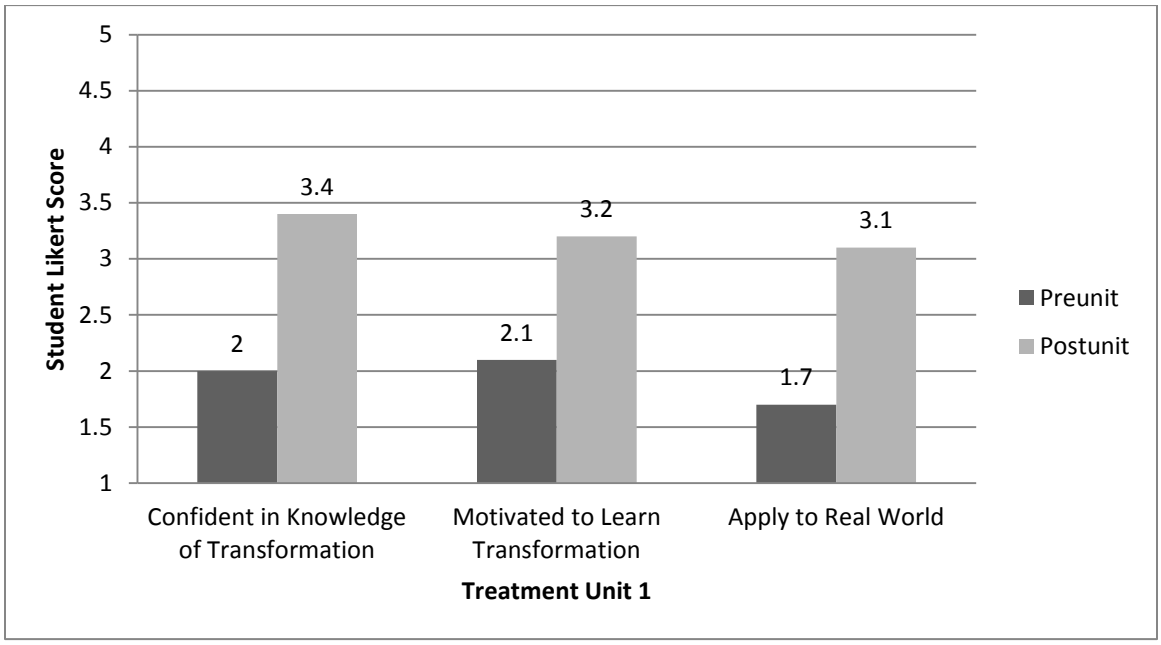

Figure 2: 5th and 6th Period Average of Pre and Post Unit Transformation Survey, *(N*=61*)* Likert Scale Strongly agree = 5, Agree = 4, Undecided = 3, Disagree = 2, Strongly disagree = 1.

Students completed a CAT prior to the real world application. By asking what their muddiest point was, I was exploring what their struggles were at that point to aid my planning and teaching. Overall, the student replies included a variety of responses which were mixed, but promising. Student responses included a lack of understanding such as, "I am sorry Scott, its really muddy and I just don't get it." Responses that showed understanding of the process but not why it occurs included, "I get the steps, but not sure of the plasmid." Student comments that showed understanding and questioning its application included, "What does it help if the bacteria to turn blue in the world?" The student responses were noted as part of my journaling and questions were addressed as part of the real world application.

My expectation for the pre unit survey matched the student responses in part because I was aware that few students had been introduced to transformation prior to this unit. Also, during my previous experiences in teaching this lab, I have noted that the concept of the transformation was challenging. Once the lab and treatment was complete, there seemed to be a strong connection in students' minds between transformation and engineered microbes as evidenced during a long discussion regarding transformation. I wrote in my journal, "Students really seemed to like the engineered microbes and I had fun. I feel like they have a good picture of what is going on." Thus, I did expect the post unit survey to be in higher in the agreement range.

Treatment Unit Two: Photosynthesis and Cellular Respiration

Treatment unit two began and ended with a Likert survey that is shown in Figure 3. Results of the survey showed that students felt they improved in their confidence, motivation and their ability to apply their learning to the real world in comparing pre and post unit surveys. In comparison to treatment unit one where confidence began at 2 and ended at 3.4, motivation started with 2.1 and ended at 3.2, and applying to real world began at 1.7 and ended at 3.1, the results were similar in each category.

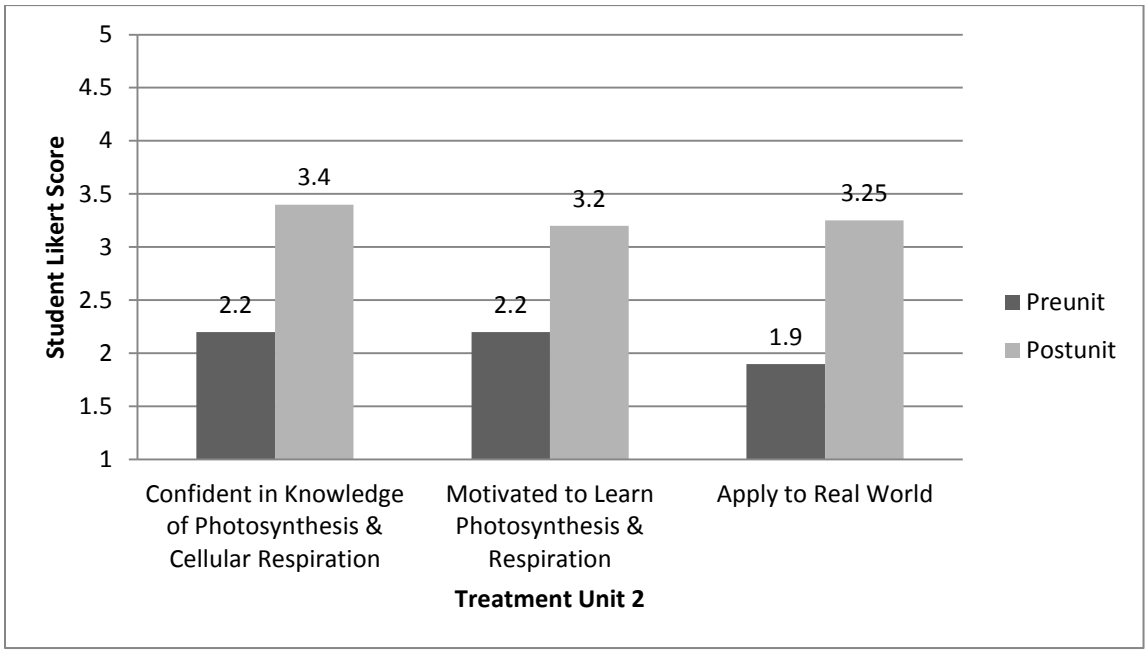

Figure 3: 5th and 6th Period Average of Pre and Post Unit Photosynthesis and Cellular Respiration Survey, *(N*=61*)* Likert Scale Strongly agree = 5, Agree = 4, Undecided = 3, Disagree = 2, Strongly disagree = 1.

Teacher journaling during this unit included noticing that in both classes the students' seemed more engaged when questions were asked following lectures, as well as when answering questions on the assigned classwork and labs. This unit encompassed an extended lab on photosynthesis of which the expectation for learning was placed on the student. The lab included students using different variables to work through the scientific method including making predictions, collecting data, forming conclusions and integrating their learning to the real world. During this time many conversations were had and documented in my teacher journal regarding the processes incorporating real world applications. On day three of the lab the students were well into the process and I wrote, "Today was so good. They all have their scientific method done, their posters

have a good depth of information. They were able to list and explain factors that affect photosynthesis and did it really well." Thus, I expected the post survey results to be closer to the range showing agreement in this unit and thus, they did not meet my expectation. As I reflected on these expectations, I realized that the students still had difficulties with understanding all of the concepts in this unit and that my expectations were a bit too high early in this process.

Following the completion of the treatment unit two, interviews regarding photosynthesis and cellular respiration were conducted with my three IEP students. Though I had initially wanted to interview freshman and sophomore students as well, scheduling time for the interviews was difficult due to multiple school activities in which they were participating. In regards to what they found most difficult in photosynthesis, the students on IEPs identified the lab procedure as challenging because they were unsure they could figure out the parts to the experiment. One of their responses included, "I didn't know all the parts and because I didn't get it, I kind of stopped trying a little bit." Another IEP student replied, "The poster part was hard, they gave me stuff to do I didn't know what to do so I asked my resource teacher and she helped me."

Through the interview it was noted that the concept of cellular respiration was more difficult than photosynthesis for my students on IEPs. Included in their replies regarding difficulty was, "that whole drawing and those parts, I really had no idea when we made the booklet." Another student replied, "Are you kidding me? That was so hard!" When asked what part helped them understand the processes, their replies were not too specific. Such as, "well I guess seeing everyone's poster helped me, but I don't know really. I did like the story thing we did, but I'm not sure how it works." Also, "I

don't know. I like the figure the thing out part, I found that fun but I guess I don't know." This interview indicated though I do work diligently to help my IEP students, I need to check in on them more often and look at the work they are completing, even when they seem confident.

Treatment Unit Three: Protein Synthesis

The final treatment unit began and ended with a Likert survey that is shown in Figure 4. Results of the survey demonstrated that students improved in their confidence, motivation and their ability to apply their learning to the real world in comparing pre and post unit surveys. Their initial numbers were similar to treatment one and two, but their ending ranges were close to or in the agreement range. This coincides with teacher journaling as students were engaged in this unit. The results seen here show the highest post survey results and again, this coincides with teacher journaling and the level of student engagement during the unit. I wrote in my journal, "During the Rice Krispy lab a few groups had difficulty transcribing the DNA but they persevered. Every group had fun and found that it helped them a lot."

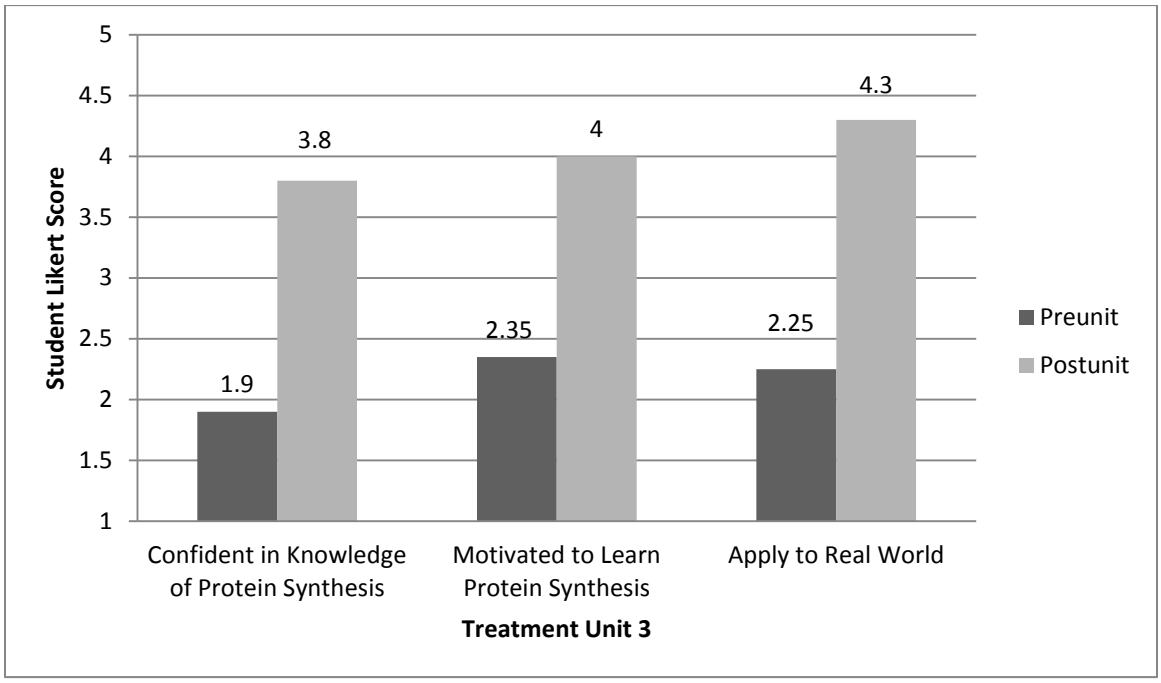

Figure 4: 5th and 6th Period Average of Pre and Post Unit Protein Synthesis Survey, *(N*=61*)* Likert Scale Strongly agree = 5, Agree = 4, Undecided = 3, Disagree = 2, Strongly disagree = 1.

At the end of treatment units, and prior to the interviews, students were given two concept maps to complete as review prior to the summative assessment. I had never done a concept map prior to this, but I wanted to be able to gauge whether students could piece together the cellular processes in a way that made sense to them, as well as allow for data collection of their work. The first concept map encompassed protein synthesis vocabulary and the second concept map, given on the following day, encompassed photosynthesis and cellular respiration.

Once the students completed the assignment, I grouped their completion of the assignment into the percentages of words used. See the results in Table 3 below. In the first concept map, 47 students were able to use all of the vocabulary and the number increased to 53 with the second concept map. In the end, only 2 students did not use all

the vocabulary words in protein synthesis and all students used all vocabulary words in photosynthesis and cellular respiration. The students that I noted which did not use all the words included one IEP student, two students that generally struggle with their learning, and the rest are students who have been consistently unmotivated to complete all of their work during the school year.

Table 3
5th and 6th Periods Concept Map Assessment (N=61)

Assessment Categories	Protein Synthesis (25 words)	Photosynthesis and Cellular Respiration (30 words)
Used all vocabulary words	47	53
Used 80-99% of vocabulary words	6	8
Used 60-79% of vocabulary words	6	0
Used 59% & below of vocabulary words	2	0

Another goal of this assignment was to respond to their questions with as little information as possible, allowing them to work through their difficulties and make the connections themselves. I walked throughout the classroom each period so I could note students that were struggling, and so I could be available for their questions as quickly as possible. On day one, the students definitely struggled in the beginning. Their responses included, “I have no idea what I am doing” and, “I don’t know where to start.” I encouraged them to pick a word or two they were familiar with and proceed from there. As the class time progressed I noted students being more confident in their understanding and the majority of students were able to complete the assignment during class time. Day two incorporated the same goals, it included a larger amount of words, plus two processes compared to one. They were a bit more confident in the beginning, but struggled connecting the two processes. On both days as they were near to or had completed their work I heard multiple students make statements such as, “It was hard at first, but it really

helped me." The use of the concept maps placed the burden of recollection and learning on the student, it was definitely beneficial to their learning and gave them confidence in their abilities and learning.

Student interviews were implemented at the conclusion of treatment unit three and included in the interview were two freshmen females and males, and two sophomore females and males. The freshmen were interviewed together and the purpose of the interviews was for students to reflect on their learning. The freshmen ranked the concepts from the most to least difficult and are as follows: cellular respiration, photosynthesis, protein synthesis and transformation. According to the students, the reasoning behind their ranking included statements such as, "The cycles involved in respiration and photosynthesis just didn't make sense. I didn't see the purpose in them and they were crazy hard." Also, "I was glad we did photosynthesis together with respiration because that helped me but I am still not sure I understand it all." As to what they found most beneficial to their learning, the freshmen stated the case study and learning about proteins because there was a story associated with their learning.

The sophomores also ranked the concepts from most to least difficult as: protein synthesis, cellular respiration, photosynthesis, and transformation. According to these students, their reasoning included, "The proteins were hard because they fold and they do so so many things that I couldn't tell them apart." Another student replied, "Respiration puzzled me and I know it helps us breathe, but there are too many parts. I learned about photosynthesis before so that's not new, but that pBLU was cool and probably my favorite." I also asked what they found most beneficial and they stated the labs, the case study, and the coloring as it gave them a picture of the processes.

Another perspective on student motivation comes from my analysis of student work. As they progressed throughout the units, I noted an increase in the quality and quantity of their responses made on their work and this is different from what I had seen in previous years. Early in the units, the students answered questions on worksheets and labs directly from lecture notes and information they could find in their book. As the units progressed, students were able to connect information taught in previous sections and attach these to the processes they were learning. This was noted both in written assignments, as part of the discussions and teacher journaling. As I graded the last unit of students work I looked through their previous work and I wrote in my journal:

> In DNA, it was easy for them to apply it to their world. I could see in their responses they got it. When we started transformation, student answers were pretty much straight from their notes. They did pretty good on their write up of the lab but I can see they are note sure as to what it really means. After we watched the BP Oil Spill their replies to questions are more of their own thinking. Photosynthesis and respiration were tough again in the beginning and they were back to answering from their notes until they did the case study and then, I could see they were getting it on their own. The fact that protein synthesis referred back to DNA might have helped their confidence and when they decoded the DNA of hemoglobin and answered the questions/discussion, I saw they made connections. Kind of crazy that I really didn't add to much more to my planning/their time but I can see a big difference. It's been fun too, to have the discussions we have had. So worth it all.

Student comments provided insight into what they found interesting and important. They stated, “I liked using the amino acid wheel and seeing how just one change can make things so different and scary too.” Another reply was, “Learning about how the medicines for diabetes was made was wild and pretty cool. Bet that’s worth a pretty penny.” In regards to what they wanted to learn more about their replies were quite general such as, “I guess more of the same” and, “Doing labs is always fun, as long as there isn’t a lot of work.” Lastly, when asked what they could apply to their life now their answers were more specific. They included, “I enjoy learning about diseases and stuff and learning how those are treated was cool since I am a diabetic.” Also, “I want to study the environment in college and learning about how the bacteria are cleaning up oil spills is something we are using now.”

The final data on my project comes from the summative assessments given at the completion of each unit, which are shown below in Figure 5. These are included as I wanted to note the trend of student summative assessment from the baseline unit through each treatment unit. I expected a decreasing trend as the units progressed, due to the increasing difficulty each unit had. Instead, the trend was increasing from the baseline unit through treatment unit two, and then decreased slightly from treatment unit two to three.

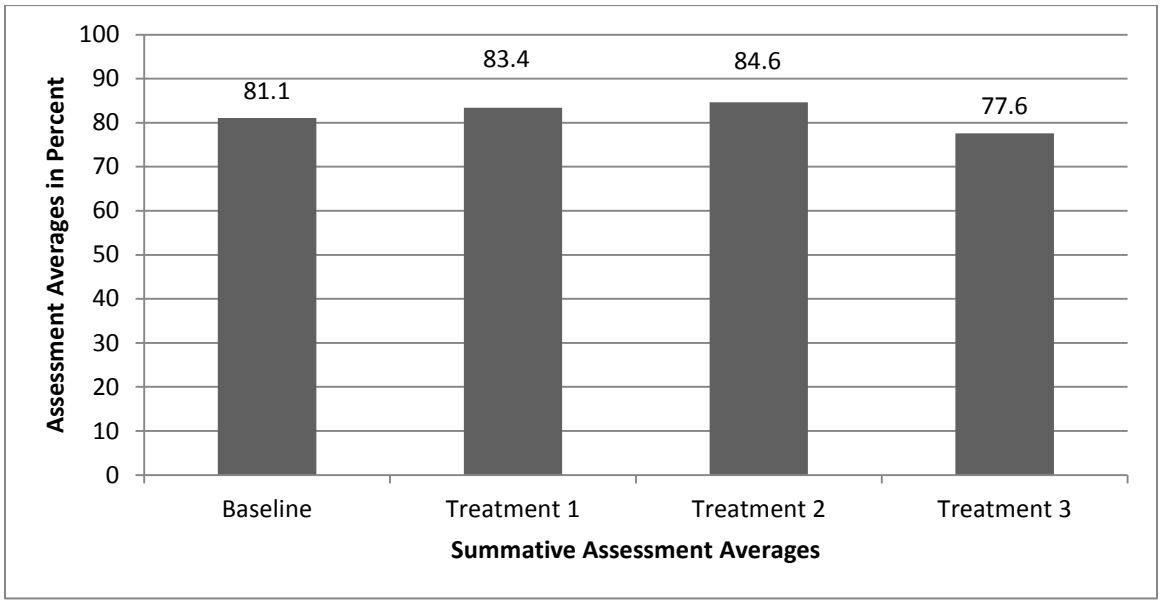

Figure 5: 5th Period and 6th Period *(N*=61*)* Summative Assessment Averages

These results were actually surprising. Each summative assessment included recall of terms as well application of their learning. Treatment unit three showed the lowest percentage, yet it was actually higher than I expected. I did have two students within each period who have consistently been disengaged for most of the year, yet do enough work to pass. On this particular test, they failed with an average score of 44% which was their lowest average of the tests. Other scores which contributed to the decreasing trend in treatment unit three were my IEP students whose average was 69%.

In the end, the data were promising. In each part of data collected and as the units progressed, students motivation increased, students were more confident in their learning, and students felt they could apply their learning to the real world. These were noted in the student work, discussions in class, in my journal and in assessments. In the end, as students took part in active learning through the use of the real-world applications, they built ownership of the topics taught which can scaffold their learning.

INTERPRETATION AND CONCLUSION

In order to answer my questions of focus regarding the application of real world examples in high school biology, a variety of data was compiled. The data offers evidence of positive effects on students in the form of increases in confidence, motivation, being able to reflect on their learning, and being able to apply their learning to the real world.

In regards to the primary question, "What are the effects of real-world applications on student learning in a high school biology class?" multiple effects were seen. As each unit progressed I noted there were more questions asked as part of their learning; they were intrigued by the applications. An example of this is prior to the real world application in treatment unit one (transformation), the students were enjoying the lab as the concept of turning bacteria blue was exciting, but as to what it really meant, they had not made that connection. Once we viewed the documentary and the CAT was completed, almost a full class period of discussion ensued regarding the use of microbes in bioremediation. In 5 years of doing this lab, this has not happened before.

Though the photosynthesis and cellular respiration unit post survey results were a bit lower than expected, between the lab performed in photosynthesis and the case study done in cellular respiration I felt that student understanding was increased compared to prior years. As part of their summative assessment students were asked to make a foldable comparing photosynthesis and respiration that included what it means in the real world; most students were able to complete this task with success. Success was noted by grading students work using the rubric given, and by noting the assessment score which had the highest average of all the units. Students listed the reactants and products of each

process and what we use them for in nature, as well as references to global climate change. In the future, I will continue to use this combination, and I do realize that there will always be struggles with certain topics.

Protein synthesis has been the one unit I have found that students find the most difficult; thus, the fact that the unit post survey results were the highest was surprising to me. I took the time to connect the concepts back to DNA and transformation, but time was a bit rushed due to the Math HSPE, and I was not sure they were grasping the concepts. Once I introduced diabetes and sickle cell anemia, many questions were asked about sickle cell and diabetes, but not necessarily the connection to protein synthesis and I had noted this in my journal. Thus I find it hard to know what portion of the treatment hooked the student interest, and I had not completed the survey results at the time of the interview so I did not include questions that would enlighten me in this area.

In regards to the sub question, "In what ways do real-world applications impact student motivation in high school biology?" I noted that students' confidence and motivation increased in each unit when I compared their pre unit and post units. The importance of this relates to the struggles I have continuously seen in these units that deal with difficult concepts; these struggles were noted in the CAT. By asking students to self-assess themselves regarding their confidence and motivation, my hope was that it became one their thought processes on a continuous basis. I do feel students showed more self-reflection even when not prompted, and I will continue with this process in the future.

An important part of this process was the ability of students to reflect on their learning and this was asked in the following sub question: "What are the effects of real-

world applications on students' ability to reflect on their own understanding?" The concept maps were very helpful to me in providing an insight into students' level of understanding; and also to the students, as it helped them to integrate what they had learned into something they built on their own. This taught me that reflection is a process that I will help students to actively pursue when learning new material.

Finally, in regards to the sub question, "What impact has planning, researching and teaching biology using real-world applications affect my professional development as a teacher?" I found that implementing treatments that included real-world issues was very beneficial and motivating and it is something I plan to utilize as much as possible. Specifically, I enjoyed teaching these new concepts, I enjoyed the increased level of student engagement, and most importantly, I enjoyed being able to see that students were able to learn and understand difficult concepts. I had not done this previously simply because of the pressure of time and high stakes testing. I found that as students became more aware of these real world topics and as they were able to connect their learning to their world, they were more active in their learning.

VALUE

The experience of developing and conducting my capstone gave me a new and fresh perspective to teaching biology. In my first two years of teaching, I was working diligently to improve on my lesson planning, as well as my scope and sequence, but the thought of improving students' connections was in the forefront of my mind; I knew that I could do better. As I began my third year of teaching, I embarked on this program knowing that changes were coming to Washington state standards and thus, I wanted to find a way to incorporate my capstone into these changes. The changes included students

having to pass the Biology EOC in order to graduate, and these changes gave me a vision to hopefully help my students increase their learning, as well as feel more confident and motivated.

Early into the process of my teaching career, I began to visualize my students as citizens of science that would hopefully enjoy the process enough to become future scientists. I also realized that this is not likely to happen if I simply teach content alone; it became evident that the more interest, motivation and confidence students have in the process of science, the more likely their journeys to learn about science will continue. The completion of my capstone was integral in this. Throughout the process of my capstone, I noted the benefits occurring such as in increase in students interest, motivation, confidence, and most importantly, their learning. In regards to my teaching, I also have an increase in motivation and I will continue to look for more and more ways to integrate this type of teaching to my students' learning.

As to which real world application I found most beneficial, I would say the case studies and the engineered microbes. During each of these lessons, there were many conversations that the students had, and it was easy to steer their conversation towards the specific standards I was covering. I also have to note the concept map assignments as well. I knew these were difficult, I knew the students would feel frustrated and lost in the beginning, but I hoped they would be able to make the connections between the words. Once the majority of the students got going, it was empowering. I was able to walk around my classroom and see them making the connections and they also felt empowered.

Data collection and analysis about my students learning provided me with information I could use to guide my instruction. Measuring the information and responses from my students allowed me to plan the responses and make informed decisions that I believe positively affected student outcomes. By assessing results and student work I felt that I was able to gain a deeper understanding of students needs and develop strategies to better serve students. The data collected also helped me to identify factors that motivated student performance and from this, I was able to adjust my instruction to better meet my students' needs.

I feel that I am looking at new way to teach biology in bringing an understanding to my students; that this is a new beginning. I truly have a passion for this topic and I believe that the guidance given to me through this journey will direct me to being the teacher I aspire to be. Fortunately, real-life connections to science topics abound and a key to effective instruction lies in seamlessly integrating scientific applications and current topics of interest into the existing science curriculum. In the end, when science is presented and connected to the world they live in, I believe students begin to understand its true importance.

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APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD

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For the Protection of Human Subjects
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MEMORANDUM

TO: Christina Scott and Walter Woolbaugh

FROM: Mark Quinn, Chair Mark Quinn Chj

DATE: December 2, 2013

RE: "*Using Real-World Applications to Enhance Learning in a High School Biology Classroom*" [CS120213-EX]

The above research, described in your submission of December 2, 2013, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

__X__ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

__X__ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

____ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

____ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

____ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

_____ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

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

APPENDIX B

BASELINE TREATMENT SURVEY

Baseline Treatment Survey

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

Please complete the survey by reading each statement and circling the answer which represents your feelings about the statement.

SA = Strongly Agree A = Agree U = Undecided D = Disagree SD = Strongly Disagree

I always try to do my best in school.	SA	A	U	D	SD
I am good at science. Why did you answer the way you did in the above statement?	SA	A	U	D	SD
I am learning new and interesting things in science class.	SA	A	U	D	SD
I feel good when I complete an assignment or project.	SA	A	U	D	SD
I feel that I get enough help in science class.	SA	A	U	D	SD
I feel that I get enough feedback on assignments, projects and labs from adults (teachers, coaches, parents). Why did you answer the way you did in the above statement?	SA	A	U	D	SD
I feel that science is useful and relevant to my life. Why did you answer the way you did on the above statement?	SA	A	U	D	SD
I am motivated by labs.	SA	A	U	D	SD
I am constantly improving as a science student and this helps me better understand the world around me.	SA	A	U	D	SD

APPENDIX C

BASELINE LESSON PLAN AND POST UNIT SURVEY

Baseline Lesson Plan

Teacher reflection and journaling continuous throughout.
January 23rd: Pre-Unit Survey. DNA vocabulary
January 24th: DNA notes (PowerPoint)
January 28th: DNA extraction lab
January 29th: DNA coloring worksheet
January 30th: DNA replication notes
January 31th: DNA replication lab / activity. Post unit survey.

Post Baseline Survey

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

Please complete the survey by reading each statement and circling the answer which represents your feelings about the statement.

A = Agree
U = Undecided
D = Disagree

I feel confident in my knowledge about DNA.	A U D
I feel motivated to learn about DNA structure.	A U D
I feel motivated to learn about DNA replication.	A U D
I feel that I can apply my understanding about DNA to real world situations.	A U D
What motivates you to learn new concepts in biology? Please explain.	

APPENDIX D

TREATMENT UNIT ONE LESSON PLAN AND SURVEYS

Treatment Unit 1 Lesson Plan.

February 3rd: Pre Unit Survey, Bacteria notes (PowerPoint) and Bookwork
February 4th: pBLU story, Transformation PowerPoint
February 5th: pBLU procedure
February 6th: pBLU lab
February 7th: pBLU flip chart (for results)
February 10th: pBLU post lab results
February 11th: pBLU write-up
February 12th: Grade pBLU lab
February 13th: Bacteria coloring
February 18th: Jigsaw activity
February 19th: BP Documentary
February 20th: Finish Documentary, CAT

Treatment Unit 1 Pre Unit Survey

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

Please complete the survey by reading each statement and circling the answer which represents your feelings about the statement.

SA = Strongly Agree
A = Agree
U = Undecided
D = Disagree
SD = Strongly Disagree

I feel confident in my knowledge about transformation.	SA	A	U	D	SD
I feel motivated to learn about transformation	SA	A	U	D	SD
I feel that I can apply my understanding about transformation to real world situations.	SA	A	U	D	SD
What motivates you to learn new concepts in biology? Please explain.					

Treatment Unit 1 Post Unit Survey

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

Please complete the survey by reading each statement and circling the answer which represents your feelings about the statement.

SA = Strongly Agree
A = Agree
U = Undecided
D = Disagree
SD = Strongly Disagree

I feel confident in my knowledge about transformation.	SA	A	U	D	SD
I feel motivated to learn about transformation	SA	A	U	D	SD
I feel that I can apply my understanding about transformation to real world situations.	SA	A	U	D	SD
What motivated you to learn about transformation? Please explain.					

APPENDIX E

TREATMENT UNIT 2 LESSON PLAN AND SURVEYS

Treatment Unit 2 Lesson Plan.

February 20th: Photosynthesis Foldable
February 21st: Chemical energy lesson
February 24th: Experimental design
February 25th: Poster
February 26th: Demonstrated lab, Poster
February 27th: Poster
February 28th: Test leaves
March 3rd: Poster conclusion
March 4th: Poster parade
March 5th: Cellular respiration bookwork
March 10th – 11th: Cellular respiration foldable
March 11th: Cellular respiration lab
March 12th: Case study
March 13th – 14th: Summative assessment foldable

Pre Unit Survey

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

Please complete the survey by reading each statement and circling the answer which represents your feelings about the statement.

SA = Strongly Agree
A = Agree
U = Undecided
D = Disagree
SD = Strongly Disagree

I feel confident in my knowledge about photosynthesis and cellular respiration.	SA	A	U	D	SD
I feel motivated to learn about photosynthesis and cellular respiration	SA	A	U	D	SD
I feel that I can apply my understanding about photosynthesis and cellular respiration to real	SA	A	U	D	SD

world situations.	
What motivates you to learn new concepts about photosynthesis and cellular respiration? Please explain.	

Post Unit Survey

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

Please complete the survey by reading each statement and circling the answer which represents your feelings about the statement.

SA = Strongly Agree
A = Agree
U = Undecided
D = Disagree
SD = Strongly Disagree

I feel confident in my knowledge about photosynthesis and cellular respiration.	SA	A	U	D	SD
I feel motivated to learn about photosynthesis and cellular respiration	SA	A	U	D	SD
I feel that I can apply my understanding about photosynthesis and cellular respiration to real world situations.	SA	A	U	D	SD
What motivated you to learn new concepts about photosynthesis and cellular respiration? Please explain.					

APPENDIX F

TREATMENT UNIT THREE LESSON PLAN AND SURVEYS

Treatment Unit 3 Lesson Plan.

HSPE Week 17th – 21st (extended classes)
March 17th: Protein synthesis notes (PowerPoint), Bookwork, and Vocabulary
March 19th: Protein synthesis coloring, Amino acid wheel, Lab intro
March 21st: Rice Krispy Lab
March 24th: Protein synthesis treatment
March 25th: Cellular respiration and Photosynthesis Concept map
March 26th: Protein synthesis Concept map
March 27th: Summative assessment
March 28th: Student interviews

Pre Unit Survey

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

Please complete the survey by reading each statement and circling the answer which represents your feelings about the statement.

SA = Strongly Agree
A = Agree
U = Undecided
D = Disagree
SD = Strongly Disagree

I feel confident in my knowledge about protein synthesis.	SA	A	U	D	SD
I feel motivated to learn about protein synthesis	SA	A	U	D	SD
I feel that I can apply my understanding about protein synthesis to real world situations.	SA	A	U	D	SD
What motivates you to learn new concepts about protein synthesis? Please explain.					

Post Unit Survey

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

Please complete the survey by reading each statement and circling the answer which represents your feelings about the statement.

SA = Strongly Agree
A = Agree
U = Undecided
D = Disagree
SD = Strongly Disagree

I feel confident in my knowledge about protein synthesis.	SA	A	U	D	SD
I feel motivated to learn about protein synthesis	SA	A	U	D	SD
I feel that I can apply my understanding about protein synthesis	SA	A	U	D	SD
What motivated you to learn new concepts about protein synthesis? Please explain.					

APPENDIX G

CLASSROOM ASSESSMENT TECHNIQUE

Classroom Assessment Technique: Muddiest Point

Administered February 19, 2013

Muddiest Point – The instructor asks students to jot down a quick response to the following question: “What is the muddiest point from today’s lecture?”

APPENDIX H

TREATMENT UNIT TWO STUDENT INTERVIEW QUESTIONS

Treatment Unit Two Interview Questions

Student interviews were completed on Friday, March 14th with three students on IEPs. Students had access to their notebook for all questions and interview was recorded with their permission.

Question 1: In regards to photosynthesis, what did you find the most difficult?

Why do you think that?

Question 2: In regards to cellular respiration, what did you find the most difficult?

Why do you think that?

Question 3: Which of the two was more difficult?

Why do you think that?

Question 4: What would have helped you learn this better?

APPENDIX I

TREATMENT UNIT THREE STUDENT INTERVIEW QUESTIONS

Treatment Unit Three Interview Questions

Student interviews were completed on Friday, March 28th with two female freshmen students, two male freshmen students, two sophomore female students and two sophomore male students. Students had access to their notebook for all questions and interview was recorded with their permission.

Question 1: Rank the units from the most difficult to the least difficult?

Why do you think that?

Question 2: What helped you the most in this section?

Why do you think that?

Question 3: What did you find interesting?

Why do you think that?

Question 4: What did you find important to learn about?

Why do you think that?

Question 5: What would you like to learn more about?

Why do you think that?

Question 6: What can you apply to your life now?

Why do you think that?

APPENDIX J

TREATMENT UNIT TWO SUMMATIVE ASSESSMENT

Treatment Unit Two Photosynthesis and Cellular Respiration Summative Assessment

Yes, this is a quiz, but it is open note, open book, open friend... For this 'quiz', you will need to make your OWN foldable (not copy the person next to you) comparing photosynthesis and cellular respiration. A foldable is uses more than one piece of paper (and that second piece could be sticky notes) that you can flip open in *some* way – be creative! Think about the processes! I have examples of foldables on my desk and of course you can make them up yourself as well – they do need to fit in your Compbook though. USE YOUR BOOKLETS – they have great info! Last piece of advice, DON'T make this too wordy...just include each piece!

Here are the required elements:

- Equation for photosynthesis and cellular respiration with ALL parts labeled including inputs/reactants, outputs/products, glucose, carbon dioxide, water, oxygen, energy
- The main purpose of each – what is it, why does it happen and who does the process?
- Organelles involved as well as the *specific* place in the organelle (it may be a good idea to draw and label these!)
- Similarities / differences [address where energy (ATP/ADP+P) plays a part – input? output?, NADPH, NADP+ vs NADH NAD+, light dependent / independent / Calvin cycle vs the 3 stages of cellular respiration, both occur in membranes, have electrons ect
- Must include color and include at least two pictures

Let's talk due date ... this 'quiz' is due on Friday by the end of class. Thus, this may require you to work at home if you don't feel that you can get it done during class. Read through the rubric so you KNOW you have met the criteria.

CATEGORY	10	8	5	3
Required Elements	The foldable includes all required elements as well as additional information.	All required elements are included on the foldable.	All but 1 of the required elements is included on the foldable.	Several required elements were missing.
Labels	All items of importance on the foldable are clearly labeled.	Almost all items of importance on the foldable are clearly labeled.	Many items of importance on the foldable are clearly labeled.	Labels are too small, messy OR no important items were labeled.
Graphics - Relevance	All graphics are related to the topic and make it easier to understand.	All graphics are related to the topic and most make it easier to understand.	All graphics relate to the topic.	Graphics do not relate to the topic.
Attractiveness	The foldable is exceptionally attractive in terms of design, layout, and neatness.	The foldable is attractive in terms of design, layout and neatness.	The foldable is acceptably attractive though it may be a bit messy.	The foldable is distractingly messy or very poorly designed. It is not attractive.

APPENDIX K

TREATMENT UNIT THREE CONCEPT MAP

Treatment Unit Three Concept Map Assignment

Protein Synthesis Concept Map

In this assignment, your task is to create a concept map relating to protein synthesis. Concept maps are frequently represented with nodes (the concepts) and links (the relationships) that relate to a central idea such as protein synthesis. It helps to use words that link your nodes to each other in some way, but this is not required. Below is a list of words for you to use, you must use 20 of the 25 words, you must include color of some sort and at least 1 picture. It may help you to begin the assignment on a page in your notebook so you can practice linking your terms and then complete the concept map on the paper given.

Main concept = Protein Synthesis

Words to choose from:

1. transcription
2. anticodon
3. nucleotides
4. translation
5. nucleus
6. polymer
7. stop codon
8. protein
9. tRNA
10. amino acid
11. cytoplasm
12. mRNA
13. ribosome
14. start codon
15. polymer
16. rRNA
17. polypeptide chain
18. DNA
19. enzymes
20. trait
21. U,A,G,C
22. sickle cell anemia
23. genetically modified crops / pesticides
24. genetically engineered insulin

25. pBLU

Photosynthesis and Cellular Respiration Concept Map

This time, your concept map includes pictures. You will draw a concept map just like you did yesterday, but you also must link the terms to the drawings. You must use 25 of the 30 words listed.

1. cellular respiration
2. sunlight
3. water
4. electron carrier
5. NADPH/NADP+
6. photosynthesis
7. glucose
8. electrons
9. ATP
10. carbon dioxide
11. stroma
12. ADP + P
13. light dependent
14. matrix
15. inner membrane of mitochondria
16. NADH/NAD+
17. electron transport chain
18. pyruvic acid
19. oxygen
20. fermentation
21. inputs
22. outputs
23. energy
24. thylakoid membrane
25. glycolysis
26. light independent
27. Krebs cycle
28. chlorophyll
29. enzymes
30. Mrs. Scott is _____ (fill in the blank)