EFFECTS OF CHALLENGE BASED LEARNING ON STUDENT MOTIVATION AND ACHIEVEMENT

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

High school freshmen Physical Science students participated in a challenge based learning (CBL) project to assess the effect of this teaching style on student motivation and achievement. The students were tasked with design and completion of an environmental project that would benefit our community. Three units were taught during the treatment, and in addition, students spent 50% of of each class working on their projects. My results indicated CBL did increase the motivation of students and maintained achievement even though the students spent half as much time on the normal curriculum for the freshmen Physical Sciences class.

INTRODUCTION

Project-Based Learning (PBL) has been of interest to me because as a student I struggled in a traditional setting and PBL is how I would have preferred to learn. At a training session provided by Apple Inc. when our school became a one to one school with Mac Books, the presenter talked about their version of project based learning which they call Challenge-Based Learning (CBL), where CBL attempts to make connections between real world activities and the content students learn in the classroom. This research project focused on the implementation of the CBL method in my biology classroom.

I teach Biology at Watertown High School which is located in Watertown, northeastern South Dakota. The city of Watertown has over 21,000 people, and the high school has 1200 students in grades 9 through 12. The majority of our students are Caucasian with 2% Hispanic and 3% Native American. There is usually an average of 30% of students every year on free or reduced lunch. Watertown has an agriculture-based economy and has a two-year technical school. The Watertown High School uses a 4 x 4 block schedule in which classes run for 90 minutes every day. A one credit class will run for one semester. I teach biology which is a one credit class and I get new students each semester.

The participants of this study were my biology students at Watertown High School during the 2012-2013 academic year. The treatment was performed on one freshmen biology class with 19 students. A second freshmen biology class was used as a comparison and had 23 students. In the treatment class one student was Hispanic and

the rest were white/non-Hispanic. In the non-treatment class there were three Native American students and one Hispanic student.

One of the main issues I see with my students is the lack of motivation. The students are very apathetic, and because of this, they do not perform as well as they should. The lack of motivation is attributed to different factors, including, but not limited to previous experiences, parental support, disconnect from the content, or a desire to drop out, of which some are out of the teacher's control. Several studies have proven that there is a possitive relationship between student motivation and performance (Benware & Deci, 1984; gottfried, 1981; Grolnick & Ryan, 1987; Perlumutter & Monty) One of the factors affecting motivation that I can control is my teaching method. I believe I can increase student motivation through my teaching strategies, and greater student motivation will lead to higher student achievement.

The primary focus of this research study was to assess whether Challenge-Based Learning could increase student motivation and achievement in a high school biology classroom. I also looked specifically at whether or not implementation of CBL would allow the students to impact the local community. The questions I focused on were:

1.Will a challenge based project increase student motivation?

2.Will a challenge based project increase student achievement?

3.Will the students be able make an impact with their projects?

CONCEPTUAL FRAMEWORK

Since there is very little formal research on CBL itself, and given that it is a modified project-based learning (PBL) approach, this conceptual framework focuses mainly on the theoretical background of the latter. I found no formal research on CBL

but there are examples CBL projects. In PBL, or CBL for that matter, you are trying to build on the students' prior knowledge. With that in mind, it is important first to define constructivism and then present how PBL fits into the constructivist theory. I then discuss the type of positive impact PBL could have on my students' academic performance and the characteristics that make CBL unique from PBL.

Project-based learning (PBL) is an instructional strategy that is based on giving the students a guiding question and allowing the students to engage in the content through a project. A project is defined as authentic activity that engages the student who then directs their learning and creates artifacts to demonstrate knowledge gained (Knoll, 1997). PBL is based in the constructivist theory and is centered around John Dewey's "learning by doing." Constructivist theory says that learning is done by constructing, creating, inventing, and developing our knowledge (Marlowe & Page, 1998). PBL is a way for students to build their knowledge through a specific task rather by than passively receiving the information from the teacher.

What we learn and how we learn it is based on several factors which include content, context, activities, and the goals of the learner (Savery, 1996). Constructivists believe in the active building of knowledge. You do not gain deep understanding through imitation or repetition but rather learn by actively doing (Kroll, 1996). PBL allows students to connect and give meaning to learning by building on their past experiences (Westwood, 2006). This is a constructivist idea of scaffolding which is building on a students' prior knowledge. Dewey (1938) determined that it is the learners' prior experiences that understanding is built upon. PBL is student centered, meaning the

students direct their own learning, build upon what they all ready know, and the learning process is different for every student.

Lebow (1993) described the core constructivist values which match up very closely to the 21st century skills that our school uses: “the seven primary constructivist values of collaboration, personal autonomy, generatively, reflectivity, active engagement, personal relevance, and pluralism”. These values are an essential part of a CBL based teaching strategy. Apple (2010) states that their CBL is “a collaborative learning experience in which teachers and students work together to learn about compelling issues” and “students reflect on their learning and the impact of their actions.” Within a CBL lesson students create and present a group project focused as much on collaboration as on personal autonomy.

Moursund (1999) described the main characteristics of a project-based learning lesson as follows:

1. It is learner-centered and intrinsically motivating.
2. It encourages collaboration and cooperative learning.
3. It requires students to produce a product, presentation, or performance.
4. It allows students to make incremental and continual improvement in their product, presentation, or performance.
5. It is designed so that students are actively engaged in “doing” things rather than in” learning about” something.
6. It is challenging, focusing on higher-order skills.

Fosnot (1996) provided some guidelines for creating a PBL lesson:

1. Learners need to create their own questions, which allows for them to create and test their own hypothesis.
2. The project needs to be challenging, open-ended, and realistic.
3. Reflection through journals and discussions should be used to help the students learn.
4. The classroom should be seen as a "community of discourse engaged in activity, reflection and conversations."
5. The learner presents their learning to the community.

There is research in Kanter's study (2010) that links project-based learning (PBL) with increased meaningful learning. In one study, students who were given a PBL project, meaningful learning was increased by 62%. In this research study 652 students were given a project that was designed in three units and assessed at the end. Kanter's assessment was based on Bloom's Taxonomy with major gains in lower level knowledge and gains in meaningful understanding. Kanter makes the statement that PBL can be designed in such a way that students can do the performance but at the same time develop a meaningful understanding of the related science content. In another study comparing students that are taught in a normal classroom to students who are taught at a project-based school, a higher percentage of students passed a national test at the project-based school (Boaler, 1998).

PBL promotes meaningful learning where students have increased enthusiasm and motivation (Westwood, 2006). This connection between motivation and real world activity was connected by Curtis (2002) when he compared PBL to projects that are carried out in the business world. A study of 126 teachers and 631 students found that

PBL increased student and teacher motivation (Lam, 2009). The students ranked their motivation level at 4.06 out of 6 (6 being strongly agree that it increased their motivation). Teachers said that their intrinsic motivation improved as well with PBL; the teachers scored their motivation at a 3.99 on the same scale. PBL is a way to give them lessons that are more relevant, challenging and have a purpose (Bridgeland, 2006)

I researched project-based learning because challenge-based learning is basically project-based learning with some special characteristics. Apple created their classroom guide for teachers to give them some tips on implementing a CBL. According to their guide (Apple, 2010), CBL is"a new approach to teaching and learning called Challenge-Based Learning, an engaging, multidisciplinary approach that starts with standards- based content and lets students leverage the technology they use in their daily lives to solve complex, real-world problems. Challenge-Based Learning is collaborative and hands on, asking students to work with other students, their teachers, and experts in their communities and around the world to develop deeper knowledge of the subjects they are studying, identify and solve challenges, make a difference in their community, and share their results with the worldwide audience. (pg. 3)" The real difference between PBL and CBL is CBL's push for investigating real world problems, such as improving the use of sustainable resources.

METHODOLOGY

This study treatment for my research was carried out in one of my freshmen biology classes and a second freshmen biology class was used as a comparison group. The students started their projects over a period of nine weeks beginning in February and ending in March

2013. The Units taught during this time were Ecology, Classification, and Evolution. The focus of the treatment was on the effects of CBL on student motivation and achievement.

First, within the treatment group, students established their CBL learning groups before the start of the treatment. Learning groups of 2-5 students were created and each group selected their own topic. I followed the CBL implementation process outlined in Apple's CBL Teacher Planning Guide (p.5, 2010). The CBL Timeline Template on page 21 in the CBL Classroom Guide (Appendix I) was used to set objectives for the CBL. The nine week treatment was broken down into three sections. The first section involved student research for the project and writing a proposal, all of which lasted two weeks. The students selected a challenge and then they submitted a challenge proposal in the form of a short video that highlighted their goals and invited others to join them. From their challenge the students made a list of guiding questions.

Next came the execution of the project, which lasted for six weeks. During this second phase, students used answers from the guiding questions to find the solution to their challenge. The students had to plan their project, collaborate with community members, and complete their projects.

The final phase of the treatment was an evaluation. The students had to present what they had accomplished and learned during their CBL project. The goal of the CBL was to provide a connection between the content in the class and a real world project that they worked on. The key properties of the challenges were that they needed to be something measurable and attainable.

I teach in a school that uses a 4 x 4 block schedule and each day we spent on average 30 minutes on the CBL project. To hold the students accountable for their parts of the project they filled out the Group Challenge Guide (Appendix J). This helped

define the roles of the individual students within their CBL group. The 19 students were broken up into 6 self-selected groups. The challenge that was presented was to make an impact on their local environment. The triangulation matrix used to assess the impact of this teaching strategy is located in table 1.

Each of the six groups of students selected a different challenge project based on their interest. One of the groups decided to work on learning more about biodiversity. So they chose a challenge of working with a class or expert and exchanging information about local biodiversity. Another wanted to raise awareness of a local raptor rehab program. Two groups choose to work on different recycling programs. Of the remaining two groups one chose to raise awareness on local invasive species while the other wanted to lower electrical usage in a local business.

To assess the CBL's ability to increase student motivation, I used three data collection tools. First both classes took a student motivation survey (Appendix A) on their current motivation level. This was before the treatment and after the treatment. The second data collection tool I used was an interview at the end of the treatment. Seven random students were interviewed about the effects of the CBL on their motivation. They were selected randomly by a randomly drawn number. A CBL specific survey was used as the last data collection tool and was administered to all 19 students in the treatment class.

To assess the impact of the CBL on the students' achievement I used a pre-test and post-test that were given for each unit. I used the same pre- and post-test on the non-treatment group. The students were surveyed on the effects of the CBL on their

achievement. The third data source was a comparison of a pre-unit assessment that the treatment class completed.

I wanted to assess the student's perception about their ability to make a difference and see if the students would be able to follow through and complete their projects, and allow them to make a difference in the community. To accomplish this goal, at the start of the CBL treatment, I gave the students an impact survey (Appendix C) as well as surveyed students again at the end of the treatment. The survey consisted of a few questions that were given on a Google form (Appendix D). Every person that the students worked with outside of the classroom received an electronic survey to fill out during the treatment (Appendix E).

"This study was reviewed and approved by the Montana State University Institutional Review Board for research involving human participants. Students and their parents provided informed consent to participating in this study."

Table 1
Data Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3
Primary Question: 1. Will CBL increase student motivation?	Student Surveys	Student Interviews	Treatment vs Non treatment comparison survey
Secondary Questions: 2. Will CBL increase student achievement?	Pre-Post Test with comparison to non-treatment class	Student Surveys	Achievement comparison to pre-treatment unit.
3. Will student be able to make an impact with an environmental issue?	Student Interviews	Student Surveys	Survey community assistance people. (People who the students work with that were not affiliated with the students classroom.)

DATA ANALYSIS

Data was collected from two different classes. One 9th grade biology class received the treatment of a nine week CBL project in addition to normal instruction. The other 9th grade biology class received only my normal instructional strategies. The data was used to determine if the CBL project improved student motivation and achievement.

Motivation

To determine if the CBL project had an effect on the student motivation I surveyed the treatment and non-treatment classes, interviewed the treatment students, and did a CBL specific survey of the treatment students which can be found in the Appendices. The student motivation survey was given to the treatment class at the start and at the end of the treatment. The non-treatment class was only surveyed at the same time the treatment class took their post survey to have had more time in class to evaluate. To evaluate their motivation I wanted to look at how

they perceived the class and what their attitudes were towards course work. Figure 1 shows the average scores for all three surveys. The scores were averaged and used for comparisons.

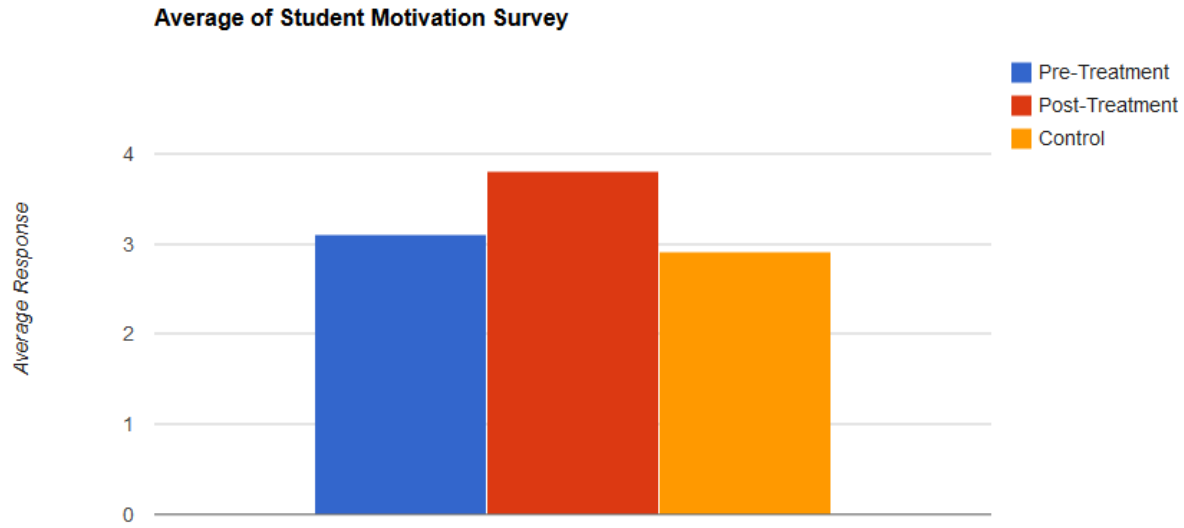

Figure 1. Student motivation survey pre and post-treatment (*N*=19) non-treatment (*N*=23). Scale 1-5 1 Strongly Disagree, 2 Disagree, 3 Neutral, 4 Agree, 5 Strongly Agree

The pretreatment scores on the motivation survey were higher than the non-treatment class but I believe this was caused by the anticipation of the CBL project. The students started selecting projects at the start of the course and started the CBL three weeks later. The post-treatment scores were all higher than the pre-treatment and the non-treatment surveys. Statement one was, "In general the course work is useful to me." I wanted to see if the CBL would increase their implied application of the course work. The results in Figures 2 show that there was a difference between the three surveys and the student interest in the class topics. Post-treatment averaged a 3.7, compared to 2.9 and 2.8 for the pre-treatment and non-treatments respectively (Fig. 2).

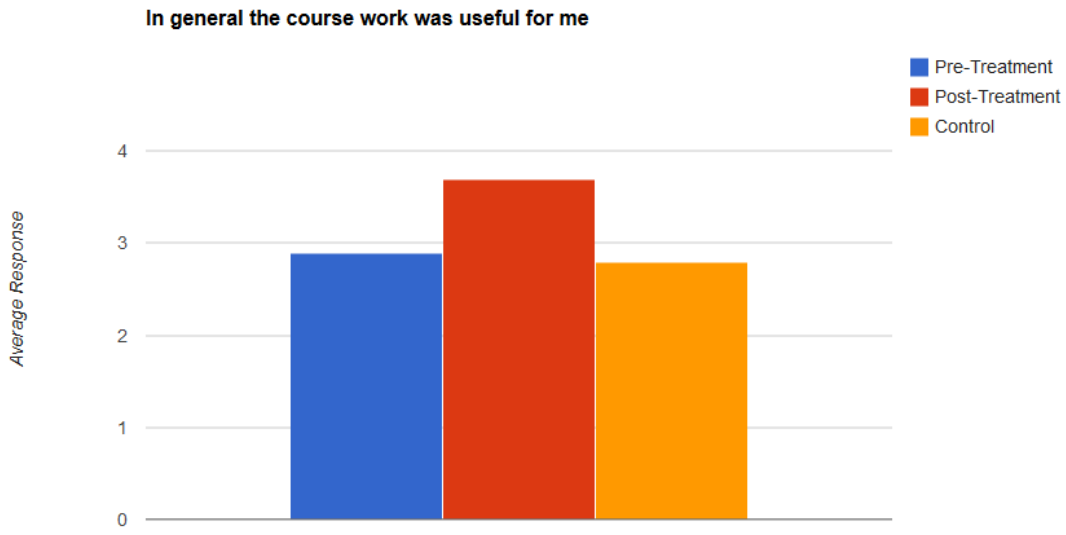

Figure 2. Student motivation survey pre and post-treatment (*N*=19) non-treatment (*N*=23). Scale 1-5 1 Strongly Disagree, 2 Disagree, 3 Neutral, 4 Agree, 5 Strongly Agree

There were similar results on the statement, “The knowledge I gained in this course is important for my future.” In comparing the pre and post surveys on this statement (Figure 3.), I observed a definite change in response. I believe this was caused by the multiple discussions throughout the treatment of real world skills. When students would have to call different companies, or have to collaborate and work on the project outside of class, we would discuss when they would use these skills. Those skills were mentioned multiple times in their interviews.

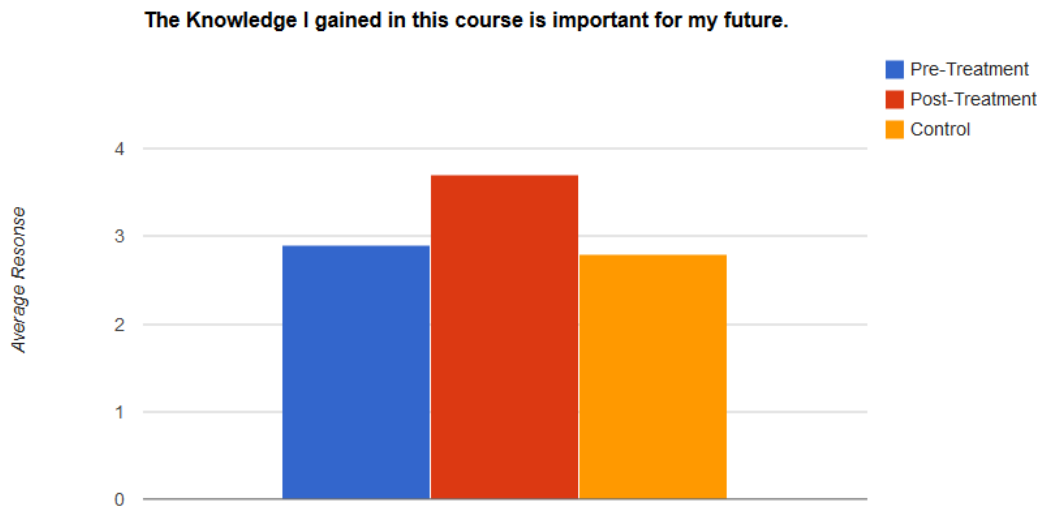

Figure 3. Student motivation survey pretreatment and post-treatment responses (*N*=19) non-treatment (*N*=23). Scale 1-5 1 Strongly Disagree, 2 Disagree, 3 Neutral, 4 Agree, 5 Strongly Agree

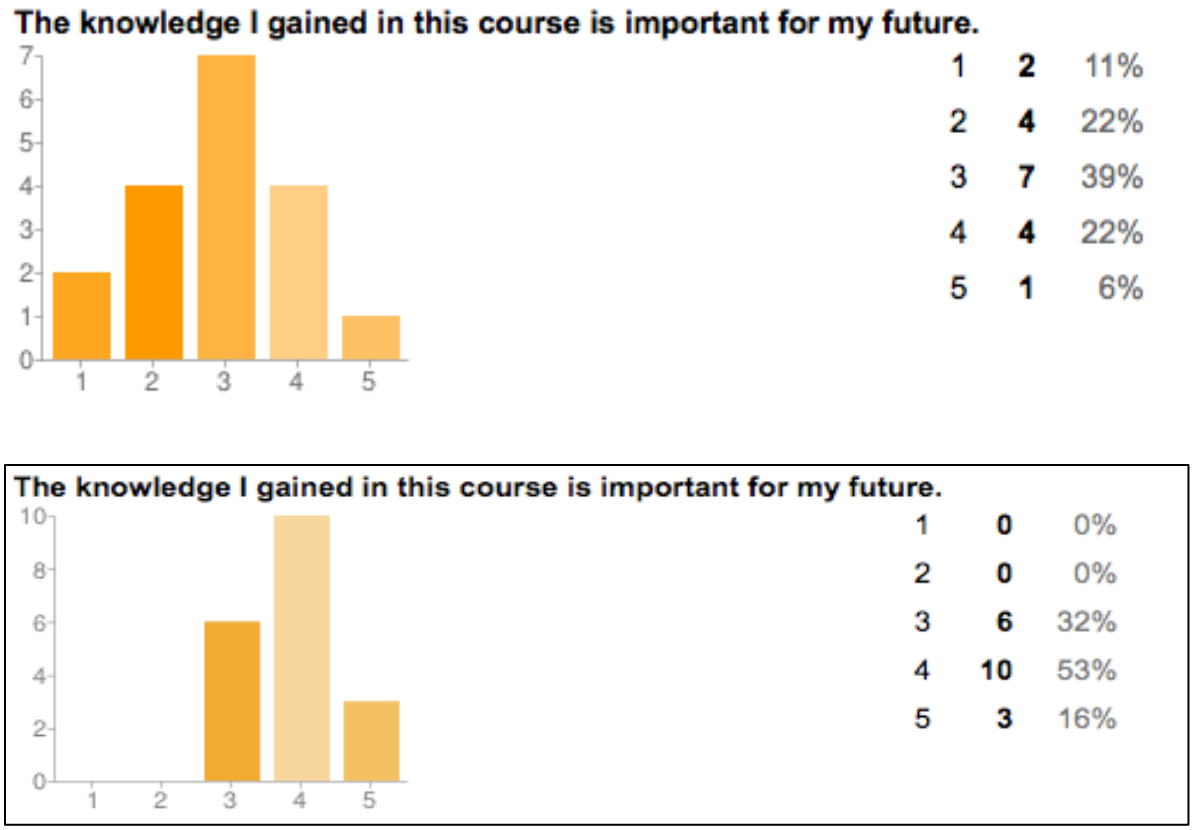

Figure 4. A Post-treatment B. Pre-treatment
1 Strongly Disagree, 2 Disagree, 3 Neutral, 4 Agree, 5 Strongly Agree

When directly asked about their motivation and how they wanted to do in class Figure 5 shows a difference as well. When looking at the specific number of students who selected each answer there were six students from the non-treatment class that strongly agreed with the statement they felt connected to their work and wanted to do their best in class (Figure 5.) However, there were 28% of the students that disagreed and did not feel connected and did not want to do well in class. Not a single treatment student selected a disagreement answer for that statement.

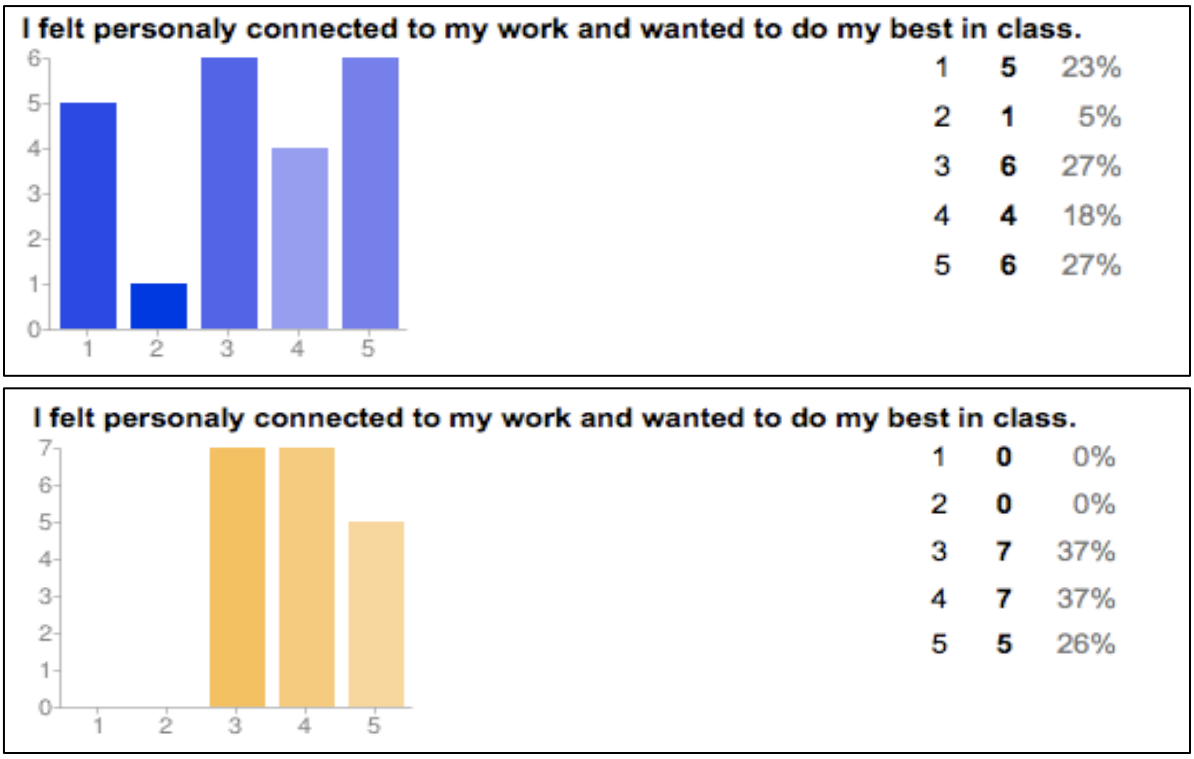

Figure 5. Control A vs Post-treatment responses B 1 Strongly Disagree, 2 Disagree, 3 Neutral, 4 Agree, 5 Strongly Agree

Of the students who were interviewed at the end of the treatment, 5 of the 9 students all said that they felt more motivated by the CBL project. One student said, “I did not want to let my group members down.” So, they felt the peer pressure to do a good job such as one student saying “I felt like I had a bigger role to play than on my own. I felt like it was a great motivator

to get my things done in the group." Another student said, "It was different, I was interested in what we were working on." Of the two that I interviewed that said they did not feel like the CBL motivated them; one said that they just were not motivated by the CBL while the other saw the CBL as a distraction from the normal course work. Two other students said the CBL had no impact on their motivation level.

I asked the students to describe what specifically about the CBL improved their motivation. Some of the students liked the fact that they were encouraged to work in groups and to extend themselves into the community. I felt like the external application of working with experts outside the classroom was a very rewarding experience for the groups that were able to connect with those individuals. The biggest reason that students found the CBL non-motivating was because of the time commitment. They found the CBL work engaging but they could not get everything done in class "I did enjoy it (CBL) I just feel like it was was a lot of work to get done on top of our regular biology." The classes were set up to have the students work on their regular biology work and once they were finished they would have time for their projects. If they were a slower worker or distracted they would not get as much time for either their biology work or their CBL work. I can understand their frustration with this but I tried to make it so that if they worked hard they would get everything done.

In addition to the interviews, I also surveyed the students at the end of the treatment and asked them how the CBL changed their motivation. In Figure 6 you can see the results. These questions, asked to all 19 treatment students, were averaged to show the group's scores. These scores are similar to the interview results. I found that it was interesting that 7 out of 9 that were interviewed would have scored a 3 or above on the first question of the survey but the class only averaged 3.2 on the scale, which is basically neutral or that the CBL had no impact on their

motivation. I believe there was a disconnect between what actually happened and the student perception. When looking at the other data used to triangulate these results, I would say that the students were not fully aware of the impacts that the CBL was having on them. In the interviews they would explain why they were motivated and why they cared, but when asked in a survey, they put different responses. I also noted that the CBL was only effective in my class and they did not transfer it from my class to another based on the interview responses.

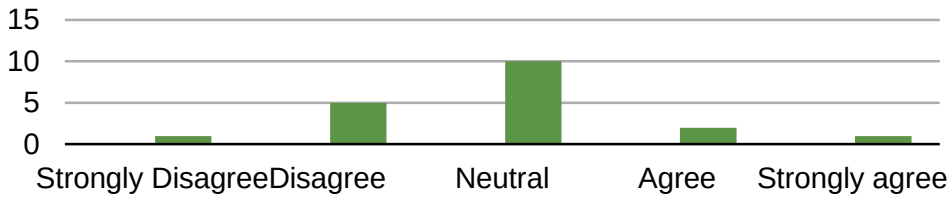

Figure 6. Post-treatment survey, (*N*=19).
1 Strongly Disagree, 2 Disagree, 3 Neutral, 4 Agree, 5 Strongly Agree

Achievement

The Second research question investigated the impact of the CBL project on student achievement. To answer this question I administered pre and post tests for the three units during the treatment time frame to both the treatment and non-treatment classes. I surveyed the students at the end of the treatment to find out their take on how the CBL helped them in the biology class. For my third assessment of the CBL's effect on student achievement I compared the treatment assessments to an assessment taken before the treatment.

The pre and post tests were given for three different units Ecology, Classification, and Evolution. In Figure 7 it compares the treatment class to the non-treatment class. All of these assessments were done during the treatment.

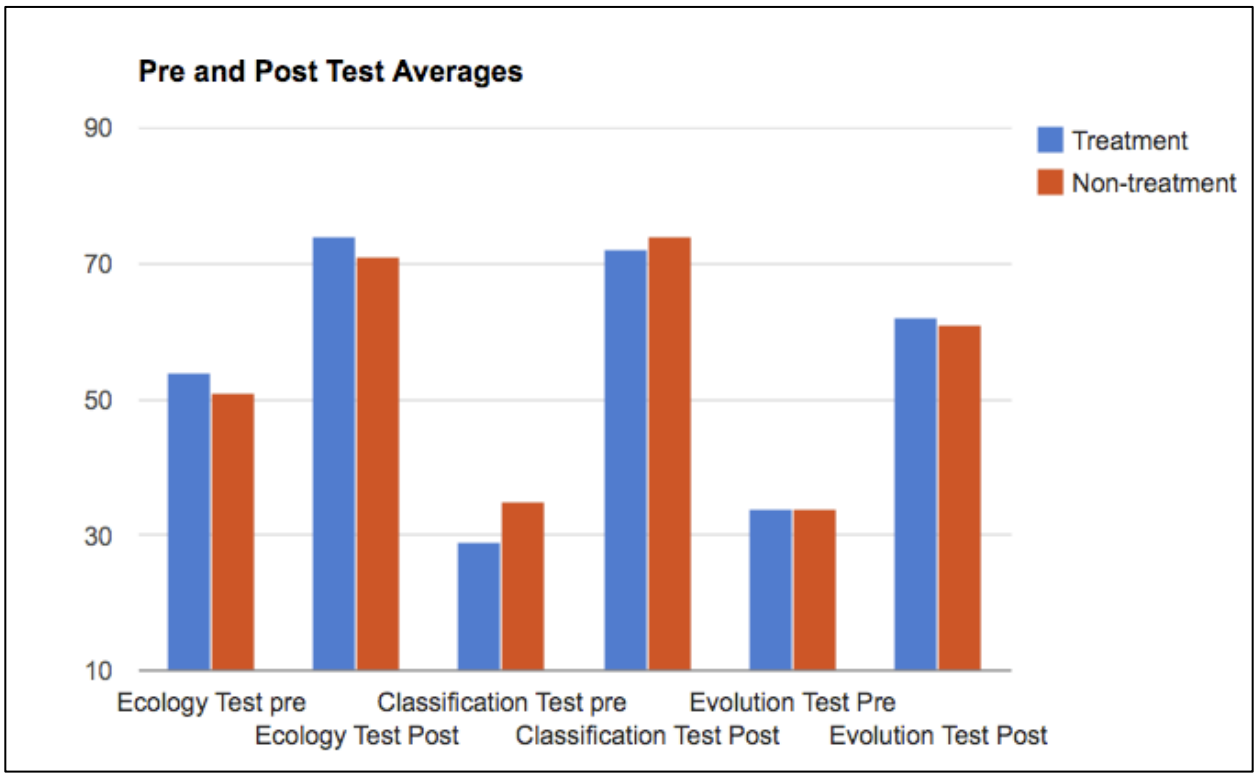

Figure 7. Treatment (*N*=19), non-treatment (*N*=23), ecology post test has a SD treatment 14.3 non-treatment 15.8, classification post test has a SD of 13.6 treatment and 15.6 non treatment, and the evolution test has a SD of 9.8 for treatment and 16.6 for the non treatment.

The analysis of the post test revealed there was not a significant change in student achievement. There is not a significant difference between the treatment and non-treatment assessments. The percent change is also very similar. In Figure 8 the percent change for each test revealed that they were very similar between the two classes with the classification text being the only test that has a different percent gain.

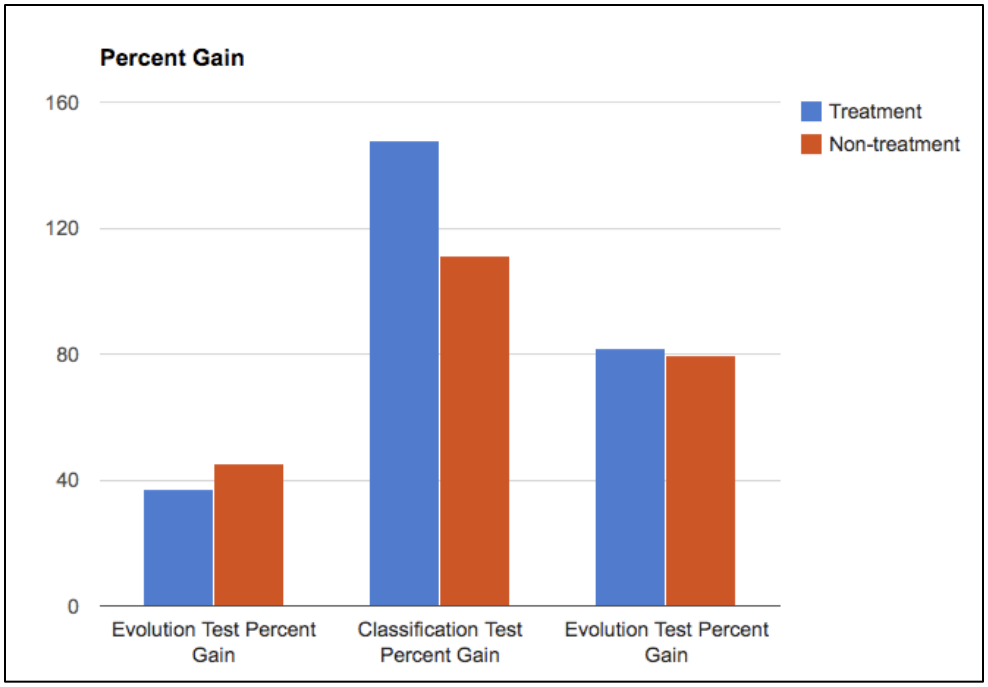

Figure 8. Percent gain for Treatment and Non-treatment.

One important aspect to keep in mind is that the student test scores for the treatment groups were based on half the traditional exposure to content versus the non-treatment group, and yet achievement scores were quite similar overall (Fig. 8). There are some possible explanations for this; the activities I had the non-treatment students working on may not have been beneficial or the students in the treatment group were more focused and retained the information in less time. When surveyed the students were almost 50/50 on whether or not they thought they learned more because of the CBL project. In Figure 9 you can see their responses to their post treatment achievement survey.

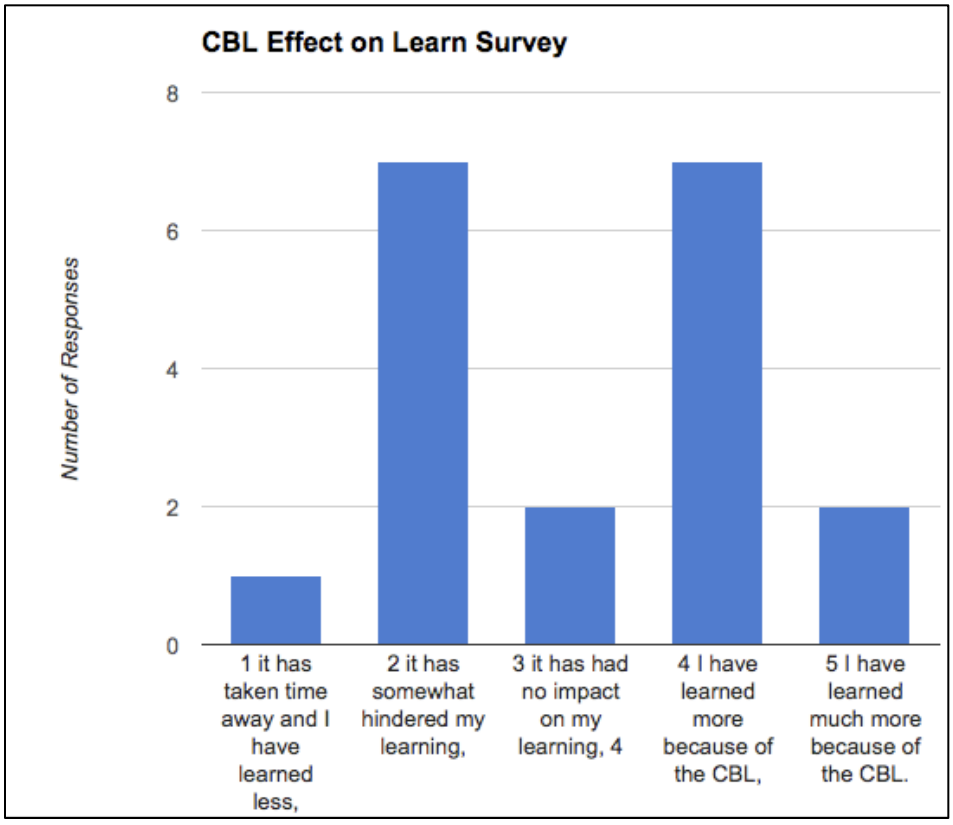

Figure 9. Student Achievement Survey Appendix B.

Again we see that many students perceived that they learned less from the CBL approach, but the assessment results were similar to those of the non-treatment group.

The final assessment tool was using a pretreatment assessment to compare against the assessments during the treatment. The scores were fairly close with the students scoring higher on the treatment assessments but a larger percent gain in the pre-treatment assessment. The pretreatment test was over macromolecules. The treatment test were over ecology, classification, and evolution. Figure 10 shows the average treatment scores to the pre-treatment assessment. When looking at the figure you see that there is a slight improvement in the treatment scores but it is not a significant change. The percent gain was lower in the treatment scores than the pre-treatment scores but I wonder if this was just a consequence of a single test that had a large percent gain. This is because the largest percent gain was the classification test. There results were inconsistent on the percent gain but I believe that is caused by the variance in the prior knowledge of the students and what they had learned in previous classes.

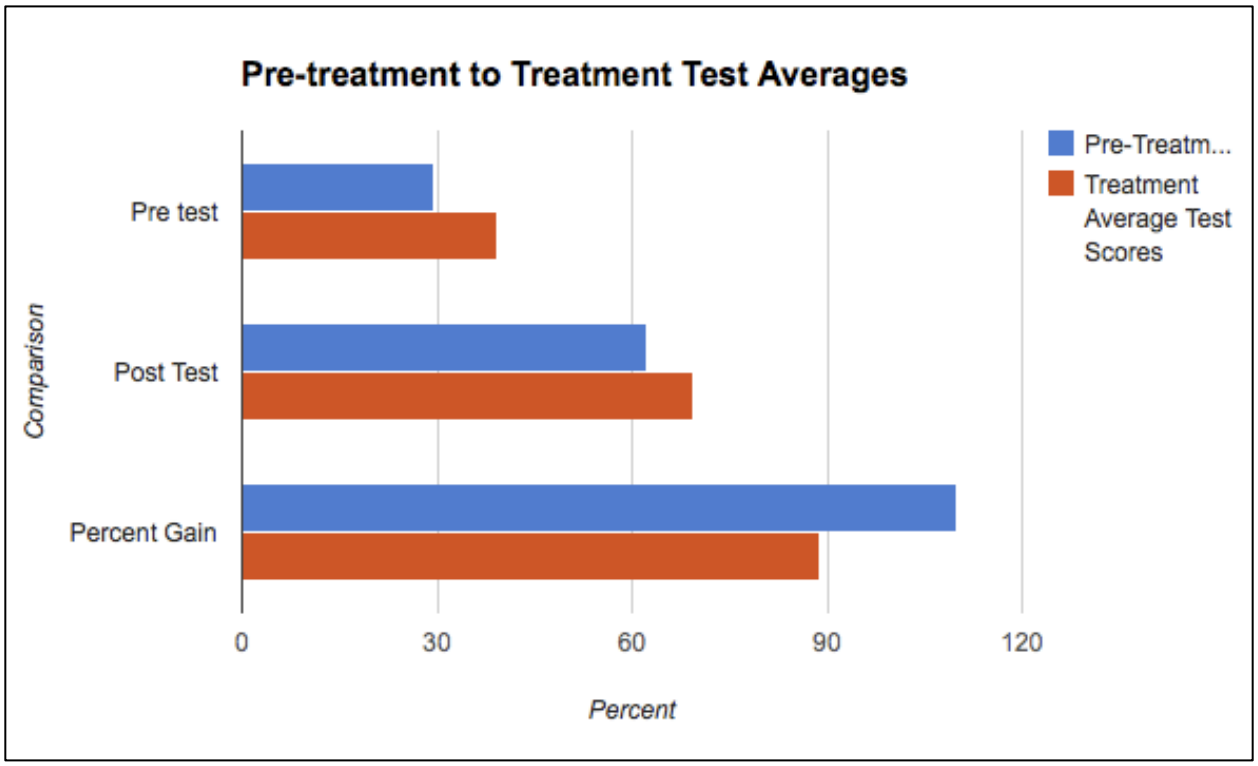

Figure 10. Treatment class comparison of non treatment assessment vs treatment assessments.

Student Impact

My final question was to assess whether or not students could make a difference and complete their challenge. The three ways that I assessed this question were student interviews, post-treatment survey, and a survey filled out by the people who assisted the students. We encountered a variety of problems and not all of the groups were able to complete the challenge in the given time period. The largest problem we faced was the time constraint, so we changed the question to focus on the potential to accomplish their goal rather than what they actually accomplished in the time frame. To adjust for the fact that we were constrained by time on the project I asked what they thought the opportunities were to make a difference in the survey. Although some groups ran into issues with response times and others seemed to not believe that the students were working on actual projects the vast majority of the students had extremely positive experiences working together with members of the community. I sent the students a link to a survey and every time they worked with an adult outside the classroom they needed to send them a link and instruct them to please fill out this survey. We did run into troubles getting the survey returned from some of the people. Figure 11 has the results of the survey given to the adult contacts.

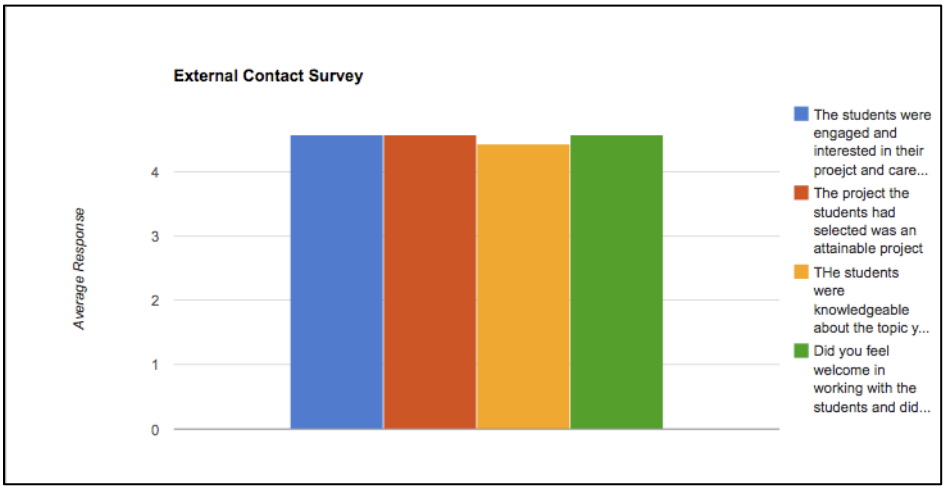

Figure 11. The average response for the external contact survey, (*N*=7). For each statement they were asked if they: 1 Strongly Disagree, 2 Disagree, 3 Neutral, 4 Agree, 5 Strongly Agree

All of the external contacts answered with either an agree or strongly agree for all of the statements. All of the external contacts also said that they would be willing to help in the future. I felt like this reinforces the fact that although we do not always take advantage of the experts within our communities, the community is always happy to assist in the education of our students. The people who responded all thought the students could accomplish their goals that they had set out to accomplish.

The treatment class was given a CBL impact survey at the end of the treatment to evaluate their views of what they accomplished and if they found the CBL project worth while. The results showed that the students on average thought that they either could or had the potential to make a difference on the task that they had set out to accomplish. The responses for the survey were fairly consistent. The students were ask a series of statements and they had to choose which most fit their opinion from strongly disagree to strongly agree. Figure 12 shows the average response for each question.

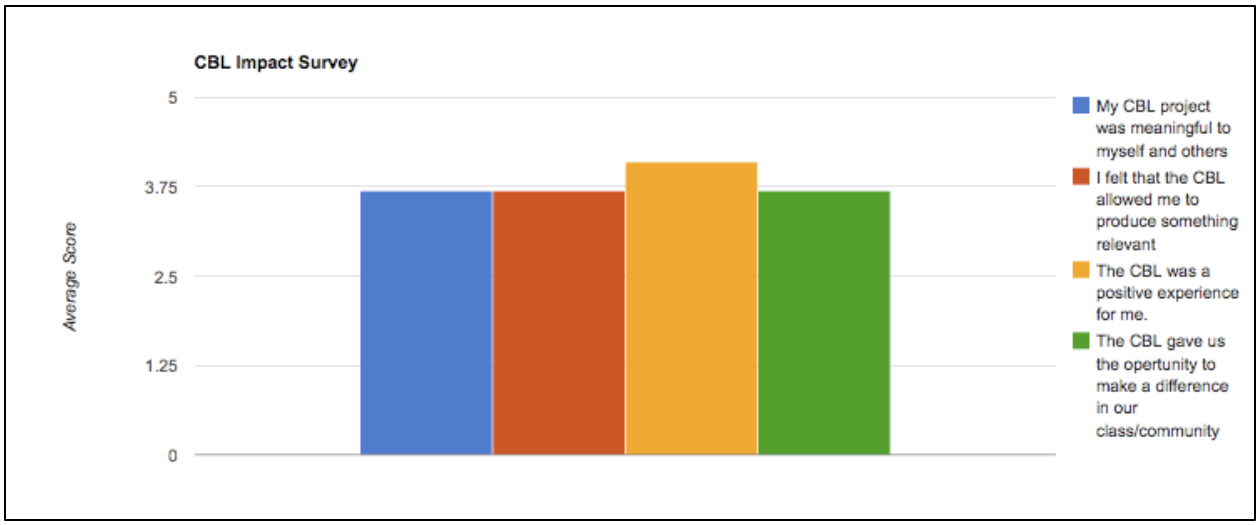

Figure 12. The average response for the CBL impact survey, (*N*=19). For each statement they were asked if they: 1 Strongly Disagree, 2 Disagree, 3 Neutral, 4 Agree, 5 Strongly Agree

Figure 12 shows the responses for each statement. The first point that stuck out from the CBL impact survey and had a higher average than the other statements was the statement the CBL was a positive experience for me. The majority of the students agree with that statement. 79% of the students either strongly agree or agree with that statement while only 10% disagree with that statement.

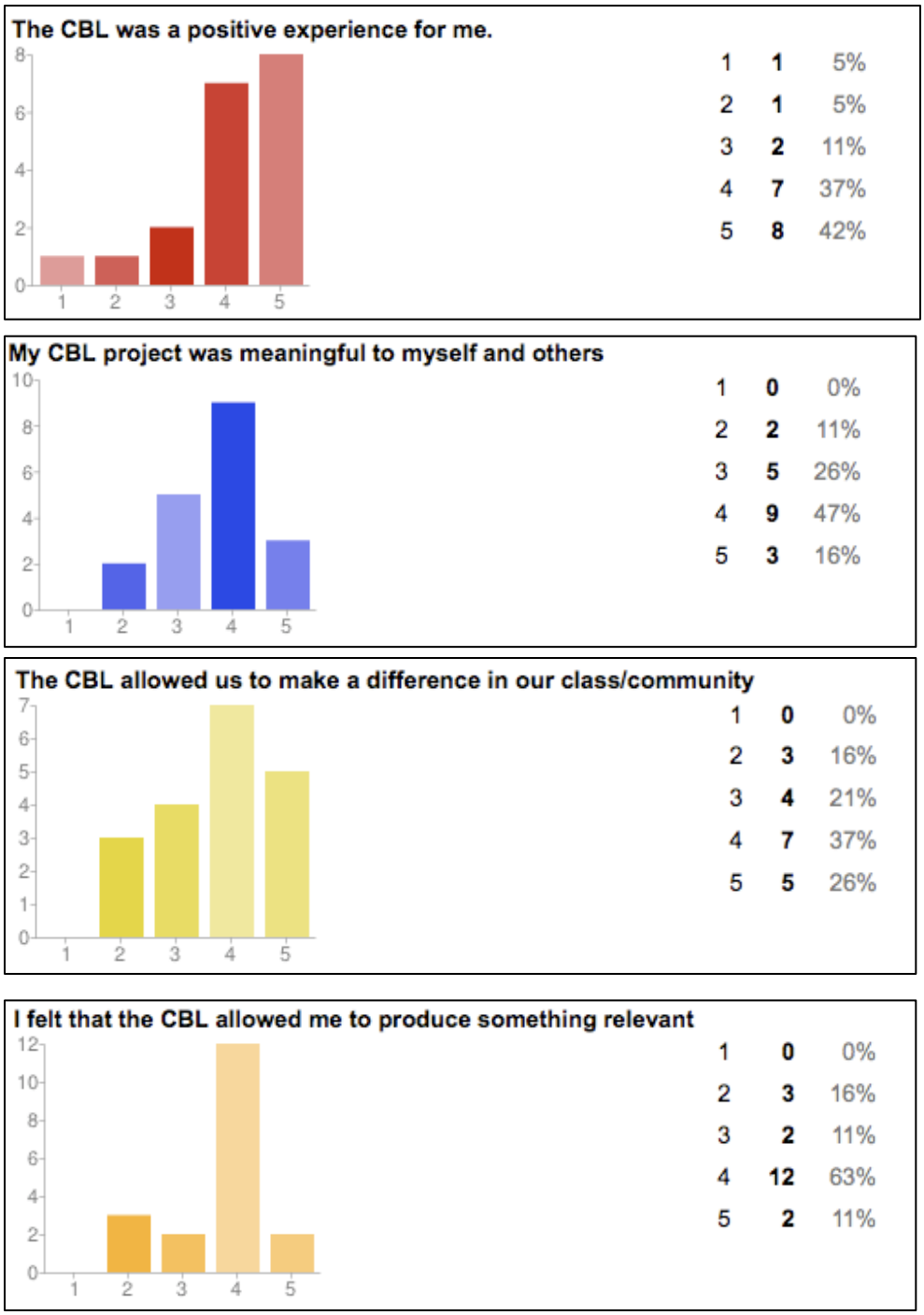

Figure 13 CBL impact survey Statements, (N=19) They were asked if they: 1 Strongly Disagree, 2 Disagree, 3 Neutral, 4 Agree, 5 Strongly Agree

When asked if they were able to make something relevant in the CBL project 75% of the students agreed with that statement (Figure 13). Sixty-three % of the students thought that the CBL allowed them to make a difference in their community (Figure 13). This number is a little lower, although there were 21% that were neutral on that question, because of some of the issues that we ran into throughout the treatment. Most notably students became frustrated waiting for responses from our external contacts to allow the students to move on to the next step.

When interviewed the students gave a variety of answers evaluating their impact on the community. One student thought they made a major impact based on the number of individuals that heard their radio interview. There project was to raise awareness about the Raptor Rehab Program at the Bramble Park Zoo. The students met with an animal care taker and interviewed him about the raptor rehab program. After they gathered their information they arranged a time to go on the radio. They went on the What's Up Watertown morning show and the radio station interviewed them on Air, with the potential for thousands of listeners each morning. Another group worked on improving the number of people using our single stream recycle program in the city of Watertown. They were able to make flyers and get them out to different members of their communities. When interviewed one student stated "that they were excited to do something they felt worthwhile during class.

INTERPRETATION AND CONCLUSION

Even though the students and I ran into some problems, the CBL was a very enjoyable process. Some of the problems included lack of time, issues with contacts not returning emails or calls, and complication associated with working with group members. Throughout the project we talked about how these issues represent real world challenges in research and team building. I believe that part of the success of the project was based on the fact that it was easy to explain

why they need to know 21st century skills of communication, collaboration, technology skills, creativity, and critical thinking and why they were important.

The CBL project did improve the motivation of the students. In figure 2 there was an increase from 2.8 to 3.7 on the average score for the student motivation survey. I felt like they were more connected to the content and they cared more about how they did in class. The students really like coming to class and working on the project. They cared about how they did in class. I offered an extra credit review session before school during the treatment for all of my classes, one sophomore and two freshmen biology, and 9 of the 11 students that showed up for the review session were from my treatment class. The reasons the CBL improved their motivation based on interview responses included; the feeling of ownership in the project, being part of a team with other students relying on them, and that the project focal area was something relevant for their community. Based on the post-treatment survey, student achievement was not necessarily changed by the CBL project. In figure 5 I showed a comparison between the treatment and non-treatment scores, which were very similar for all three unit assessments. Figure 8 also shows that there was not much change during the treatment versus the pre-treatment assessment. However, I argue that student achievement, or at least student efficiency in studying, was increased by the CBL project because the students were able to achieve the same scores in half the time. They had to work more efficiently, and with more focus, to achieve the observed results in nearly one half the study time. It is also important to point out that the achievement instrument measured “traditional” content knowledge, so it could not measure if students had more depth of knowledge or developed more connections between concepts. There was also development of real world skills and additional learning throughout the CBL that could not be measured within the CBL achievement measures.

Although the students were not all able to reach all their goals they set out to make, the students were able to have the opportunity to make, or potential to have an impact in their community. The survey and interview results support the idea that they were able to accomplish their goals. Figure 11 shows that 74% of the students thought they could produce something relevant while 63% thought they could make a difference. The community members that the students worked with were all very supportive of the process and appreciated the work the students put into their various projects.

I learned from this that motivation is a critical part of the classroom. The CBL acted as a hook for most of the students. The CBL gave them some ownership in what we did everyday. The students mentioned in their interviews that the collaboration was a big reason they were motivated. Collaboration also has been shown to increase student's achievement. Knowledge accumulates as the students share their experiences and work together to find solutions to their CBLs (Bell et al. 2010). This also helped the students learn the content throughout their CBLs because the differences in perception between the students allowed them to work out their own understanding (Ching & Kafai, 2008). The result was that students were able to maintain their achievement levels even thought they were only doing traditional learning methods half of the time.

The combination between ownership and collaboration gave the students something to look forward to and I used that as a motivating factor to get them to work on their normal class work. I found that the students are willing to work hard if there is something they believe in that they can put their time and energy into. The normal daily grind creates a disconnect from what the students understand as reality and for the unmotivated or disconnected students in my class

they were able to create something that was meaningful, relevant, and for some they were able to accomplish their goal in a short period of time.

VALUE

Our teaching responsibilities in the Watertown School District classrooms extend far beyond the science curriculum standards. All teachers in the District have technology standards that are designed to be integrated into curriculum. We also need to focus on 21st century skills. Challenge Based Learning provided a way for me to engage the students in a real world projects in addition to the traditional science content.

As I discuss issues with other teachers at Watertown High School, one of the most common comments about the students is that they are often apathetic and lack motivation. In a world of instant feedback and information for multimedia sources students struggle in the classroom. The CBL did motivate the students in the classroom on the traditional classwork and provided them an opportunity to work on 21st century skills. The hurdles that students encountered during the treatment lead to other questions that would be interesting to further study. For example, I let the students choose their own groups, but how would random groups effect their motivation? Would a shorter class period extended over a semester or year effect how the students perceive the CBL project? Or, what about greater than 30 min sessions, so that students were not rushed? In the CBL survey some of the students thought that the CBL reduced from their learning and students stated that there was too much time during the class period spent on the CBL and not on the content.

I was hoping for evidence of increased student achievement. The students were able to maintain their achievement level even though their traditional classroom time was reduced almost half. The impact of the increase in motivation was that the students put forth more effort during their normal class time. The fact that the students had half the time had a significant

impact on the student achievement. If the students had more time they may have been able to raise their achievement scores. The students were able to maintain their achievement on the normal curriculum even though they were given half of the time. There were various things that the students learned out side of what I measured in the CBL assessments. In the interviews the students mentioned the real world skills that they developed as an important part of the process. If I were to reapply the treatment I would also put a survey together that would assess student development of 21st century skills. I also would attempt to asses the learning the students did outside of the current class content. The actual assessments also did not provide any feedback regarding the durability of the content. Would the students in the treatment retain more information than the students in the non-treatment class?

This project revealed that instructional strategies have a large impact on student motivation. As a new teacher directly out of college, I recall not realizing that you have a lot more to teach other than the content. This project really made me reflect on what is important in the classroom. Many of the skills I observed the students using I value as much as the content we do in class. To see 9th grade students develop, plan, perform, and evaluate a project completely designed by themselves is a constructive instructional outcome. One group researched a local program, lined up a meeting with an animal care taker, conducted an interview, established a time to be on the radio and took part in a radio show to raise awareness about our raptor rehab program at our local zoo. The skills required and developed were amazing to watch. The students worked on organizational skills, collaboration skills (there were some bumpy moments), and communication skills within the project and they also had to create several different technical pieces to go along with the project such as a two iMovies and a concept map on inspiration. These skills were just as important as the content learned in class.

The students enjoyed having something that was self directed. It was very frustrating at first for the students because they were not use to being in charge of their learning. In addition, I learned a lot about how to effectively administer the CBL project during this project. The application of the CBL does take time but one cannot condense it into a shorter time frame. What would have been more successful would have been a shorter amount of time each class period 15-20 min and completed over a longer time frame from a semester to all year.

I will take what I have learned during this project and set up all of my classes to run CBLs that run the entire length of the class. The ability to build relationships with the community and allowing community members to help educate the students provides amazing opportunities for learning. Using the evidence gathered during this process was very beneficial. To take the time and have evidence that what you do and how you do it has an affect on every student is very humbling. I think to how often I see teachers that are stuck in the same routine and never stop and reflect about how they can improve their instructional strategies. The CBL also allowed me to ask for student input in their learning. The students were eager to share their insights in how the project affected their learning. We as teachers can learn with and from our students. There were many times during the CBL treatment that a student would ask me a question and I would not know the answer. This allowed me to model life long learning and that we could learn together. Collaboration is a powerful tool. This helped build a relationship with the student has continued through the rest of the semester.

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APPENDICES

APPENDIX A

STUDENT MOTIVATION SURVEY

This will be put into a google form and completed by the students on their computer.

Please rate the 7 items below using the following scale 1 Strongly Disagree to 5 Strongly Agree.

7. _____ In general, the coursework was useful to me.
8. _____ The knowledge I gained in this course is important for my future.
9. _____ Throughout the course, I felt that I could be successful on the coursework.
10. _____ I enjoyed the instructional methods used in this course.
11. _____ The coursework was interesting to me.
12. _____ The instructor cared about how well I did in this course.
13. _____ I felt more motivated in class because of the CBL project

APPENDIX B

STUDENT ACHIEVEMENT SURVEY

Do you feel the addition of your CBL project has increased your ability to learn the material?

1 it has taken time away and I have learned less,
2 it has somewhat hindered my learning,
3 it has had no impact on my learning, 4
4 I have learned more because of the CBL,
5 I have learned much more because of the CBL.

APPENDIX C

CBL IMPACT SURVEY

Please fill out this form using this scale.
5 Strongly Agree, 4 agree, 3 Neutral, 2 Disagree, 1 Strongly Disagree

1. What I did in class/CBL was meaningful to myself and others
2. I felt that the CBL will/allowed me to produce something relevant
3. CBL will/was a positive experience for me.
4. The CBL will/did allow us to make a difference in our community

APPENDIX D

STUDENT INTERVIEW QUESTIONS

1.Did you feel like the CBL process was productive? (Why or Why not)
2.What is your overall evaluation of the CBL project?
3.Did you feel motivated in class because of the CBL project?
4. Did the CBL give you an opportunity to make a difference in the environment?

APPENDIX E

COMMUNITY MEMBER SURVEY

Will be sent through email as a google form.
Please rate these statements on a scale of 1-5
5 Strongly Agree, 4 agree, 3 Neutral, 2 Disagree, 1 Strongly Disagree

1.The students were engaged and helpful.
2.The students were able to assist and make a difference within their chosen topic.
3.The students were knowledgeable about the topic I assisted with.
4.The CBL project made a cooperative learning environment in which I felt welcome.
5.I would be willing to assist in the future.

APPENDIX F

ECOLOGY TEST

Version A

www.quia.com **Name** _____ **Date** _____

Ecology Pretest
Take your time and do the best that you can!

1. Anything the restricts the number of individuals living in a population is _____. (1 point)
   - a limiting factor
   - the biotic potential
   - population spacing
   - symbiosis

2. The _____ is the part of earth that supports life. (1 point)
   - biosphere
   - producer
   - ecosystem
   - environment

3. All of the populations in an ecosytem make up a _____. (1 point)
   - environment
   - bioshphere
   - community
   - niche

4. Of the following, which are NOT living organisms? (1 point)
   - producers
   - animals
   - plants
   - minerals

5. What do you call an organism that cannot make its own food? (1 point)
   - producer
   - consumer

6. Organisms belonging to the same species living together in the same place at the same time are a _____. (1 point)
   - community
   - population
   - niche
   - all of the above

7. What lists the levels of organization in order from smallest to largest? (1 point)
   - organism, community, population, biosphere, and ecosystem
   - biosphere, ecosystem, community, population, and organism
   - organism, population, community, ecosystem, and biosphere

8. Refer to the picture below and identify what type of Symbiotic Relationship is represented in the picture. (Ostrich & Gazelle) (1 point)

- ○ Mutualism
- ○ Commensalism
- ○ Parasitism

9. Which of the following is an example of a limiting factor? (1 point)
   - ○ predator
   - ○ disease
   - ○ accidents
   - ○ all of the above

10. Match the term with the correct definition. (6 points)

_____ use the Sun to make energy-rich molecules	a. omnivores
_____ consumers who capture and eat other consumers	b. predator
_____ plant eaters	c. producers
_____ eat plants and other animals	d. herbivores
_____ a consumer captured and eaten by another consumer	e. prey
_____ consume wastes and dead organisms	f. decomposers

11. The largest number of species that an ecosystem can support over time is called the _____. (1 point)
    - ○ population density
    - ○ limiting factor
    - ○ carrying capacity

12. Refer to the picture below and identify what type of Symbiotic Relationship is represente the picture. (Cuckoo and Warbler) (1 point)

- ○ Mutualism
- ○ Commensalism
- ○ Parasitism

13. Match the term with the correct definition. (10 points)

_____ living things in an ecosystem

_____ all the populations in an ecosystem

_____ non-living things in an ecosyterm

_____ the study of interactions among organisms and their environment

_____ organisms that cannot make their own energy-rich particles

_____ the largest number of individuals of one species that an environment can support and maintain

_____ made up of interconnected food chains

_____ the size of a population that occupies a specific area

_____ model that shows feeding relationships

_____ all the organisms living in an area and the nonliving features of their environments

a. food web
b. ecosystems
c. population density
d. abiotic
e. carrying capactiy
f. consumer
g. food chain
h. ecology
i. community
j. biotic

14. All the organisms living in an area and the nonliving features of their environment make an _____. (1 point)
    - ○ ecosystem
    - ○ environment
    - ○ ecological community

15. The role a species plays within a community is its _____. (1 point)
    - ○ population
    - ○ habitat
    - ○ niche
    - ○ ecology

16. Organisms that use any outside energy source, such as the sun, to produce energy-rich molecules are called _____. (1 point)

- Ecologist

19. Habitat or Niche? A chameleon changes its colors to blend in with its surroundings. (1 p

_____

20. The number of individuals in a given area is a _____. (1 point)
    - population
    - community
    - population density
    - none of the above

21. Habitat or Niche? Your cat's sense of smell helps it find its way home. (1 point)

_____

22. Refer to the picture below and identify what type of Symbiotic Relationship is represente the picture. (Barnacle & Whale) (1 point)

    - Parasitism
    - Commensalism
    - Mutualism

23. Of the following, which is NOT a nonliving feature of the environment? (1 point)
    - light
    - fungi
    - soil
    - water

24. Habitat or Niche? Ducks and amphibians live in or near a pond. (1 point)

_____

25. Habitat or Niche? Woodpeckers use their beak to pry insects from trees. (1 point)

_____

APPENDIX G

CLASSIFICATION AND TAXONOMY TEST

- Animalia
- Eubacteria
- Fungi
- Plantae

5. Which of the following is a kingdom of prokaryotes? (1 point)
   - Animalia
   - Plantae
   - Eubacteria
   - Fungi

6. Which is the correct way to write the scientific name of humans? (1 point)
   - Homosapiens
   - Homo Sapiens
   - HOMO SAPIENS
   - Homo sapiens

7. At which taxonomic level do the Canadia goose and human differ? (1 point)




Classification Level				
Common Name	Human (?)	Canada goose	Lake darner	Mosquito
Kingdom	Animalia	Animalia	Animalia	Animalia
Phylum	Chordata	Chordata	Arthropoda	Arthropoda
Class	Mammalia	Aves	Insecta	Insecta
Order	Primate	Anseriformes	Odonata	Diptera
Family	Hominidae	Anatidae	Aeshnidae	Culicidae
Genus	*Homo*	*Branta*	*Aeshna*	*Aedes*
Species	*sapiens*	*canadensis*	*eremita*	*fitchii*

   - Class
   - Genus
   - Kingdom
   - Species

8. What is the genus of a human? (1 point)

Version A

www.quia.com

Name _____ Date _____

Classification and Taxonomy Test

1. Please answer the question (1 point)

The insect in the picture on the right is

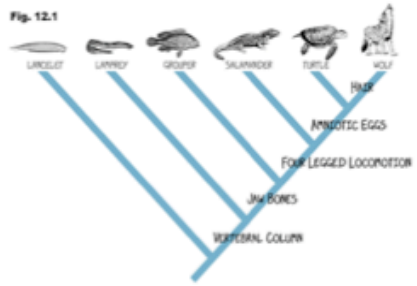
1. a. Has a short body with jointed tail and lacks wings -- *Dynastes tityus*
b. Has a long body with jointed tail and has wings --- go to step 2.
2. a. Front and hind wings similar in size and shape, folded parallel to the body when at rest ---- *Calopteryx maculata*
b. Hind wings wider than front wings near base, and extended on either side of the body when at rest --- *Leucorrhinia borealis*

- a. Dynastes tityus
- b. Calopteryx maculata
- c. Leucorrhinia borealis

- A
- B
- C

2. Please answer (1 point)

What is the most recent derived characteristic below?



- a. Jaw bone
- b. Four legged locomotion
- c. Amniotic eggs
- d. Hair

- A
- B
- C
- D

Order	Primate	Anseriformes	Odonata	Diptera
Family	Hominidae	Anatidae	Aeshnidae	Culicidae
Genus	*Homo*	*Branta*	*Aeshna*	*Aedes*
Species	*sapiens*	*canadensis*	*eremita*	*fitchii*

- Homo
- Human
- Animal
- sapiens

9. What is the lowest taxonomic level both humans and mosquitos share? (1 point)

Classification Level				
Common Name	Human (?)	Canada goose	Lake darner	Mosquito
Kingdom	Animalia	Animalia	Animalia	Animalia
Phylum	Chordata	Chordata	Arthropoda	Arthropoda
Class	Mammalia	Aves	Insecta	Insecta
Order	Primate	Anseriformes	Odonata	Diptera
Family	Hominidae	Anatidae	Aeshnidae	Culicidae
Genus	*Homo*	*Branta*	*Aeshna*	*Aedes*
Species	*sapiens*	*canadensis*	*eremita*	*fitchii*

- Order
- Domain
- Class
- Kingdom

10. Which organisms are more closely related? (1 point)
    - They have the same class in common
    - They have the same family in common
    - They have the same kingdom in common
    - They have the same genus in common

11. Which term is more inclusive? (1 point)

- it wasn't a problem
- He grouped organism based on what they ate.
- He didn't take into account convergent evolution, that organism look similar because they occupy the same hat
- He didn't take into acccount divergent evolution that organism look the same because they are in different habi

14. An organism is multicellular and made up of eukaryotic cell. The organism can move from one place to another. Its chloroplasts. Into what kingdom should the organism be classified? (1 point)
    - Animalia
    - Fungi
    - Protista
    - Plantae

15. What is one important way that members of the domain Archaea are different from Bacteria? (1 point)
    - Archaea have unique DNA and cell wall composition
    - Archaea lack cells with a nucleus
    - Archaea are multicellular
    - Archaea lack cell walls

16. What do all members of the domain Eukarya have in common? (1 point)
    - The all have cells with a nucleus
    - They are all autotrophic
    - They all lack cell walls
    - They are all multicellular

17. What subgroups make up a class? (1 point)
    - genera
    - phlya
    - orders
    - species

18. The term prokaryotic means the cell (1 point)
    - lacks a nucleus
    - has a nuclues

19. Organism that are autotrophic (1 point)
    - decompose food
    - have to obtain food from other organisms
    - make their own food
    - digest food

20. The father of our classification system? (1 point)
    - Pastuer
    - Darwin
    - Mendel
    - Linneaus

23. The domain that corresponds to the kingdom Eubacteria is (1 point)
    - Archae
    - Fungi
    - Eukarya
    - Bacteria

24. Which kingdom contains heterotrophs with cell walls made of chitin? (1 point)
    - protists
    - fungi
    - plant
    - animal

25. All organisms in the kingdoms Protista, Plantae, Fungi, and Animalia are (1 point)
    - photosynthetic organisms
    - prokaryotes
    - eukaryotes
    - multicellular organisms

26. An analysis of derived characters is used to generate a (1 point)
    - family tree based on external appearance
    - cladogram
    - traditional classification system
    - family tree based on DNA structure

27. In biology, an evolutionary innovation is also referred to as a (1 point)
    - taxonomic group
    - molecular clock
    - physcial similarity
    - derived character

28. What kind of analysis focuses on the order in which derived characters appeared in organisms? (1 point)
    - taxonomy
    - cladistic analysis
    - anatomy
    - traditional classification

29. The procedure for grouping and naming organism based on the evolutionary history is called? (1 point)
    - traditional classification
    - binomial nomenclature
    - evolutionary classification
    - derived characteristics

30. In an evolutionary classification scheme, species within one genus should (1 point)

- phylum
- domain
- order

33. Several different classes make up a (1 point)
    - phylum
    - kingdom
    - family
    - order

34. A genus is composed of a number of related (1 point)
    - kingdoms
    - phyla
    - orders
    - species

35. In Linneaus's system of classification, how many taxonomic categories were there (1 point)
    - one
    - five
    - three
    - seven

36. The second part of the scientific name is unique to each. (1 point)
    - species in its genus
    - family in its order
    - genus in its family
    - order in its class

37. Based on their names, you know that the baboons Papio annubis and Papio cynocephalus do not belong to the same
    - species
    - class
    - genus
    - family

38. The scientific version of a species name, which of the terms is capitialized? (1 point)
    - the first term only
    - neither the first or second term
    - bothe the first and the second terms
    - the second term only

39. In taxonomy, a group at any level of organization is referred to as a (1 point)
    - cladogram
    - bionomial
    - system

APPENDIX H

EVOLUTION TEST

Version A

www.quia.com

Name _____ Date _____

Evolution Post Test

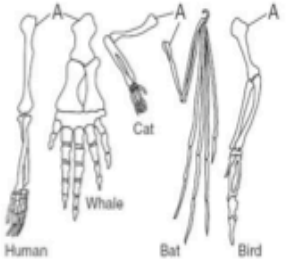
1. Please explain Directional, disruptive, and stabilizing selection. (5 points)

2. Evidence for the process of evolution can be found in (1 point)
   - ○ Fossil Record
   - ○ Geographical Distribution
   - ○ Homologous Structures
   - ○ All of the above

3. The major idea that Darwin presented in his book The Origin of Species was that _____. (1 point)
   - ○ species changed over time and never competed with each other.
   - ○ species changed over time by natural selection.
   - ○ animals changed, but plants remained the same.
   - ○ giraffes and peppered moths changed constantly.

4. Darwin thought that the plants and animals of the Galapagos Islands were similar to those of the nearby coast of South America because _____. (1 point)
   - ○ they had all been created by God to match their habitat.
   - ○ the island organisms had the same nucleotide sequences in their DNA as the mainland organisms.
   - ○ their ancestors had migrated from South America to the Galapagos Islands.
   - ○ he found fossils proving that the animals and plants had common ancestors.

5. The similarities of the bones labeled A provide evidence that _____. (1 point)



   - ○ all species have one kind of bone structure.
   - ○ the cells of the bones contain the same type of mutations.
   - ○ all structural characteristics are the same in animals.
   - ○ the organisms may have evolved from a common ancestor.

6. How does natural selection lead to evolution? (1 point)
   - ○ Stronger offspring kill weaker members of the species.
   - ○ Helpful traits accumulate among surviving members of the species.
   - ○ Overproduction provides food for stronger members of the species.
   - ○ Environmental changes kill weaker members of the species.

- evolution
- migration
- variation

10. What evidence suggests that the ancestors of whales once walked on land? (1 point)
    - Scientists have found fossils of whale-like creatures that walked on land?
    - Whales perform walking motions as they swim.
    - Whales have similar DNA to elephants.
    - Whales breathe through lungs.

11. Which term refers to similar structures that related species have inherited from a common ancestor? (1 point)
    - DNA sequences
    - developmental organisms
    - homologous structures
    - punctuated equilibria

12. Why do scientists think related species have similar body structures and development patterns? (1 point)
    - The species inherited many of the same genes from one another.
    - The species inherited many of the same proteins from a common ancestor.
    - The species inherited all the same genes from a common ancestor.
    - The species inherited many of the same genes from a common ancestor.

13. What did Darwin observe about finches in the Galapagos Islands? (1 point)
    - Their feathers were adapted to match their environment.
    - Their beaks were adapted to match the foods they ate.
    - They had identical phenotypes in all locations.
    - They had identical genotypes in all locations.

14. Whales and snakes both have tiny leg bones that are not visible or used. This would suggest that: (1 point)
    - both evolved from animals that had legs
    - they are evolving into animals with legs
    - whales and snakes are related
    - leg bones are not necessary

15. What is evolution by natural selection use the peppered moth study to explain your answer (include terms fitness and selection) (

- the natural variation found in all populations
- the struggle for existence undergone by all living things.

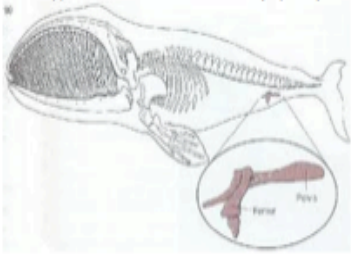
28. A pattern of evolution that results when two unrelated species begin to appear similar because of environmental conditions is (1 p
    - migration
    - disruptive selection
    - convergent evolution
    - direct evolution

29. In a population of finches in which one group has a short, parrotlike beak and another group has a long, narrow beak, what proce
    - directional selection
    - disruptive selection
    - chance selection
    - stabilizing selection

30. The main sources of genetic variation is (1 point)
    - genotypes and phenotypes
    - single-gene traits and polygenic traits
    - directional selection adn disruptive selection
    - genetic mutations

31. Charles Darwin called the ability of an organism to survive and reproduce in its specific environment (1 point)
    - fitness
    - diversity
    - evolution
    - adapatation

32. What type of structures are these? (1 point)

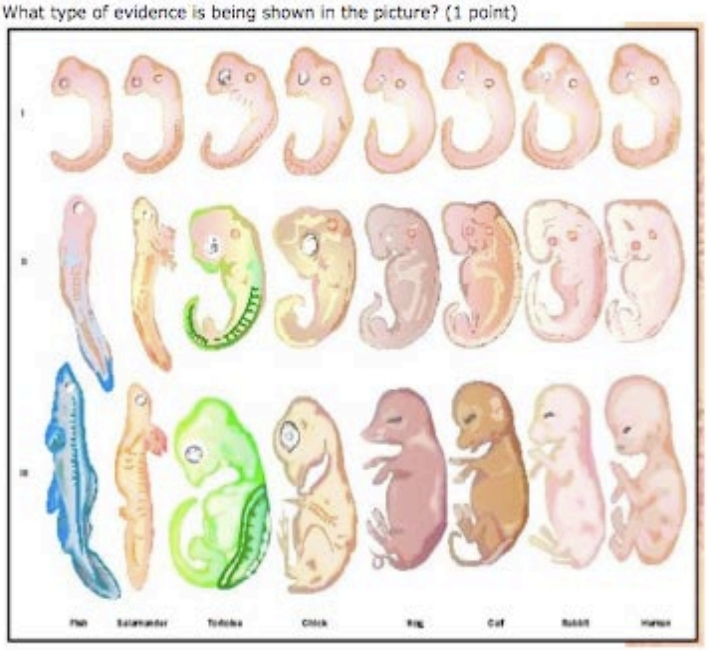


    - hemizgyous structures
    - vestigial structures
    - homologous structures
    - analgous structures

33. What type of structures are shown in this picture? (1 point)

- embryological structures
- vestigial structures
- homologous structures
- analgous structure

34. What type of evidence is being shown in the picture? (1 point)



- embryological evidence
- convergent evolution
- fossil
- DNA evidence

35. What pattern of evolution is being displayed? (1 point)