THE EFFECTS OF THE 5E LEARNING CYCLE ON UNDERSTANDING HIGH SCHOOL BIOLOGY

by

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In presenting this professional paper in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the MSSE Program shall make it available to borrowers under rules of the program.

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ABSTRACT

In this investigation the 5E learning cycle was used to see if student learning, motivation, and teacher attitude were improved in high school biology. A restructured curriculum was implemented to emphasize the 5E learning cycle model. Student assessments, surveys, and interviews were analyzed to see the change in student learning and motivation. Teacher journals, observation, and surveys were analyzed to see the change in teacher attitude. Results did not reveal an overall change in student learning, however student perception of their learning and motivation did improve. Teacher motivation and attitude improved but at the expense of time.

INTRODUCTION AND BACKGROUND

In my classroom, I see a lack of continuity between students' motivation to learn about biology and their understanding of the reasons why they study biology. In my class, students always ask the question "Why do we need to know this?" As I reflected on my capstone project idea, I realized that my project intervention could help my students determine answers to the "why" question and to help them to become more interested in biology while getting a better understanding of the concepts. I chose to do my capstone project on the 5E learning cycle and its effects on an unconventional high school biology classroom.

My observations suggest students tend to increase their understanding of concepts when they have an active interest in the subject matter. To me, this indicates that my students are not interested in the topics that I am teaching. The topics, however, are dictated by my school district's Common Unit Design team, which I was not on when they developed these units. My thought was if I can change the method of my teaching, away from a straight-forward method of a reading to notes to teacher-directed labs to a cycle of engaging activities, students would find more enjoyment and deeper understanding of biological ideas and concepts.

I teach at Marshalltown Learning Academy (MLA) in Marshalltown, Iowa. Students at MLA are nontraditional and have needs outside of school. Because of this, students are able to come and go as they please, so long as they are making adequate progress in their courses. Each student's curriculum is tailored to his or her needs and any previous progress a student may have had in the conventional high school setting. Students are also preassessed for background knowledge so that I can spend time

teaching students what they don't know rather than what they learned already but did not pass in a classroom activity before. Nearly all of students are considered free and reduced lunch and most have at least one child while many hold full time jobs. Even though I may have students working on a multitude of science courses in my room at a time, I focused my project on second semester biology instruction. Typically, biology is taught to 10th-grade students but at my school grade level and age level are not dependent on each other, which leads to students with varying ages taking the same course.

The focus question for this study was: What are the effects of the 5E learning cycle on students' understanding of high school biological concepts? To better clarify such a general question, I also developed subquestions for this study and myself. My subquestions were: what are the effects of the 5E learning cycle on students' approach to learning; what are the effects of the 5E learning cycle on students' interest and motivation; and what are the effects of the 5E learning cycle on my teaching and attitudes towards teaching?

When I refer to the 5E learning cycle, I am referring to the instructional model in which students progress through a set of five activities. The five activities used in the 5E learning cycle are engage, explore, explain, elaborate, and evaluate.

To aid the development of this project, I have assembled a support group of friends and colleagues. The first member of my support group was my wife, Kristi Kenealy. Kristi is an elementary music teacher who spends a majority of her time thinking outside the box of conventional education. Kristi has been a great asset in helping me formulate my thoughts and focus on a cohesive project for my class and myself. The next member of my support group was my sister, Stephanie Kenealy.

Stephanie is currently studying for her master's degree in English with a focus in publishing. Stephanie is a great proofreader and has extensive knowledge of writing succinctly and professionally. The third member of my support group was Mickie Hovel. Mickie is a fellow teacher at my school and she has done extensive work refining curriculum for years to help students who do not learn in a conventional setting. In addition to this support team, I had a content reader from Montana State University, Terrill Paterson and my MSSE project advisor, Jewel Reuter, Ph.D.

CONCEPTUAL FRAMEWORK

During this age of expected student outcomes and standards-based quality indicators, it is important to continue to find alternative routes to student understanding and inquiry (National Research Council, 1996). I will show that current literature shows, through a constructivist approach, the 5E learning cycle has positive effects of understanding and motivation to learn in the classroom.

Constructivism is a teaching pedagogy in which the learner (student) takes on an active role in both finding and constructing new knowledge by building upon both prior knowledge and personal experiences (Dhindsa, Kasim, & Anderson, 2011). The 5E learning cycle promotes a classroom climate that is both student-focused and student-generated; therefore, constructivism is a major part of the 5E learning cycle. As a result of this pedagogy, a student-centered focus must be utilized in order to allow the learner to have their input into what projects and ideas are researched in the science classroom.

Research suggests that the 5E learning cycle can positively impact students' understanding in biology. In a study of 60 prospective teachers and their outlook of the 5E learning cycle, 54 teachers thought that the 5E learning cycle promotes the learning of

students (Metin, Coskun, Birisci, & Yilmaz, 2010). Another study summarized that the 5E learning cycle helps students both understand and reinterpret their misconceptions through the stepwise process of the cycle (Stamp and O'Brien, 2005). Stamp and O'Brien came to this conclusion in a study of graduate and undergraduate fellows that worked in classrooms with practicing teachers. In a study of children ages 14-16 during a summer school course, student posttest scores in a 5E learning cycle cohort were higher than their peers in a traditional practices cohort (Wilson, Taylor, Kowalski, & Carlson, 2009). The 5E learning cycle can have a tremendous impact of student achievement and student understanding in a classroom.

The 5E learning cycle can positively impact student motivation through the use of the cycles method. Bybee and Van Scotter (2006) propose that through the use of a 5E learning cycle, students could become in charge of their own learning. Through metacognitive strategies students could internalize the 5E learning cycle and apply it to their everyday lives.

The idea that the 5E learning cycle can positively affect student interest and motivation is important to curricular change. Stamp and O'Brien (2005) also found through their fellow's observations that elementary students displayed more scientific knowledge and a higher interest in science after a unit using the 5E learning cycle. Bybee and Van Scotter (2006) also found that by combining the different activities of a biology class into a cycle approach, 9th and 10th-grade student's interest was engaged and allowed to flourish in scientific disciplines. Hopefully, through increased interest students would continue to be engaged in scientific discussions and news.

Studies indicate that the 5E learning cycle has been found to change the role of the teacher. The constructivist model and studies have found that the role of the teacher must change from the lecturer to a collaborative problem-solver and coach (Rogers, Cross, Gresalfi, Trauth-Nare, & Buck, 2011). It was shown that teacher's attitudes towards teaching were improved by the 5E learning cycle (Metin, Coskun, Birisci, & Yilmaz, 2010). Stamp and O'Brien (2005) also found that teacher disposition was positive while using the 5E learning cycle. However, Metin, Coskun, Birisci, & Yilmaz (2010) did find that some teachers did express an opinion that time was a factor in being able to fully implement a 5E learning cycle approach to student learning. Time was also discussed as being a negative factor in developing the 5E lesson plan in the study by Stamp and O'Brien (2005). Stamp and O'Brien found that teachers became overwhelmed with preparation needs when implementing the 5E learning cycle in their classrooms.

The 5E learning cycle can be implemented in various ways but the five keystone components of engage, explore, explain, elaborate, and evaluate steps still occur (Bybee et al.,2006; Goldston, Day, Sundberg, & Dantzler, 2009). By comparing one nonintervention unit to two intervention units utilizing the 5E learning cycle, a difference in student understand may be found (Tural, Akdeniz, & Alev, 2010; Wilson, Taylor, Kowalkski, & Carlson, 2009; Metin, Coskun, Birisci, & Tilmaz, 2011).

While maintaining a focus on the National Science Standards (NRC, 1996) and The Common Core Curriculum (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010), studies conducted to learn about the 5E learning cycle were read in order to understand current trends, ideas, and

conclusions. The cited literature discusses a connection between increased student achievement, motivation, and retention when a 5E learning cycle is employed in the classroom setting.

This topic is relevant to myself and my students because if there is a way to allow students to feel more involved in their curriculum, it will not only help them see relevance in the topics being studies but will also help them become self-motivated. I think that motivated students would lead to better learning and better standardized test scores, which are a goal for the school district that I teach in. Motivated students would also help push students towards science careers and disciplines of study later in life.

METHODOLOGY

Project Treatment

This study included both a nonintervention unit as well as two intervention units to allow for comparison. The nonintervention unit was on DNA and Protein synthesis and lasted approximately two weeks. The two intervention units consisted of a two week unit on DNA Replication and Cell Cycle and a two week unit on Genetics and Evolution. The nonintervention unit on DNA and Protein synthesis included the elements I have used in the past in the order described by my unit menus. As a school everyone uses the term "menu" to describe our list of assignments. Because each student comes to us at a different point in their development we do not, normally, have one assignment that meets a standard. Instead we offer a variety of assignments to meet each individual student's need. Hence, we refer to our assignment lists as menus. The DNA and Protein Synthesis menu is included as Appendix A. Included in the nonintervention unit were the use of textbook reading, outlining, vocabulary study and concept mapping, a reading strategy

activity, labs (and explorelearning.com gizmos), a review concept map, and assessment. Normally students do the assignments, listed above, in the order that they were listed. A sample outline is given in Appendix B.

The intervention units included portions of the units above (i.e., vocabulary concept mapping, reading strategy activity, labs, and assessment) but each activity was adjusted to fit the 5E instructional model (Engage, Explore, Explain, Elaborate, Evaluate). Both intervention units were broken down by objectives that were derived from the Mid Iowa School Improvement Consortium standards and benchmarks that the school district has chosen to adopt. Beneath each objective was listed the Engage, Explore, Explain, Elaborate, and Evaluate activities that are designed to help students gain an understanding and show mastery in the objective. The activities were listed in order to have students follow the 5E learning cycle. Written and direction instructions were provided to help students understand the process and each individual activity. Students were allowed to work both individually and in groups on certain tasks within each unit. All students in this study chose to work independently. The sequence of activities in these units were the same for each student.

For each intervention unit, the Engage activity was a task meant to probe student prior knowledge through the use of short activities. The hope was for these same activities to provoke student interest in the subject matter as well. For each intervention unit probes were used and are an example of an engage activity. The probe allows students to show prior knowledge and lead to a student discussion about the objective.

The Explore activity provided students with activities that allow students to begin to understand content concepts, misconceptions, processes, and skills necessary for the

content objective. For intervention unit 1 the DNA Gizmo allows students to explore the idea of cell division, specifically the replication and passing on of DNA to the new cells. For intervention unit 2 the Human Karyotyping Gizmo allows students to experiment with the human chromosomes and understand all the different types and numbers of chromosomes that humans have. Within this Gizmo students are able to learn about genetic diseases that stem from missing or additional chromosomes such as Down's syndrome.

The Explain activity was designed to help students understand the content through textbook readings, vocabulary activities, and reading strategies so that students show their understanding and gain specific knowledge about the content objectives. The questioning activities for both intervention units start with a direct instruction strategy, vocabulary study, and a reading. This fits the explain activity description because it focuses students on the content of the objective and allows for teacher and text given explanations that students synthesize with their prior understandings.

The Elaborate activity was designed to allow students to continue studying the objective and expanding their knowledge along with developing and extending understanding of the content. The stages of mitosis flipchart activity from intervention unit 1 allows students to practice their skills with cell division and apply their understandings while creating a product. For intervention unit 2 the Evolution: Mutation and Selection Gizmo has students develop their ideas about genetics and apply them to the process of evolution.

The Evaluate activity was designed to allow students to show their mastery of the objective. Express 9 and the observing cell cycle phases lab from intervention one allow

students to show their understanding in two short lab scenarios while the Evolution: Natural and Artificial Selection Gizmo from intervention unit 2 has students show their understanding of the content in the frame of a simulation. The 5E cycle menu of assignments for the RNA Replication and Cell Cycle and the Genetics and Evolution units is included in Appendix C and D. In the appendices are a sample vocabulary activity from intervention unit 1 (Appendix E) and a sample activity from intervention unit two (Appendix F).

During each day of both intervention and nonintervention units, students were asked progress monitoring questions to ensure understanding of the units and the coursework involved. To help with progress monitoring, feedback was given both to and from me to help students understand the expectations and succeed with coursework. Students were expected to show complete mastery of content knowledge and remedial activities and corrections were completed in both the intervention and nonintervention units. However, student corrections were not used as data points in this study. The initial scores for students were recorded as data in this study, but students were allowed to show mastery for their grades in the course.

Data Collection Instruments

The subjects of this study were all the current second semester biology students at the Marshalltown Learning Academy in Marshalltown, Iowa who are working on these three units. There were 15 students included in this study. At my school students are able to come and go as they please, so long as they are making adequate progress in their courses. This leads to numbers fluctuating and changing throughout the day and also allows for students to focus on one or two classes at a time until they finish the course.

As a school we have an equal number of boys and girls as well as 50% Caucasian and 50% Hispanic. The average reading level of our students is at the sixth-grade level and one third of our students are special education identified. Nearly 99% of the population is considered free and reduced lunch and 80% of our population have at least one child while 30% of our students hold full time jobs. The average age of students in the study ranged between 17 and 20, as it is legal for students in Iowa to go to high school until they are 21 years old. Even though students in my class may by taking a multitude of science courses at a time, I focused my project on second semester biology instruction. The students included in this study were nine girls and six boys spanning high, middle, and low-achievement levels.

To inform each project question a data triangulation matrix was constructed and is shown in Table 1.

Table 1
Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3
Primary Question			
• What are the effects of the 5E instructional model on students' understanding of biological concepts?	Pre and postunit student concept assessments	Pre and postintervention student surveys about perception of understanding	Pre and postunit student concept interviews with concept maps
Secondary Questions:			

	Pre and postunit student interviews	Pre and postintervention student surveys	Instructor field notes
• What are the effects of the 5E instructional model on students' approach to learning?			
• What are the effects of the 5E instructional model on students' interest and motivation?	Pre and postintervention student interviews	Pre and postintervention student surveys	Instructor field notes
• What are the affects of the 5E instructional model on my teaching and attitudes towards teaching?	Instructor weekly reflection journaling with prompts	Pre and postintervention teacher surveys	Nonintervention/intervention interviews with observations by colleagues

Triangulation of data helped make a comparison between the nonintervention and intervention units due to the use of similar data collection techniques and data synthesis. Consideration was made in understanding the each unit had different subject matter and different prior knowledge for each study. Each question, for this study, was tested and

compared using three data sources, which allowed for both careful reflection and valid conclusions based on data collection techniques. The subjects of this study (students and me) were also the subjects of each data collection technique along with the outside influence of my colleagues to help bring a new perspective to the study and limit bias.

The primary question asked how the 5E instructional model affects students' biological knowledge. I used to collect information for this question was pre and postunit student interviews. Interview questions were developed based on content standards and included the use of concept mapping to explain students' thoughts, ideas, and connections. The interview questions can be found in Appendix G, H, and I. Three high, medium, and low-achieving students were interviewed and the data was examined. The same six female and three male students were interviewed each time to provide consistency in data. Each interview was conducted during class time in order to keep students interested and allow for minimal disruption to their school day. Another method of data collection was pre and postunit student assessments. A set of assessment questions was developed. The preunit assessments were given at the beginning of each unit. The postunit student assessments were paper/pencil tests and had the assessment questions for this study worked into the test. The pre and postunit assessments can be found in Appendix J, K, and L. The final data collection instrument used for the primary question was pre and postintervention student surveys on perception of understanding. Each student was given this survey in either paper or electronic format. The survey questions can be found in Appendix M.

Secondary question one was asking about the 5E instructional model and its effects on students' approach to learning. Students were interviewed before and after

each unit of instruction. Interview questions were developed to include questions that would elicit responses from students that correlate to ideas about learning. As few as three high, medium, and low-achieving students were interviewed. The interview questions used for this question can be found in Appendix N. Another method of data collection used for this question was pre and postunit student surveys. Survey questions were developed to focus on students ideas about learning before and after the unit of study. All students were given the survey either through written form or electronically. The survey questions can be found in Appendix M. The last data source for this question was instructor field notes. The method of note taking used for this data source was the "Observe and look for nothing" method as described by Mills and writing prompts developed beforehand (2011, p.77). The instructor field notes for this data source can be found in Appendix O.

The next secondary question was probing students' interest and motivation. Once again pre and postunit interviews were used to collect data and interview questions were developed in order to gather data on student motivation and interest. As few as three high, medium, and low-achieving students were interviewed. The list of interview questions can be found in Appendix N. The questions chosen for this interview were developed in order to collect data specifically for this secondary question. Data from these questions were used to determine the effectiveness of the intervention and focus of this study. A second method for gathering data on this secondary question was pre and postunit student surveys. Survey questions were gathered to elicit student responses as to interest and motivation. All students were surveyed in written form or electronically. Survey questions can be found in Appendix M. The third method data collection used

was instructor field notes. In order to facilitate consistent note taking, writing prompts were included for a better data collection instrument. The instructor field notes for this data source can be found in Appendix O.

The third secondary question was about the effects of the 5E instructional model on my teaching and attitudes towards teaching. Pre and postunit surveys were developed and taken to gain reflective data on my own attitudes and behaviors. Survey questions can be found in Appendix P. The survey questions found in Appendix P were chosen to elicit teacher understanding of teaching and current attitudes towards teaching. Each question focuses on different part of teacher motivation and includes Likert scale questions accompanied by open-ended explanation space for me to answer and include the reasoning behind my response in the hopes of understanding the background for each answer. Another method of gathering data on this secondary question was nonintervention and intervention interviews with colleagues. These interviews included questions developed to gain insight from an outsiders' perspective on my teaching. A list of interview questions can be found in Appendix Q. The third data collection instrument for this question was instructor weekly reflection journaling. Sample journal entries can be found in Appendix R.

The timeframe for this survey was January through March of 2013. Both the nonintervention and intervention units were based on approximately 2-3 weeks of student study with the data collection instruments interspersed as shown in Appendix S.

DATA AND ANALYSIS

During the project, I collected data during nonintervention and intervention units to understand the effects of the 5E instructional model on the understanding of biological

concepts for high school students. The data were collected using a variety of methods to allow for triangulation.

The effects on understanding concepts is shown in Figure 1, which shows student pre and postunit assessment data in percentages. The data show that in each unit students increased from the preunit to the postunit assessment. However, there is no recognizable difference between the postunit scores of the nonintervention and intervention units.

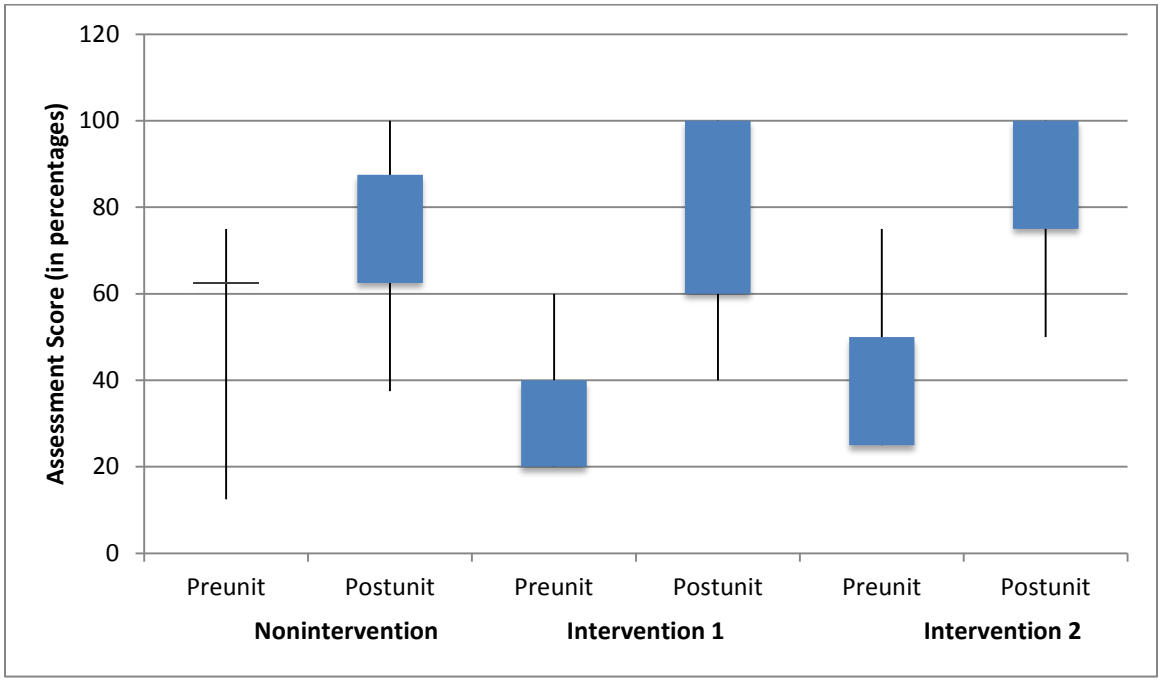

Figure 1. Student pre and postunit assessment data. Units split into nonintervention, intervention 1, and intervention 2, (N = 15).

Another method of analyzing the assessment data was comparing percent change and normalized gain scores. These data were broken down into achievement levels, high, middle, and low-achieving student groups. Due to varying preunit scores, a normalized gain was also calculated to compare the change in understanding between units. The normalized gain was calculated as follows: Normalized Gain = $\frac{\text{postunit \% - preunit \%}}{\text{100 - preunit \%}}$. These data can be found in Table 2.

Table 2
Average Scores, Percent Change, and Normalized Gain from Preassessment to Postassessment for All Units Split into Low-Achieving (n=6) Mid-achieving (n=5) and High-Achieving and (n=4) and All Students N=15 Groups

Group Description		Low	Mid	High	All
Nonintervention	Preunit	2.5	4.2	5	3.73
	Postunit	5.17	6.6	7.75	6.33
	% Change	106.8	57.14	55	69.7
	Normalized Gain	.49	.64	.92	.60
Intervention 1	Preunit	1.67	1.4	2.5	1.8
	Postunit	2.83	3.8	4.75	3.67
	% Change	69.5	171.4	90	103.9
	Normalized Gain	.27	.66	.90	.58
Intervention 2	Preunit	1	1.6	2.5	1.6
	Postunit	3	3.4	4	3.5
	% Change	200	112.5	60	118.75
	Normalized Gain	.67	.75	1.0	.80

Before breaking students down into separate groups based upon achievement level, the percent increase in comparison to pre and postunit assessments was greater for the intervention units when compared to the nonintervention units for the unseparated data. Medium and high-achieving student followed the trend of having a greater percent change during intervention units as compared to the nonintervention unit suggesting that the intervention was most effective with these levels of students. The low normalized gain for the low-achieving students indicated that their high percentage change in all phases was due to the low preunit assessment scores. In general the mid-achieving and high-achieving students realized the highest gain in scores based upon having the highest normalized gain. In terms of students' ability to explain their thinking on assessment questions requiring a written explanation, all students showed a greater use of scientific vocabulary and elaborate thinking on the postassessments as compared to the

preassessments regardless of nonintervention or intervention units. For example, a preassessment answer for the nonintervention unit included statements like “Meiosis gives us more species”. Whereas, in the postassessment a student said, “Mitosis and meiosis are similar in that they make new cells but at the end of mitosis we get an identical diploid cell whereas at the end of meiosis we have unique haploid cells”. This trend continued throughout all preassessments and postassessments but there was not a distinguishable difference between postassement student thinking between intervention and nonintervention units.

Another measurement of student understanding that supported the pre and postunit assessment data were based on student surveys given to each student. The student surveys were given before the intervention units and at the conclusion of the second intervention unit. The results of select Likert scale questions from the surveys given to the students are shown in Table 3.

Table 3
Student Responses for Select Survey Questions (N= 15*).*

Question	5	4	3	2	1
Understand all Concepts and Content in Unit					
Preintervention	0	0	4	6	5
Postintervention	4	6	5	0	0
Don’t Need the Required Activities to Show Mastery					
Preintervention	0	2	1	5	7
Postintervention	3	5	3	3	1
Objectives Clearly Labeled Helped					
Preintervention	5	2	5	1	2
Postintervention	3	4	4	2	2

Note. 5 = Strongly Agree, 4 = Agree, 3 = Indifferent, 2 = Disagree, 1 = Strongly Disagree.

The questions included on the survey were created to ascertain students’ perception of understanding. The data shows that student perception of their

understanding of the concepts and content in the unit increased from the nonintervention unit to the intervention unit. Students thinking moved only slightly in the area around their perception of whether they needed the required activities to show mastery. The intervention did not show a significant change in student thought in the area of having the objectives clearly labeled for each unit and each activity.

The final data collected to determine the effect of the 5E learning cycle on student understanding was student concept interviews with concept maps. Student interviews were graded using a rubric. Data from the pre and postunit concept interviews allowed the calculation of percent change in increased understanding on unit concepts, and then allowed for comparison between nonintervention and intervention units. The results are shown in Table 4.

Table 4.
Average Concept Map Scores and Percent Increase from Preunit to Postunit Concept Interviews for All Units Split into Low-Achieving (n=2) Mid-achieving (n=2) and High-Achieving and (n=2) and All Students N=6 Groups

Group Description		Low	Mid	High	All
Nonintervention	Preunit	2.5	4.5	5.5	4.17
	Postunit	9.5	7.5	8.0	8.33
	% Change	280	66.67	45.45	99.76
	Normalized Gain	.93	.55	.56	.71
Intervention 1	Preunit	1.5	2.5	5	3
	Postunit	7.5	8.5	9.5	8.5
	% Change	400	240	90	183.3
	Normalized Gain	.71	.80	.90	.79
Intervention 2	Preunit	1.5	3.5	3.5	2.83
	Postunit	7	8.5	9.5	8.33
	% Change	366.7	142.9	171.4	194.3
	Normalized Gain	.65	.77	.92	.76

For all students the percent increase in comparison to preunit and postunit concept interviews was greater in the intervention units than the nonintervention units. The middle and high-achieving students had high percentage change with higher normalized gain, which indicate the intervention was more effective with these groups of students than the nonintervention amount of percent change from preunit to postunit but the least normalized gain, which indicates low preassessment score and does not necessarily indicate better understanding. There was a large difference of scientific discussion involving the concept maps between preunit and postunit concept interviews as well, however there was not a large difference between those discussion between intervention and nonintervention units. For example, “Genetics are the characteristics and heredity is the passing of these traits to offspring” was said during a postunit interview after intervention unit 2, whereas, students had very good explanations for where each phase of transcription and translation occurred inside the various parts of the cell. This trend continued throughout both the nonintervention and intervention units. The concept map data suggests that the intervention helped students to understand concepts.

Data were collected and triangulated to understand the effect of the 5E learning cycle on students and their approach to learning. The first data source considered was student pre and postunit nonconcept interview questions. Trends from the interview questions showed that students didn’t notice a different in their way of thinking from preunit to postunit and nonintervention to intervention units. Most students noticed the change in order of activities but did not attribute that change in their success for learning. A few students noted that the change in activities did allow them to do something more fun at first before reading. A couple student responses were, “I really liked the engage

activity first to get me interested," and "It helped me learn more." Other students commented on the entire 5E learning cycle and said, "It was different but I think it helped" and "It think it is helpful but it isn't a big change."

The second data point in understanding students' approach to learning was pre and postintervention student surveys. Students were asked which activities helped them to understand the most and the key preintervention comments included, "Outlines", "Gizmos", "Nothing", and "I just want packets". Postintervention comments included, "The setup of understanding why the activities were put in a particular order", and "Explore activities". There were 40% of the students interviewed who mentioned the Explore activities in a positive manner during the student surveys. I also asked students that if they could change something about the assignment they were given what would it be. Preintervention responses to this question included, "Less assignments so we could go faster", and "No more gizmos, they suck". Postintervention comments included, "Less assignments", "Less reading", and "Shorter assignments".

A third data point for student approach to learning was instructor field notes. The instructor field notes were filled out daily and recorded in a journal. The results of a select Likert question from the instructor field notes is found in Table 5. The data show that during the nonintervention unit, the teacher's observations stayed towards the "Agree, Indifferent, Disagree" area. While during the intervention units, the teacher observations trended closer to the "Strongly Agree" and "Agree" ends of the Likert scale.

Table 5
Teacher Response for Field Notes Question on Student Questions That Were More Focused on the Concept Being Studied (N =30*)*

Project Phase	Likert Score				
	5	4	3	2	1
Nonintervention Unit	0	4	2	4	0
Intervention Unit 1	2	7	0	1	0
Intervention Unit 2	6	3	1	0	0

Note. 5 = Strongly Agree, 4 = Agree, 3 = Indifferent, 2 = Disagree, 1 = Strongly Agree.

The questions included in the field notes were designed to help gather information about teacher observation of student behavior. When considering student questions a majority of the questions that were asked were focused on clarifying assignments but as students moved from the nonintervention unit into the intervention units a shift was observed in that questions became more focused on the content of the assignments rather than the fulfillment of the assignments. These results are shown in Figure 2.

My next question was about the effects of the 5E learning cycle on students' interest and motivation. Student interviews, student surveys, and instructor field notes were used as data sources for this subquestion. The data are discussed below.

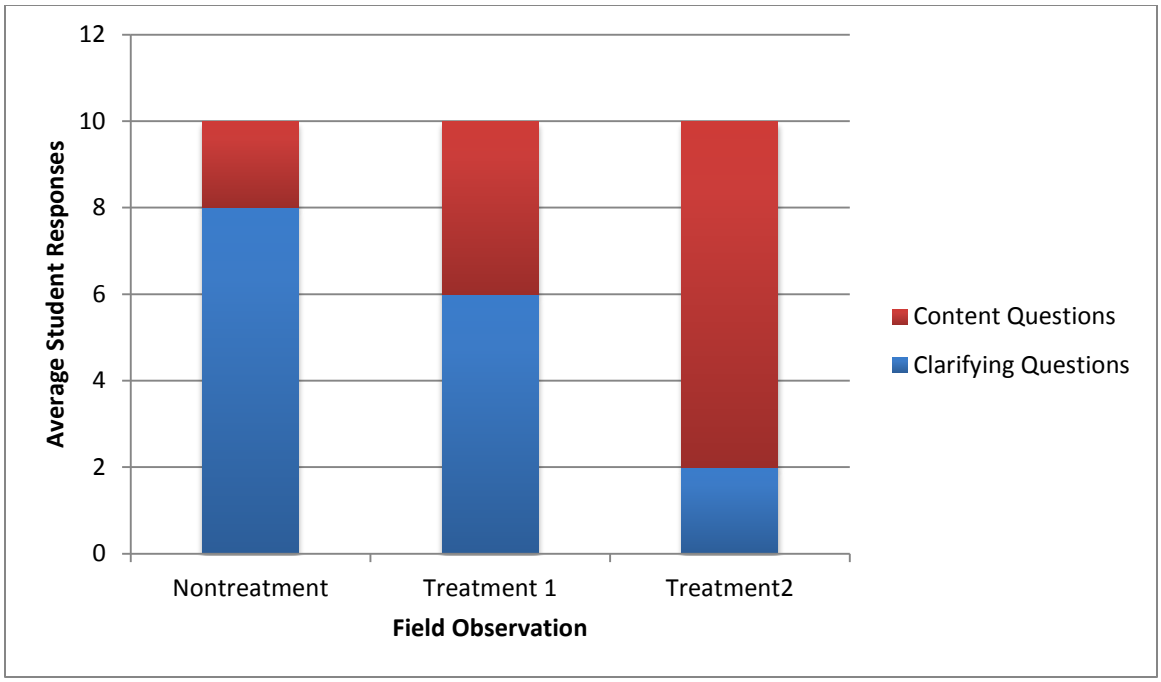

Figure 2. Observed question types from field notes. Units split into nonintervention (n = 10), intervention 1 (n = 10), and intervention 2 (n = 10), (N = 30).

The first data source was pre and postunit student interviews. One of the questions that students were asked was what part of the unit was the most interesting to them. Example student answers for the nonintervention unit included, “Gizmos” and “How the parts of the cell do different things with making proteins”. Example student answers from the intervention units included, “The gizmo”, “The change in order of assignments”, “The different types of genes and traits”, and “Looking at my own traits and my parent’s traits”. Another question aimed at this focus question was what motivated the students to complete this unit. Students answered the same throughout the nonintervention and intervention units. Their answers hovered around two ideas “I want to graduate”, and “I want to get the credit”. The data from this source is very ambiguous as to whether it supports the focus question. Students did not truly change their opinions regarding their interest and motivation during the nonintervention and intervention units.

A second data source for this focus question was pre and postintervention student surveys. The student surveys were given before the intervention units and after the second intervention unit. The results of select Likert scale questions from the surveys given to the students are shown in Table 6.

Table 6
Student responses for select survey questions (*N*= 15).

Question	Likert Score				
	5	4	3	2	1
I Have Enjoyed Learning Lately					
Preintervention	2	2	2	3	6
Postintervention	2	3	5	2	3
I Feel Excited to Learn About Biology					
Preintervention	1	1	8	1	4
Postintervention	1	5	3	2	4
I am Interested in the Biological Concepts We Are Learning About					
Preintervention	1	1	6	1	6
Postintervention	2	1	6	1	5
I Am Motivated To Learn					
Preintervention	3	1	7	2	2
Postintervention	2	3	6	2	2

Note. 5 = Strongly Agree, 4 = Agree, 3 = Indifferent, 2 = Disagree, 1 = Strongly Disagree.

The questions included on the survey were created to ascertain students' change in interest and motivation. These data show that when students considered their enjoyment of learning that student's thoughts moved from the negative "Strongly Disagree" to "Indifferent" after the intervention. Student excitement showed a growth away from "Indifferent" to "Agree". Interest in the biological concepts showed no real change after the intervention. Student motivation to learn changed very little overall from nonintervention to intervention.

Included with the student survey was a question asking students about what specific activities motivate them. On the preintervention unit students answered with

"None," and "Outline or gizmo." For the postintervention survey students answered, "Engage activities", "Pretests", and "Nothing." More students answered in the positive and listed the engage activities or the specific activities that were used as engage activities. This suggests that students enjoyed being introduced to the unit's concepts and objectives through an activity meant to immerse the students as well as help the teacher to understand the student's prior knowledge in the content.

The third data source for the question of student interest and motivation was the use of instructor field notes that were compiled after each school day during the nonintervention and intervention units. Table 7 shows Likert scale data focused on teacher's perception on student's amount of time on task.

The teacher perceived that students spent an increasing amount of time on task based on whether or not students were working on the nonintervention unit as compared to the intervention units. The data showed that the teacher perceived more students on task through the answers of "Strongly Agree" and "Agree".

Table 7
Teacher responses for field notes question on students on task (*N* =30*)*

Project Phase	Likert Score				
	5	4	3	2	1
Nonintervention Unit	1	6	3	0	0
Intervention Unit 1	3	5	2	0	0
Intervention Unit 2	5	4	1	0	0

Note. 5 = Strongly Agree, 4 = Agree, 3 = Indifferent, 2 = Disagree, 1 = Strongly Agree.

The project topic that I considered for this study were the effects of the 5E cycle on my teaching and attitudes towards teaching. Data sources for this question consisted of weekly reflection journaling with prompts, pre and postintervention teacher surveys,

and nonintervention/intervention interviews with observations by colleagues. Data from the instructor weekly reflection journaling included mostly qualitative data in the form of questions and explanations written out during each week of the study. From the nonintervention unit observations were made and consisted of students being on task and working independently towards completing the unit. Observations were also made about students asking assignment clarification questions rather than content questions.

During intervention unit 1 I noticed that the week started off a little rough with having to explain how the 5E learning cycle unit was structured and why the assignments were moved around or setup in a different way than the students were used to. I noted in my journal entry under the question "What observations did you make from students today?", that students started to ask conceptual questions. I also made a conjecture on January 31st that, "Possible correlations between on task, 5E, and more conceptual questions." I also noted during the first intervention unit that I started having a difficulty completing all of my required school activities i.e. grading, lesson design, classroom monitoring due to the increased amount of activity preparation required for the 5E learning cycle, I continued to notice an increase in the amount of "higher-order thinking and conceptual questions rather than clarification". I remained very positive about the 5E learning cycle even though I was feeling pressure to complete all of my tasks during the school day. I noted that, " [The 5E learning cycle] is working well but it would require a scheduling change to fully implement in all courses I teach."

Data showed that from a teacher perception standpoint, the 5E learning cycle had a positive effect on my teaching attitudes with the only exception being that amount of time required to prepare and run a fully implemented 5E cycle for each course. An

increase in higher-order thinking questions and content involvement lead to a positive attitude for my teaching practices and myself.

The second data source for teaching attitudes pre and postintervention teacher surveys. The surveys were given once preintervention and once postintervention. Figure 3 shows teacher response to select Likert scale questions.

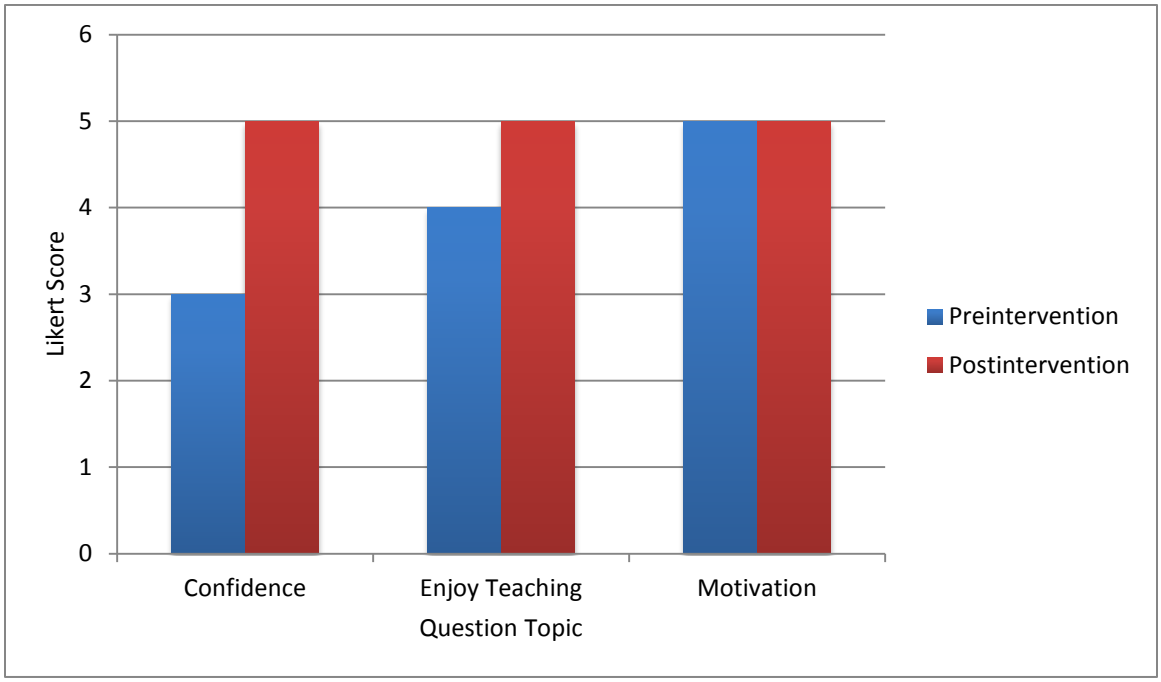

Figure 3. Teacher responses to survey for selected questions (*N* =2*). Note.* 5 = Strongly Agree, 4 = Agree, 3 = Indifferent, 2 = Disagree, 1 = Strongly Agree.

Data show a trend towards increased teacher confidence and enjoyment of teaching after the intervention units as opposed to before the intervention units. Data also show that teacher motivation for improvement was the same before and after intervention. Included on the teacher survey was a postintervention only question asking whether I thought that the 5E model had a positive effect on me as a teacher. It was a Likert scale based question in which I answered 5 and explained that I felt very positive towards the 5E learning cycle but that there may be timing issues around preparedness.

The final data for this question were nonintervention and intervention interviews with a colleague after an observation in the classroom. Over the course of the study there were three observations and interviews with a colleague, once per unit. The Likert scale data for select questions can be found in Figure 4.

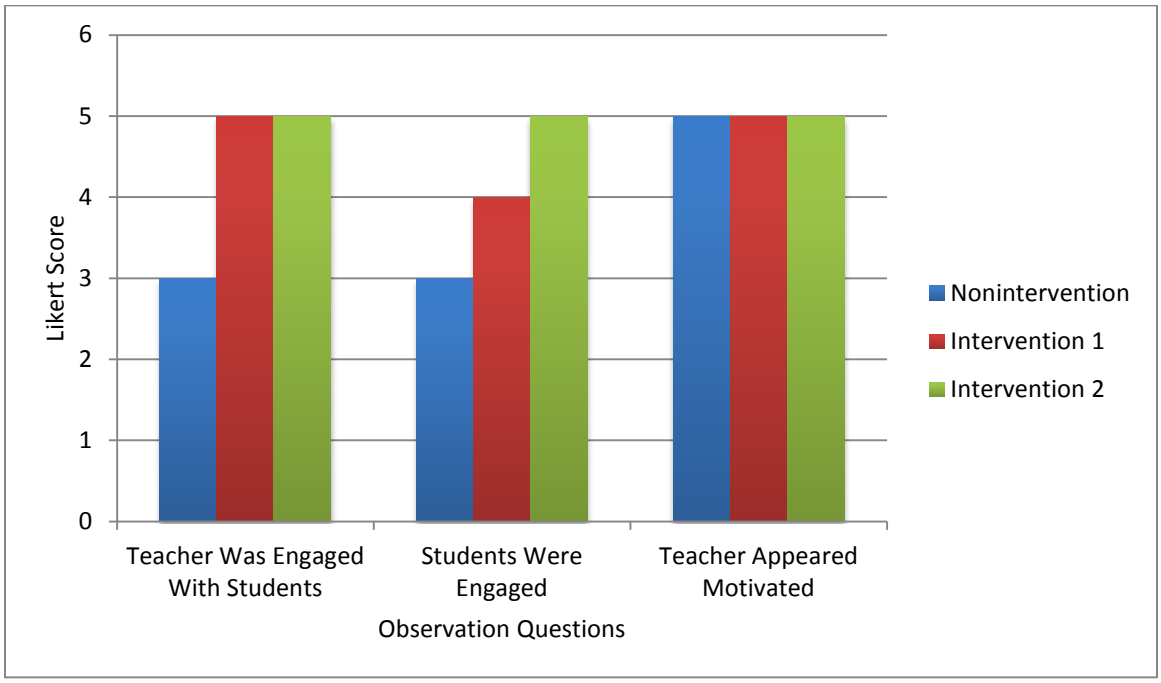

Figure 4. Colleague responses to select interview questions (*N* =3*). Note.* 5 = Strongly Agree, 4 = Agree, 3 = Indifferent, 2 = Disagree, 1 = Strongly Agree.

These data show a trend towards positive student and teacher engagement from the nonintervention to intervention units. The colleague responded that the teacher was highly motivated throughout the study. Along with the Likert scale questions were interview questions designed to gather more specific comments regarding changes in the teacher as observed by the colleague. The colleague responded that the only major change that they noticed in the teacher was that, "Kevin is very focused on what his students are working on and engaged with them constantly." When considering changes in students the observer noted that during the intervention units students were "asking

very high-quality questions and seemed to be more on task." From an outsider's point of view it can be noted that the 5E learning cycle had a positive influence not only on students but on the teacher's motivation and teaching attitudes.

INTERPRETATION AND CONCLUSION

The primary question of this study was asking about the effect of the 5E learning cycle on students' understanding. It can be seen from the data above that student understanding improved when comparing a nonintervention and intervention units, though that improvement is not statistically significant. The normalized gain scores for pre and postassessments varied in both nonintervention and intervention units. Student perception of their learning was shown to increase through student surveys, interview data also support this claim.

Considering students' approach to learning, the data showed no significant changes between the nonintervention and intervention units. In interviews and surveys students did not overwhelmingly promote the 5E learning cycle as having a difference in their learning. Instructor field notes did show a change in student questioning in class. A focus on the types of questions students ask could be used as a later study so as to ascertain the true change in student questions. The data collection instruments were not created to ascertain the direct change in student questions from the beginning of the study.

Interest and motivation of students is an important part of being an educator. If students are not motivated or believe that the subject matter is important it can be difficult to facilitate student learning and activities. For this study question the data were again inconclusive in that students did not show a change in motivation, however, it can

be noted that many students made mention of the order of activities did make things different for the class. The data sources indicating student enjoyment and excitement of learning did show a change from "Disagree" to "Agree". A few students mentioned that exploring the content before reading about it helped to peak their interest. Teacher observations also noted that students were more on task during the intervention units as compared to the nonintervention units.

An important aspect of any educational study is the change in what the teacher feels or experiences. While we are looking for student outcomes, if those outcomes come at the expense of teacher security or job satisfaction it may be difficult to keep teachers in classrooms. The data on this question show distinct patterns. Teachers' teaching attitude and motivation are improved. However, the trade-off is in teacher time. There are many tasks that are required of teacher throughout the school day. Duties, preps, grading, just to name a few take a lot of time away from students and because of this adding a high intensity teaching model may lead to burnout or unwillingness to continue the model. Through colleague observations it was noted that teacher and student engagement increased during the intervention units.

If I were to do this project again, I would make some changes throughout the process. There was at least a question or two on each data collection instrument that was not helpful towards answering the project questions. For example, on the journal reflection prompts for the teacher I found the data gathered by the first two questions, "How did this week go for you and how did this week go for your students?" did not give very detailed or valuable data towards the project questions. Questions like these persisted across all data collection instruments and I think they could be cut out or

replaced with better questions with more purpose. Another data collection change that I think would have helped this project would have been to specifically observe student questions from the beginning of the project. I think some correlations could have been made between student questions and the effect of the 5E learning cycle.

VALUE

This study has many implications on my students and myself. My students showed a growth in their knowledge and questioning behaviors. These are potentially large changes for students and their ability to learn. If students are thinking in the higher orders then they are making connections between the content and their lives. If this is occurring then it could be concluded that students are learning more about the content. A future study could be conducted on this idea to provide better data for this claim. For myself as the teacher there is a trade-off and personal reflection to decide about the time commitment for this teaching model. If I can rationalize the time commitment to the 5E learning cycle, then it is a positive model for the students and myself. If the time commitment is going to be too much for me to handle then forcing the 5E learning cycle will not benefit myself or my students.

The implications of this study would allow administrators to have another tool to help present the 5E learning cycle to teachers as a viable option to help increase student learning and thinking. For colleagues this study does help both explain and give examples of the 5E learning cycle. It also helps to explain the potential positive influences of the 5E learning cycle as well as its pitfalls. If time wouldn't be an issue for teachers, then perhaps the 5E learning cycle is something should give a try in your classroom.

This study does bring to the forefront students' metacognitive thinking. A study could be designed to help understand students thinking and what affects their thinking has on learning. Do metacognitive strategies lead to more student learning? This is a great question that could be the basis for another study in the future. Personally, I am very interested in student questions and what the effects of certain teaching strategies would have on those questions that students have in class. I spend a majority of my day answering questions and if I could influence and direction those questions towards higher-order, content specific areas then I could see what affect that could have on student learning.

This project has helped me really understand the applications of educational research. There are many positive ways to do research but those methods do become questionable in the educational setting but through action research ideas about education could be better tested and data could be provided to answer to the questions that come with teaching. I am finding myself searching for the data behind different teaching methods and models, which was not something that I did before I started working with action research. I feel confident in evaluating research that I do read and I understand another research strategy that is highly used in education. This project has led me to think more proactively about the teaching strategies I choose to use in my classroom and the potential effects that the methods have on my students.

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APPENDICES

APPENDIX A

NONINTERVENTION: DNA AND PROTEIN SYNTHESIS UNIT MENU

Unit 5: DNA and Protein Synthesis

Overview:

Watch both videos (you may stop after the 6 minutes 30 seconds mark in the first video, you don't need to worry about the Virus portion of this video)

- During the videos I want you to identify 5 (or more) key points (total not 5 per video) of the video and construct a question either about a topic from the video or about a topic we are studying in this unit.
- In an email to me, write your key points and a question and send them to me.
- I will respond to your email and either ask you to clarify your key points, clarify your question, or will ask you another question which you need to write another email in response.

_ Read the Unit 5 article click here.

- Read the entire web page
- Do the Reading Strategy Activity (Visualizing) for the Unit 5 article

_ Unit 5 Vocabulary Activity

Practice and Application:

_ Unit 5 Questions Activity

_ Building DNA Gizmo

Choose 1 from the following 2:

- _ DNA Fingerprint Analysis Gizmo
- _ Crime Scene DNA Lab

Choose 3 from below:

- _ Express Lab 11
- _ RNA and Protein Synthesis Gizmo
- _ A Faulty Protein Lab
- _ Virus Lytic Cycle Gizmo
- _ Disease Spread Gizmo

Assessment: (Choose 1 from below)*

_ Unit 5 Test

_ 5-Paragraph Essay

_ Project

APPENDIX B

NONINTERVENTION OUTLINE

Appendix B
Nonintervention Outline

I. Genetic Information Cycles

A. DNA structure

1. Each nucleotide in DNA contains the sugar _____, a _____ group, and one of four _____ bases

2. Each base follows a pattern called _____ base pairing

a. _____ pairs with thymine

b. Guanine pairs with _____

3. The double helix structure of DNA allows it to carry coded instructions to make _____

B. RNA structure

1. RNA is a _____ strand of nucleotides

2. RNA nucleotides contain _____ instead of thymine and _____ instead of deoxyribose

C. DNA replication

1. _____ new copies of DNA form during DNA replication

2. During replication the double helix _____

3. Each strand serves as a _____ for a new strand

D. Transcription and Translation

1. _____ is the creation of an RNA molecule from DNA

2. _____ is the creation of a protein created from the sequence of bases on RNA

E. Viruses

1. A virus is a _____ particle

2. A virus invades a host cell to _____

F. Biotechnology is the use of _____ and their genetics to make _____ and improve _____ crops

G. Immune System

1. The immune system defends the body against _____

2. _____ defenses, such as the inflammatory response, are the body's _____ line of defense

3. _____ defenses, such as antibodies, attack infected cells based on the presence of certain _____

4. _____ results when the immune system recognizes previous antigens

APPENDIX C

INTERVENTION UNIT 1: DNA REPLICATION AND CELL CYCLE MENU

DNA Replication & Cell Cycle Unit

DNA Replication & Cell Cycle-1
Objective: Students will know features of human inheritance.

Engage: Whale and Shrew Probe, Sam's Puppy Probe
Explore: Cell Division Gizmo
Explain: Video 1; Vocab 1; Text: Ch.9 Lesson 1 and Lesson 3 pages 248-250, 256-258, Chapter 11 Lesson 1 and 2 pages 306-308 and 310-312 (or similar reading); Questioning Reading Strategy
Elaborate: States of Mitosis Flip Chart
Evaluate: Express 9; Observing Cell Cycle Phases Lab

Assessment: *Show me what you know!*
Test
Essay
Project
Something Else?

APPENDIX D

INTERVENTION UNIT 2: GENETICS AND EVOLUTION UNIT MENU

Genetics and Evolution Unit

Genetics and Evolution-1
Objective: Students will know ways in which genes may be altered and combined to create genetic variation within a species.

Engage: DNA, Genes, and Chromosomes Probe
Explore: Human Karyotyping Gizmo
Explain: Video 1; Vocab 1; Text: Ch.10 Lessons 1, 2, and 3 pages 278-282, 284-288, and 292-295 (or similar reading); Predicting Reading Strategy
Elaborate: Evolution: Mutation and Selection Gizmo
Evaluate: Evolution: Natural and Artificial Selection Gizmo

Genetics and Evolution-2
Objective: Students will know ways information is collected, classified, stored, and analyzed to make sense of biochemical and biological information.

Engage: Baby Mice Probe
Explore: Interpreting Pedigrees Lab
Explain: Video 2; Vocab 2; Text: Ch.11 Lesson 5 pages 325-328 (or similar reading); Identifying Reading Strategy
Evaluate: Classifying Organisms Activity

Genetics and Evolution-3
Objective: Students will understand and explain how organisms change over time in terms of biological evolution and genetics.

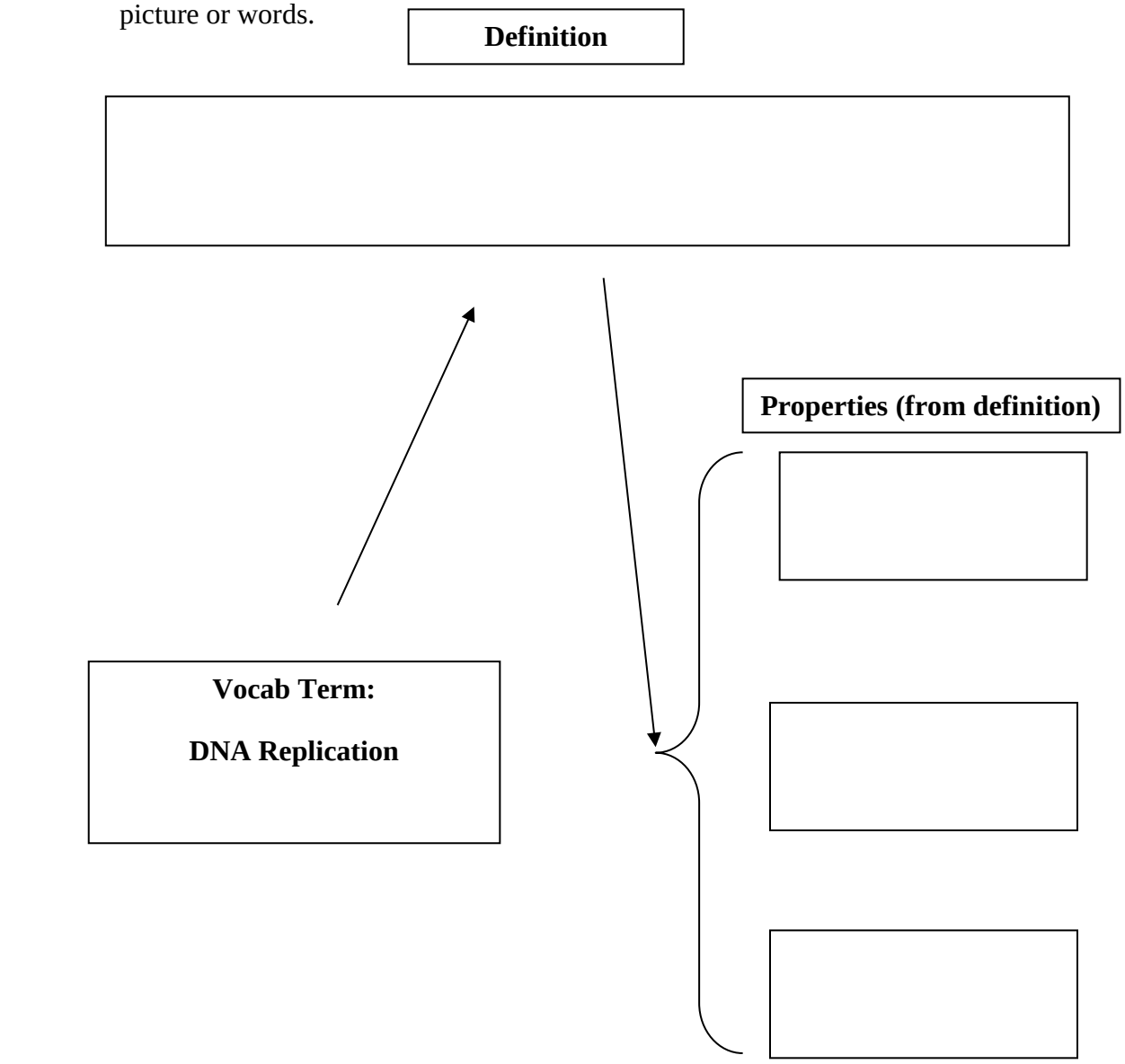
Engage: Biological Evolution Probe
Explore: Radioactive Dating Lab
Explain: Video 3; Vocab 3; Text: Ch.13 Lessons 1, 2, 3, 4, 5, and 6 pages 388-390, 392-395, 397-400, 404-408, 410-412, and 416-419 (or similar reading); Visualizing Reading Strategy
Elaborate: Evidence of Evolution Activity
Evaluate: Natural Selection Gizmo

Assessment: *Show me what you know!*
Test
Essay
Project
Something Else?

APPENDIX E

INTERVENTION UNIT 1: VOCABULARY ACTIVITY FOR THE EXPLAIN PORTION OF THE 5E CYCLE

Fill in the definition of the given word in the definition box. For the properties try to break the definition of the word into two or three most important part and list them here. For examples try to think of what the vocab word makes you think of. This could be a picture or words.



APPENDIX F

INTERVENTION UNIT 2: SAMPLE ACTIVITY FOR THE EXPLORE PORTION OF THE 5E CYCLE

Name: _____

Evidence for Evolution Webquest

Direction: Go to this webpage:
http://www.pbs.org/wgbh/evolution/educators/lessons/lesson3/act2.html
Follow the directions on the webpage to look at the different areas of evidence for evolution and fill out the following table. Write an explanation of each of the evidence areas for evolution and please include why that evidence is significant as a form of evidence.

Special Areas of Interest	Evidence (description or drawings)	Significance
Anatomy		
Molecular Biology		
Paleontology		

APPENDIX G

CONCEPT INTERVIEW: NONINTERVENTION UNIT

Appendix G

Concept Interview: Nonintervention Unit

Concept Map

Create a concept map using the materials provided: poster paper, cards with vocabulary words and terms.

Arrange these cards on the poster paper in a logical order with the starting phrase: How cells make proteins. If you would like to add any cards with your own words or phrases, feel free. Connect each of the cards with connection phrases.

You will be given cards with the following words or terms: DNA, mRNA, tRNA, Ribosome, Nucleus, Protein Synthesis, Translation, Transcription, Cytoplasm, and Protein

Feel free to add in any words that you think are applicable.

You will present your concept map to me.

Concept question: Using your concept map, explain the process of protein synthesis.

APPENDIX: H

CONCEPT INTERVIEW: INTERVENTION UNIT ONE

Appendix H
Concept Interview: Intervention Unit One

Concept Map

Create a concept map using the materials provided: poster paper, cards with vocabulary words and terms.

Arrange these cards on the poster paper in a logical order with the starting word: DNA Replication. If you would like to add any cards with your own words or phrases, feel free. Connect each of the cards with connection phrases.

You will be given cards with the following words or terms: Complementary Base Pair, Nitrogenous Base, Adenine, Guanine, Thymine, Cytosine, Uracil, Chromosome, Double Helix, and Template Strand of DNA.

Please feel free to add any words that you feel are applicable.

Your will present your concept map to me.

Concept question: Using your concept map, explain how DNA is replicated in cells.

APPENDIX I

CONCEPT INTERVIEW: INTERVENTION UNIT TWO

Appendix I
Concept Interview: Intervention Unit Two

Concept Map

Create a concept map using the materials provided: poster paper, cards with vocabulary words and terms.

Arrange these cards on the poster paper in a logical order with the starting word: genetics. If you would like to add any cards with your own words or phrases, feel free. Connect each of the cards with connection phrases.

You will be given cards with the following words or terms: gene; genotype; phenotype; dominant; recessive; chromosome; ratio; pedigree; heredity; codominant.

Please feel free to add in words that you feel are applicable.

You will present your concept map to me.

Concept question: Using your concept map, explain how genetics and heredity are inter-related.

APPENDIX J

NONINTERVENTION PRE AND POSTUNIT ASSESSMENT

Appendix J
Nonintervention Pre and Postunit Assessment

1. List the phases of the cell cycle.

2. Describe each phase of the cell cycle.

3. How are mitosis and meiosis similar? How are they different? Explain.

4.How is mitosis important to the development and survival of an organism? Explain.

5. How is meiosis important to the survival of the species? Explain.

APPENDIX K

INTERVENTION UNIT ONE PRE AND POSTUNIT ASSESSMENT

Appendix K
Intervention Unit One Pre and Postunit Assessment

1. What is DNA?

Here is a DNA sequence:

AUG

AT

CG

AT

TA

GC

GC

2. What RNA sequence would be transcribed?

3. Describe the sequence of events that will allow it to direct the formation of new protein.

4. What would happen to the protein if there is a mutation in the DNA? Explain.

APPENDIX L

INTERVENTION UNIT TWO PRE AND POSTUNIT ASSESSMENT

Appendix L
Intervention Unit Two Pre and Postunit Assessment

1. What is genetics?

2. What are the different types of evidence that support evolution?

3. If Gregor Mendel and Charles Darwin were in a room together today, do you think they would collaborate on their ideas and put them together into some sort of combined theory about genetics and evolution? Explain your answer.

APPENDIX M

STUDENT SURVEY

Appendix M

Student Survey

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

1= Strongly Disagree2 = Disagree3 = Indifferent4 = Agree5 = Strongly Agree

1. I understand all the concepts and content of the upcoming/previous unit.
1 2 3 4 5

2. I don't/didn't need to do the required activities in order to show mastery of the objectives.
1 2 3 4 5

3. I have enjoyed learning lately.
1 2 3 4 5

4. Having the objective clearly listed and labeled has helped me better understand what I am supposed to be learning about.
1 2 3 4 5

5. I feel excited to learn about Biology.
1 2 3 4 5

6. I am interested in the biological concepts we are learning about.
1 2 3 4 5

7. I am motivated to learn.
1 2 3 4 5

8. I am motivated to complete this course.
1 2 3 4 5

9. What class activities help you to understand? Explain.

10. If there was something you could change about the assignments that are required, what would you change and why?

11. What class activities help to motivate you? Explain.

12. Is there anything else you would like me to know?

13. (Postintervention only) The 5E learning cycle helped me to understand biology.
1 2 3 4 5

APPENDIX N

STUDENT NONCONCEPT INTERVIEW QUESTIONS

Appendix N
Student Nonconcept Interview Questions

1. How much do you enjoy learning?

2. Have you enjoyed Biology so far this year? Explain your answer.

3. Has the current model of instruction helped or hindered your learning? Explain your answer.

4. (Postunit only) What have you found most interesting about this unit? Explain.

5. (Postunit only) Has this unit included anything you found meant something to your life? Explain.

6. (Postunit only) What motivated you to complete this unit? Explain.

7. (Postunit only) What activites in this unit have helped you understand the objective? Explain.

8. (Postunit Only)Did the order of activities affect how you learned or your perception of how you learned. Explain.

9. Is there anything else you would like me to know?

10. (Postintervention only) Do you feel like the 5E learning cycle had an affect on your learning? Explain.

11. (Postintervention only) What about the 5E learning cycle changed your learning? Explain.

APPENDIX O

INSTRUCTOR FIELD NOTES

Appendix O

Instructor Field Notes

1 = Strongly Disagree2 = Disagree3 = Indifferent4 = Agree5 = Strongly Agree

Prompts:

1. Students were on task.
   1 2 3 4 5
   Explain.
2. Students were asking questions.
   1 2 3 4 5
   Explain.
3. What teaching strategies were being used?
4. What question(s) was asked most?
5. What strategies helped students learn the best?
6. What conjectures can be made from student questions?
7. Any other observations.

APPENDIX P

TEACHER SURVEY QUESTIONS

Appendix P

Teacher Survey Questions

1 = Strongly Disagree2 = Disagree3 = Not Sure4 = Agree5 = Strongly Agree

1. I am confident in my teaching abilities.1 2 3 4 5 Explain.

2. I am confident about the teaching strategies being used.1 2 3 4 5
Explain.

3. I enjoy teaching.1 2 3 4 5
Explain.

4. I am motivated to come to school every day. 1 2 3 4 5
Explain.

5. I am motivated to become a better teacher.1 2 3 4 5
Explain.

6. How does my motivation affect my students? Explain.

7. (Postintervention only) The 5E learning cycle had a positive affect on me as a teacher.

1 2 3 4 5

Explain.

APPENDIX Q

COLLEAGE OBSERVATION PROMPTS

Appendix Q

Colleague Observation Prompt

What phase of the class_____, date and phase of project_____

1. What changes have you noticed about Kevin since he started this project?
   EXPLAIN.

2. What changes have you noticed about students in science since Kevin started this project?
   Explain.

3. Kevin was engaged with the students.1 2 3 4 5
   Explain.

4. Students were engaged with the coursework. 1 2 3 4 5
   Explain.

5. Kevin was highly motivated.1 2 3 4 5
   Explain.

6. Has anything changed about Kevin's motivation?
   Explain.

7. Anything else?

APPENDIX R

JOURNAL REFLECTION PROMPTS

Appendix R
Journal Reflection Prompts

Journal Reflection Prompts:

1. How did this week go for you?
   Explain.

2. How did this week go for your students?
   Explain.

3. What observations did you make from students this week?
   Explain.

4. What information could be gathered from this week?
   Explain.

5. What ideas are you having about your work with students this week?
   Explain.

6. (During intervention units only) How do you currently feel about the 5E learning cycle?
   Explain.

APPENDIX S

PROJECT TIMELINE

Project Timeline

January 7- **DNA and Protein Synthesis Non**intervention **preunit Assessment.**
Started nonintervention **preunit interviews.**
January 8- Progress Monitoring
January 9- Progress Monitoring
January 10- Progress Monitoring
1st Observation by colleague
January 11- Progress Monitoring
Weekly Journal
January 14- Progress Monitoring
January 15- Progress Monitoring
January 16- Progress Monitoring
January 17- Progress Monitoring
Collect Nonintervention **student surveys**
January 18- **Last day for non**intervention **postunit assessment.**
Started nonintervention **postunit interviews.**
Weekly Journal
January 22- **DNA Replication and Cell Cycle** Intervention **Unit 1 preunit assessment.**
Started Intervention **Unit 1 preunit interviews.**
Intervention **Unit 1 preunit surveys.**
January 23- Progress Monitoring
January 24- Progress Monitoring
January 25- Progress Monitoring
Weekly Journal
January 28- Progress Monitoring
January 29- Progress Monitoring
January 30- Progress Monitoring
2nd Observation by colleague
January 31- Progress Monitoring
Weekly Journal
February 4- Progress Monitoring
February 5- **Last day for DNA Replication and Cell Cycle** Intervention **Unit 1 postunit assessment.**
Started Intervention **Unit 1 postunit interviews.**
Collect Intervention **Unit 1 student surveys**
February 6- **Evolution and Genetics** Intervention **Unit 2 preunit assessment.**
Started Intervention **Unit 2 preunit interviews.**
Treatement Unit 2 preunit surveys

February 7- Progress Monitoring
February 8- Progress Monitoring
Weekly Journal
February 11- Progress Monitoring
February 12- Progress Monitoring
February 13- Progress Monitoring
February 14- Progress Monitoring
February 15- Progress Monitoring
3rd Obersvation by colleague
Weekly Journal
February 19- Progress Monitoring
February 20- **Last day for Evolution and Genetics** Intervention **Unit 2 postunit assessment.**
Started Intervention **Unit 2 postunit interviews.**
Collect Intervention **Unit 2 student surveys.**
Weekly Journal

Progress Monitoring is used as a tool to touch base with each student and to understand that students goals and timeline. Because each student works independently and at their own pace, progress monitoring will be used to determine when postunit data collection instruments will be used.