THE EFFECT OF PROJECT-BASED LEARNING ON ACADEMIC ACHIEVEMENT IN A FRESHMAN BIOLOGY CLASSROOM

by

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DEDICATION, ACKNOWLEDGEMENT

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ABSTRACT

Biology is a required course for freshman students at my school and the majority of these students will not go on to a future career in science. As such, most do not see the value in taking the class and are unable to make connections between what we learn and occurrences in their everyday lives. This classroom research project focused on the implementation of project-based learning instruction to increase student attitude towards science, increase academic achievement, and reinforce the connection between biology and the real world.

Lessons for two treatment units focusing on Mendelian Genetics and Molecular Genetics were taught using the principles behind project-based learning. In each unit, students worked in collaborative groups to solve an overarching problem that tied together all aspects of the unit. At the end of the unit, a project-based learning artifact or final product produced by the group is presented to school, family, and community members.

Data was collected in various formats throughout project implementation. Students completed surveys prior to the start and at the end of the project-based learning units. In addition, nine students were interviewed at the mid and end point of the project. Student scores on assessments, such as quizzes and tests, were compared between students in the treatment group taught via project-based learning and students from the 2014-2015 school year who were taught in a more traditional setting.

Results showed that while project-based learning did not significantly increase student achievement it also did not negatively impact achievement. This showed that project-based learning instruction was equally effective when compared to the traditional, teacher-centered classroom. Regardless of the lack of achievement gains, students preferred this method of instruction. They found instruction via project-based learning more engaging and thought that it offered a level of flexibility they did not have in previous instructional units. This instructional method works for a large variety of students, in particular, students who prefer hands-on learning experiences.
INTRODUCTION AND BACKGROUND

As a teacher, I have observed a common trend among many of my students; an inability to connect what they are learning to the real world away from our classroom. The majority of my students are ninth graders who are required to take Biology as a graduation requirement. Most of these students have no future plans of becoming a scientist or pursuing a science related career after they graduate high school. Biology, like many science courses, is also a very vocabulary intensive course and many students learn words as individual entities rather than a web of interconnected concepts. These observations prompted me to explore the implementation of an instructional practice that would increase student attitude and achievement in my classroom as well as reinforce the connection between biology and their everyday lives.

Teaching Environment and School Demographics

My current teaching position is very different than those that I had for the first nine years of my career. In the past, I have taught at mostly low income schools with large populations of minority students from families with a low socio-economic status. Classroom management was a huge concern and many of my students had parents who did not value education. However, following that experience I had the privilege of working for three years at a charter school where discipline was handled swiftly, the administration was able to focus on curriculum rather than discipline, and most teachers could focus on teaching only one subject. I was able to focus on only teaching Chemistry and assisted in developing a yearlong standards-based curriculum.
In 2012 I moved to Germany and began teaching at a Department of Defense Dependents School. I went from being able to focus on teaching one subject to teaching three to four different subjects. At my previous school, I was able to collaborate with another Chemistry teacher during common planning time to develop a standards-based curriculum and ensure uniformity in the curriculum with common assessments and laboratory experiments. Most teachers at my current school are the only teacher in the building teaching a particular subject area so collaborative planning is difficult. While classroom management was not as much of an issue as it was at my previous school, I was now dealing with students who were mostly uninterested in the curriculum and failed to see its relevance to their everyday lives. I felt as though I only further contributed to this lack of relevance in the way that I assigned projects. I wasn’t activating a feeling of importance or interest in projects to my students. When projects were assigned, I normally passed out the papers, attempted to give an explanation of the project’s relevance to our unit, and had students get to work. Students basically saw this as a “prelude to busywork.” (Larmer and Mergendoller, 2010) I needed to infuse more meaning into my instructional units and show students the importance of what we were learning.

Bitburg Middle-High School (BMHS) is a Department of Defense Dependents School that serves American students from the areas surrounding Bitburg and Spangdahlem, Germany. The school enrolls students in grades seven through twelve with a total enrollment of approximately 210 students. Students attending the school are dependents of either United States (US) military members or civilian Department of
Defense employees. The main military base in this area is located in Spangdahlem however, the middle-high school is located on the former Bitburg Air Base which is a 20 minute drive from the main base. The US government will be returning Bitburg Air Base to the German government in the next couple years and as such, the only remaining active areas of the base are the middle-high school, elementary school, fire department, and security forces at the base gate.

Students attending BMHS are part of a unique subculture that allows them to experience many things their non-military peers in the US could never even imagine. While the opportunity to live in a foreign country is exciting and helps to build cultural tolerance, students can also experience stressful situations unique to those connected to the military. Deployments are a common occurrence in the military and many students have at least one parent deployed during the school year. This can lead to discipline problems in the classroom as the student adjusts to life at home without one or more parents. Another stressful aspect is the somewhat nomadic nature of military members and their families. While many students in the US remain in the same school district their entire life, most military dependents move every three to four years. Students often arrive or leave BMHS at various points in the school year and may arrive from schools that are on a different bell schedule. The school currently operates on an alternating block schedule with students attending four different classes each day. At times, this causes problems for students who arrive during the second semester and are possibly behind on course work. However, the life of a military child can also build a certain resiliency that is not evident in other teens their same age. Students at BMHS are part of
a loving, supportive community with a shared mission. During deployments, students may take on more responsibilities that add to their maturity and constant moves make them more accepting of new students.

Focus Question

In order to increase my students’ ability to connect our coursework to their everyday lives I decided to explore the use of project-based learning (PBL) in the classroom. During this project I explored the following question: Does the implementation of project-based learning increase academic achievement in the classroom? The following sub-questions were also addressed during the project: 1) Will implementation of PBL increase student’s abilities to make connections between the coursework and their everyday lives? 2) Does PBL increase student attitudes toward learning science? 3) What are some of the problems a teacher may encounter when first implementing PBL in the classroom? The main goal of this project is to show that student achievement and attitudes towards science will be higher during units where PBL is implemented as opposed to units where a more traditional teacher-centered approach is implemented.

CONCEPTUAL FRAMEWORK

Project-based learning is touted as a best practice for helping students make relevant connections between what they learn in the classroom to their everyday lives outside of the classroom (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991). Classrooms that include this practice are more student-centered and the teacher
takes more of a role as a facilitator rather than a lecturer or the only source of information.

The idea of learning by doing is not a new innovation by any means. In the early 1900’s, the educational theorist John Dewey touted the benefits of learning by experience. Even now over 100 years later, teachers are encouraged to include activities that allow students to fully “experience” the curriculum they are being taught. Field trips, inquiry laboratory investigations, computer simulations, and cross-disciplinary activities are just some examples of how teachers strive to enhance the learning experiences for their students. However, the implementation of these activities does not necessarily indicate an increase in student achievement. According to Dewey, authentic education is not produced solely by experience as not all experiences provide the same level of quality education or enhancement of a student’s education (Dewey, 1938). Inclusion of these types of activities also does not indicate that student understanding or academic achievement will increase. Education and experience cannot be directly correlated and for some, experiences may actually be mis-educative (Dewey, 1938). This aspect of experiential education is lost on some educators who believe that just providing any experience is going to skyrocket student performance or increase their students’ level of interest in coursework.

Over the past 25 years, the idea of learning by doing has been combined with an inherent aspect of education in the United States, projects. The *Project Based Learning Handbook* from the Buck Institute for Education (BIE) defines PBL as, “a systematic teaching method that engages students in learning knowledge and skills through an
extended inquiry process structured around complex, authentic questions and carefully
designed products and tasks” (Markham, T., Larmer, J., & Ravitz, J., 2003, p. 4). The
idea of project-based learning was first introduced in 1918 by William Heard Kilpatrick,
a professor at the Teachers College of Columbia University. Kilpatrick believed that true
learning occurred when students were able to choose educational projects for intrinsic
purposes as opposed to teacher or school directed instruction (Wolk, 1994; Kilpatrick,
1918).

A commonality in most PBL is the creation of a driving question. This driving
question is a meaningful, real-world problem developed in the context of a class’
curriculum objectives (Schneider, Krajcik, Marx, and Soloway, 2002). Depending on the
grade level of students or the teacher’s level of comfort in PBL instruction, this driving
question may be teacher created or in true PBL fashion, student created. Regardless, the
overall theme of PBL is a more student-centered classroom where the teacher serves
more as a facilitator. As the facilitator, a teacher monitors student progress as they work
towards a solution to this driving question and guides students as they choose a direction
for their research. The overall goal of PBL is to increase student motivation to learn as
well as develop a deeper understanding of the curriculum in comparison to a traditional
teacher centered classroom (Bell, 2010).

At its heart, the contemporary version of PBL has maintained many of the original
overarching ideas presented by Dewey. In May 2015, a new “gold standard” model for
PBL was introduced by BIE (Larmer & Mergendoller, 2015). This Gold Standard PBL is
composed of three parts: 1) Student Learning Goals, 2) Essential Project Design
Elements, and 3) Project Based Teaching Practices. Table 1 identifies and describes each of the essential project design elements of PBL (Larmer & Mergendoller, 2015).

Table 1
Gold Standard PBL: Essential Project Design Elements

<table>
<thead>
<tr>
<th>Design Element</th>
<th>Description</th>
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<tbody>
<tr>
<td>Key Knowledge, Understanding, and Success Skills</td>
<td>The project is focused on student learning goals, including standards-based content and skills such as critical thinking/problem solving, collaboration, and self-management</td>
</tr>
<tr>
<td>Challenging Problem or Question</td>
<td>The project is framed by a meaningful problem to solve or a question to answer, at the appropriate level of challenge.</td>
</tr>
<tr>
<td>Sustained Inquiry</td>
<td>Students engage in a rigorous, extended process of asking questions, finding resources, and applying information.</td>
</tr>
<tr>
<td>Authenticity</td>
<td>The project features real-world context, tasks and tools, quality standards, or impact – or speaks to students’ personal concerns, interests, and issues in their lives.</td>
</tr>
<tr>
<td>Student Voice &amp; Choice</td>
<td>Students make some decisions about the project, including how they work and what they create.</td>
</tr>
<tr>
<td>Reflection</td>
<td>Students and teachers reflect on learning, the effectiveness of their inquiry and project activities, the quality of student work, obstacles and how to overcome them.</td>
</tr>
<tr>
<td>Critique &amp; Revision</td>
<td>Students give, receive, and use feedback to improve their process and products.</td>
</tr>
<tr>
<td>Public Product</td>
<td>Students make their project work public by explaining, displaying and/or presenting it to people beyond the classroom.</td>
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In researching project-based learning I also came across the idea of problem-based learning. Both educational practices go by the acronym PBL which causes some confusion as to whether they are the same concept. In general, both types of PBL’s focus
on an open-ended question or task, emphasize student-directed instruction, aid in the development of 21st century skills, and last a longer duration than a typical teacher-directed lesson. BIE thinks of problem-based learning as a subset of project-based learning in that a teacher could choose to have a driving question that asks students to solve a problem. My classroom research project will focus on the use of project-based learning and hence forth, any appearance of the acronym PBL in this paper will refer to this instructional method. Differentiation between the two instructional methods, project and problem based learning, is shown in table two (Larmer, 2014).

Table 2

<table>
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<tr>
<th>Comparison of Project and Problem Based Learning</th>
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<tr>
<td><strong>Project Based Learning vs. Problem Based Learning</strong></td>
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<tr>
<td><strong>Similarities</strong></td>
</tr>
<tr>
<td>Both PBLs:</td>
</tr>
<tr>
<td>Focus on an open-ended question or task</td>
</tr>
<tr>
<td>Provide authentic applications of content and skills</td>
</tr>
<tr>
<td>Build 21st century 4 C’s competencies</td>
</tr>
<tr>
<td>Emphasize student independence and inquiry</td>
</tr>
<tr>
<td>Are longer and more multifaceted than traditional lessons or assignments</td>
</tr>
<tr>
<td><strong>Differences</strong></td>
</tr>
<tr>
<td>Project Based Learning</td>
</tr>
<tr>
<td>Often multi-disciplinary</td>
</tr>
<tr>
<td>May be lengthy (weeks or months)</td>
</tr>
<tr>
<td>Follows general, variously-named steps</td>
</tr>
<tr>
<td>Includes the creation of a product or performance</td>
</tr>
<tr>
<td>Often involves real-world, fully authentic tasks and settings</td>
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Education today is very different from the time of Dewey and Kilpatrick but their theories about learning by doing and the use of student-directed instruction are true even more so today. The dynamic nature of society in this day and age requires students to possess a different skill set than those of their parents or even individuals who are only five to ten years older. The world needs more individuals capable of viewing evidence and then making a decision based on this evidence (Sungur, Tekkaya, & Geban, 2006). In order to produce a group of students who can be successful in this type of environment, teachers must adapt their classroom instructional practices to meet these needs. Standardized test results are often viewed as an accurate indicator of student academic achievement but these tests do not truly assess the twenty-first century skill set required today (Bell, 2010). Project-based learning is capable of providing students with a modern skill set to help them be more successful in the real world. With project-based learning, students not only gain a deeper understanding of the content area but also important skills they can carry with them beyond the classroom.

Students participating in this method of student-centered instruction learn responsibility, independence, and discipline. They also learn how to function as a member of a group and gain valuable skills in communication, negotiation, and collaboration (Bell, 2010). The idea of collaboration and conversation are essential pieces to PBL (Schneider, R., Krajcik, J., Marx, R., & Soloway, E., 2002). As part of a cooperative group, students learn by explaining concepts to each other and work to dispel misconceptions. This social learning atmosphere also teaches students to be active listeners and respect the ideas of other group members. Another key aspect of project-
based learning is that this collaboration does not stop with the students, but rather it is a community collaboration including students, teachers, parents and other members of the community. In project-based learning the final essential project element involves students creating a public product. By making the product public, students are introduced to the idea that what they learn should be discussed and shared not only with classmates but their parents and the community. This public product can motivate students to produce higher quality work and provide an opportunity for schools to showcase the quality work that students are producing and the quality instruction practices being used by teachers (Larmer & Mergendoller, 2015).

In comparison to other educational strategies, project-based learning is relatively new. However, a quick search on the Internet and one will quickly discover that the number of schools implementing this type of strategy is constantly growing. This number is mirrored by the number of research studies being conducted on project-based learning and other similar student-centered instruction practices. While the verdict is currently still out as to whether project-based learning has been validated as a savior for academic achievement, studies indicate that project-based learning is able to produce equal and in many cases, better results in the classroom (Schneider et. al, 2002; Sloan, 2013). A study conducted by Schneider et al. (2002) focused on students who were educated via a project-based science curriculum entitled Foundations of Science (FOS). Students were assessed using the National Assessment of Educational Progress (NAEP) and participating students scored “as well or better on almost all of the items” (p. 11).
Student attitudes towards their science classes have also been shown to be affected by PBL and similar instructional techniques such as problem-based learning (Sloan, 2013; Tandoğan, & Akınoğlu, 2007; Aşçı, Z. & Demircioğlu, H, 2002). In PBL, students research information that has a direct meaning to their personal lives as well as the curriculum focus for that particular unit. By including information from their everyday lives, a teacher is able to engage students and increase their overall interest in the curriculum. In their research on problem-based learning, Tandoğan and Akınoğlu referenced a study conducted on ninth grade ecology students where the researchers found that relating information from student’s daily lives to the curriculum facilitated learning, took away student fears of problem-solving, and led to positive student attitudes towards science class (Tandoğan, & Akınoğlu, 2007; Aşçı, Z. & Demircioğlu, H, 2002).

Another aspect of PBL that affects student attitudes in a positive manner is the concept of cooperative learning. With project-based learning students practice twenty-first century skills as they work in a group and have the opportunity to collaborate with their classmates to achieve a final objective. This cooperative grouping empowers students and increases their belief that they can succeed in a course, which in turn leads to a more positive attitude to their course (Lord, 2001; Johnson, Johnson & Smith, 1991).

Sungur et al. (2006) conducted a study on the effect of problem-based learning in tenth grade biology classrooms. In this study, teacher-centered instruction and student-centered instruction were compared via a pre and post-test. Students who were members of the student-centered, problem-based classroom also completed a Likert-style survey to assess their thoughts on problem-based learning. Results from the post-test showed that
performance on questions requiring simple recall was similar between groups. However, the group taught via problem-based instruction (93.3%) far outperformed the teacher-centered students (48%) on questions that required students to integrate knowledge from different areas.

Similar results were produced in a study conducted by Schneider et al. (2002) during the implementation of a project-based science curriculum. Student participants in this study were tenth and eleventh graders attending an alternative high school that implemented the project based curriculum as opposed to a more traditional science program. On the NAEP test, students in the project-based science curriculum scored significantly higher on over half of the questions as compared to the national results of students who were in more traditional classrooms. The same students also scored higher on the science section of their state achievement test in comparison to students at other similar schools that offered Advanced Placement courses.

Another study on project-based learning was conducted at two British schools over the course of three years. Students at one school were taught using project-based learning while the students at the other school were taught using traditional methods. Three times as many students taught via project-based learning scored the highest possible score on the national exam in comparison to the students taught using the traditional method. The students taught using project-based learning were also able to answer higher level, applied and conceptual problems (Bell, 2010; Boaler, 1999).

As evidenced above, the implementation of a project-based learning curriculum can have many benefits to the students as well as the teacher but also presents its own set
of obstacles to both parties. In the past, teachers have used projects as a kind of reward or break from traditional classroom assessments. While many teachers implement projects in their classrooms, the process of developing and implementing a project-based learning unit requires more in depth planning. Projects are standards based and steer students toward the overwhelming goal of answering a driving question. As with the implementation of any new educational practice, common problems are bound to arise. Many students struggle with the inquiry aspect of project-based learning and are unable to develop essential questions that will guide them toward a solution to the driving question. Students are accustomed to the teacher-centered classroom where activities have a very cookbook feel and open-ended situations are a totally new concept. One suggestion to this problem is to first introduce students to a smaller scale problem-based learning activity, such as a case study, before implementing a larger scale project-based learning activity. One of the essential design elements of the gold standard of project-based learning model is critique and revision where students give, receive, and use feedback to improve their process and products. While most students have experience working in groups they do not have experience developing ideas, intertwining those ideas with others, or giving feedback. In order to combat this problem, a teacher must develop a formal evaluation system and instruct students in the use of rubrics.

Teachers implementing project-based learning for the first time will also face problems. Many teachers are unfamiliar with the format of project-based learning and struggle to create an actual project-based assignment as opposed to just a typical project they would assign students. Teachers can also have difficulty scaffolding learning during
a project-based unit as they may give students too much or too little freedom (Thomas, 2000). In order to combat this problem a teacher may start students off with limited choices such as choosing the topic to study as related to the teacher created driving question or the format of the project. As students and teacher become more familiar with this instructional practice, the teacher can give students more freedom and eventually work their way up to deciding the final product that will be produced, research methods, how they will structure research time, and even the driving question for a unit (Larmer & Mergendoller, 2010).

Another common pitfall is that project-based learning can be a time-consuming instructional practice, especially in the initial implementation. Teachers may feel overwhelmed and not in control of their classroom to the same level as which they are accustomed. Part of a study conducted by Goodnough and Cashion (2006) sought to identify issues that arose during the design and implementation of an inquiry-based method of instruction, in this case, problem-based learning. In one of her first reflections on the problem-based learning unit, the teacher participating in the study commented that most students are accustomed to a structured framework that lacks mystery (Goodnough & Cashion, 2006). This is a common argument that opponents of project-based learning and similar practices like to point out as a negative aspect. In his article against minimally guided instruction, Kirschner cited Roblyer, Edwards, and Havriluk as stating that minimally guided instruction practices, such as project-based learning, are only effective if the participating students have some prerequisite knowledge and the teacher has provided some structured educational experiences prior to the unit implementation.
(Kirschner, 2006; Roblyer et al., 1997). Teachers can easily avoid this problem by assessing their comfort level as well as their students. When first implementing a project-based learning unit, a teacher may choose to use a more structured format to help students become accustomed to a new way of learning. As the teacher and students become more comfortable with PBL the structure can slowly be disassembled until reaching a comfortable level for all parties involved.

Time constraints can also cause problems with the implementation of a project-based learning unit deals with time constraints. In the era of standardized testing, many teachers worry about the amount of time it would take the implement a PBL unit (Yeung, 2008). In project and problem-based learning, student research may lead them into areas beyond the scope of the course curriculum. Students may stray too far from the curriculum and end up taking a much longer route to an end solution. One suggested solution is to use this type of learning for enrichment or “post-holes;” shorter problems that can be added to the regular curriculum (Chin & Chia, 2006; Stepien & Gallagher, 1993). However, the problem of time constraints can be eliminated by identifying key learning outcomes for each project-based learning unit. Chin and Chia state that

A key element to consider is the intended learning outcomes---the particular science concepts the teacher wants students to learn, the skills to be acquired, and the understandings about the nature of scientific inquiry. The teacher could write down the specific curriculum and content objectives and then check off those that are relevant to the problem. If the
objectives are not met, then the problem needs to be revised so that there is a closer match (p. 19).

While implementation of a project-based learning unit may at first seem like a daunting and time-consuming task it is a successful instructional practice that forces teachers to assess their own instructional practice. According to Goodnough and Cashion (2006),

The adoption of project-based learning requires practitioners to engage in intensive curriculum development; to reflect on and examine their beliefs and values about the teacher’s role in the classroom and the nature of science teaching and learning (p. 12).

In conclusion, project-based learning units require much more planning than a traditional unit. However, this additional planning time up front will reward teachers with students who possess more enthusiasm and a deeper understanding of the course. This type of learning also allows students to experience the true nature of scientific inquiry and refine twenty-first century skills necessary to succeed.

METHODOLOGY

In the 21st century students will need to possess skills to help them succeed in a competitive, technologically advanced world. Project-based learning aids students by teaching them to “think critically and solve problems, work well with others, and manage themselves effectively” (Larmer & Mergendoller, 2015, p. 2).

My classroom research will involve the implementation of project-based learning units in my biology classes. The purpose of the study is to show that the implementation
of project-based learning would not only improve the academic achievement of students but also improve their ability to connect coursework with their everyday lives. By including this method of learning in my classrooms I plan to demonstrate a connection between the use of project-based learning and improved student mastery of the curriculum. This increased mastery will be measured by the gains in academic achievement. As my classroom research project will focus on the use of project-based learning as opposed to problem-based learning, hence forth, any appearance of the acronym PBL in this paper will refer to this instructional method.

Participants

Participants for the project included three biology classes. The total number of students enrolled in these classes and therefore number of participants for this study was 63, the majority of which were ninth grade students. There were also several tenth graders participating who had either transferred from another school or who were repeating the semester. Due to Department of Defense Dependents School classroom research requirements, the parents of all participating students had to complete the consent form shown in Appendix G. Biology is the first science class the participating students took in high school and a required course for graduation. There is no honors designation for the course and as such, all classes are composed of a mixture of students at varying academic levels. BMHS operates on an alternating block schedule, blue and red days, so classes meet either two or three times a week depending on the schedule. Two of my biology classes meet on blue days and one meets on red days. A teacher’s aide was present in two of the classes to assist students who possess an individualized
education plan (IEP). The combined male to female ratio for all three classes was approximately 1:1 and there were seven students who had an IEP. Demographics of the survey participants are representative of the school demographics. Of the sixty-three participants, 60% were Caucasian, 33% were African-American, and the remaining 7% were a mixture of Asian, Hispanic, and other races.

**Intervention**

Research was conducted between January and March 2016 during two instructional units: Mendelian Genetics and Molecular Genetics. Students were instructed using PBL during both units. Results from summative and formative assessments given to students during the 2014-2015 school year served as a comparison to the results achieved by students during this classroom research project. Students who were members of my biology classes during the 2014-2015 school year were taught using traditional teacher centered instructional methods. Assessments given during the 2014-2015 and the treatment year (2015-2016) were identical.

The first PBL was implemented during our Mendelian genetics unit. During the first treatment cycle students were instructed via a PBL unit that focused on the genetic variation of cousins whose parents are both identical twins; twin males marry twin females. On the first day of the unit, student groups received a letter asking them to assist in developing an episode of a fictitious talk show (Appendix H). The episode of the talk show needed to focus on the question, “Will all of the children resulting from these marriages be genetically identical?” The letter explains that the television studio would like to use the class instead of a local genetic research company to answer the
question. The final project for the unit was a multimedia presentation created by groups of students. At the end of the unit students presented their project to an evaluation panel consisting of the teacher, school nurse, and other individuals from the school or community.

During the second treatment cycle, students completed a PBL unit focusing on molecular genetics. In this PBL unit, students took on the role of genetics counselors. Each PBL group was given a fictitious family history for a couple who were concerned about the possibility of passing on a genetic disease to their future offspring. Students had to create a pedigree from the family history, research the genetic disease found in their assigned couple, and determine the probability that the disease would be passed on to the unborn child. For the final project, students met with two volunteers playing the role of the “couple” and presented their findings as if they were genetics counselors giving a report to their clients (Appendix I).

**Data Collection**

The project began with students completing a Likert style survey to assess their initial attitude about science class, their ability to make connections between coursework and their everyday life, and preferred instructional practices (Appendix A). This pre-treatment phase was followed up with two treatment phases, and finally a post-treatment phase. The post-treatment phase included a Likert-style survey to assess how students feel about PBL as well as differences in their attitude about science since the beginning of the project (Appendix B).
During the treatment cycles, units were based on the essential design project elements in the Buck Institute for Education’s gold standard model for PBL. Data was collected throughout the implementation of the project using a variety of methods such as pre and post-unit Likert-style surveys, interviews with students and a teacher’s aide, and formative and summative assessment scores. Scores from the end of unit assessments were compared between classes as well as to scores from the 2014-2015 school year’s biology classes as the same assessments were administered. Lessons during the 2014-2015 school year were taught using mostly teacher-centered practices so they served as a baseline for comparison between units taught via teacher-centered instruction and those where PBL was utilized. All formative and summative assessments were administered via the same method that was used during the 2014-2015 school year. All assessments were administered online via the school’s local area network except for the Mendelian genetics test as this was administered via paper and pencil for the 2014-2015 classes. Keeping the same testing procedures from year to year ensures uniformity in testing procedures between the current and previous school year. Select students were also interviewed throughout the project. Interviewees included a cross section of high, medium and low performers with a total of nine students being interviewed at the mid-point and end of the project. Appendices C and D show the questions students answered during the mid and end-point of the classroom research project. A high, medium, and low performer was chosen from each participating class based on the average of their first quarter grade and their second quarter grades until Christmas break. Data sources for the
focus question and corresponding sub questions are shown in the triangulation matrix in table 3 below.

The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

Table 3
Triangulation Matrix

<table>
<thead>
<tr>
<th>Focus Questions</th>
<th>Data Source 1</th>
<th>Data Source 2</th>
<th>Data Source 3</th>
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| **Primary Question**
Does the implementation of project-based learning increase academic achievement in the classroom? | Student survey (pre- and post-PBL project) | PBL artifact, formative, and summative assessments | Student Interviews |
| **Sub question 1**
Will implementation of PBL increase student’s abilities to make connections between the coursework and their everyday lives? | Student survey (pre- and post-PBL project) | PBL artifact, formative, and summative assessments | Student interviews |
| **Sub question 2**
Does PBL increase student attitudes toward learning science? | Student survey (pre- and post-PBL project) | Field notes from observation | Student Interviews |
| **Sub question 3**
What are some of the problems a teacher may encounter when first implementing PBL in the classroom? | Student survey (pre- and post-PBL project) | Teacher interview (special education aide) | Teacher journal |

DATA AND ANALYSIS

My classroom research project focused on whether or not implementation of project-based learning increases academic achievement in the classroom. As part of this research, I chose to collect both qualitative and quantitative data related to the use of project-based instruction in the classroom. I first looked at the efficacy of PBL increasing my students’ abilities to make connections between the coursework and their
everyday lives. The second area of research focused on whether or not PBL increases student attitudes toward learning science. The final piece of my research examined the problems a teacher may encounter when first implementing PBL instruction in their classroom.

Increase in student ability to make real-world connections

With each sub question, the most telling piece of evidence was the open-ended responses during student interviews and the Likert-style survey. In student interviews, 89% of students stated that being able to explain experiences in their lives using science concepts was important. The remaining 11% felt that many real-world experiences could be explained without science or only required common sense for understanding. One student stated that being able to explain experiences in her life “gives a purpose to all of the information I am learning in class that may seem pointless at the time.” During our interview focus group, another student shared that “a lot of people use religion as a reason for most occurrences.” She stated “I need something to explain what goes on in life, like erosion, using science rather than religion.”

At the mid and end-point of the classroom research students were also asked “Which learning method, PBL or traditional, helps you to best explain experiences in your everyday life using scientific concepts?” At the mid-point, 56% of the students interviewed stated that PBL was more effective at explaining experiences in their lives. The remaining 44% was split between students who thought traditional instruction was more efficient and half who thought both methods of instruction were equally effective. However, the percentage of students who thought PBL was more efficient increased by
22% to a total of 78% of students stating that PBL was more effective in helping them explain experiences in their lives. Interviewees stated that the information in PBL units was “retained more easily” which in turn made it easier to explain experiences using science concepts. Multiple students also stated that the real-world problem addressed during our PBL units helped them relate concepts learned in class to experiences in their lives.

Question 16 on the post-unit survey asked students to rank how “the PBL process helps me to explain the science behind things that happen in my everyday life.” A follow-up question asked the students to “explain which process – traditional or PBL – better prepared you to explain the science behind things that happen in my everyday life.”

Student’s elaboration of their Likert-survey scale responses provided insightful information on their feelings about the effectiveness of our PBL units. One student stated that the PBL projects helped him as he,

“…had to do in-depth research about specific topics. Instead of just saying ‘mitochondria is the powerhouse of the cell’ I learned about topics that impact people on a day-to-day scale, like genetic diseases and inheritance.”

The majority of the students shared that the PBL units “challenged them” and “caused them to think more in depth about the concepts we were learning in class.” The driving question introduced for each unit gave students a connection to the real-world and made lessons more relevant as “the whole project was based around applying what we learned to a scenario.” Another student stated that the PBL unit “helps link the information to the problems we will encounter in the everyday world.” Similarly, another student stated
that “I think that the PBL better prepares me to explain everyday life because it helps give context to the things that we learn.” In her response on the post-unit survey, a student I also interviewed gave one of the best examples of the effectiveness of our PBL lessons. She stated,

“The PBL process better prepared me to explain the science in everyday experiences. For example, I needed to know my blood type for a medical form but no one in my family knew so I used my knowledge of Punnett squares to determine the probability of my blood type based on my parent’s type.”

Responses like this illustrate how students were able to take the information we learned in class and directly apply the concepts to their everyday life.

The Likert scale average for question 16 which asked students how PBL instruction “helps me to explain the science behind things that happen in my everyday life” was 2.5 with a standard deviation of 1.01 (n=58) which means that the majority of the students were either neutral or agreed with this statement. Examination of student’s open-ended responses showed that 52% of the students either agreed or strongly agreed that the PBL process better prepared them to explain experiences in their life whereas only 10% of students disagreed or strongly disagreed with the statement. In examining the open-ended explanation of their Likert scale ratings, 72% of students clearly stated that the PBL units were more effective in helping them explain the science behind things in their lives.

Instruction via PBL better prepares students for assessments
Results from formative and summative assessments from biology students in the 2014-2015 school year were used as a comparison to those given in the current school year. During the previous school year, instruction occurred via traditional, teacher-centered methods. During the mid-point interviews, all of students said that they felt like the PBL units prepared them for quizzes and tests. One student said that the “PBL lessons did prepare me for the quizzes/tests because of the fact that I could take as much time with a concept as I needed (within certain parameters) until I fully grasped the topic of area of study.” Unfortunately, the percentage of students who felt like the PBL units prepared them for the quizzes and tests dropped to 56% by the end-point interviews. Students who preferred the traditional instruction methods stated that they did better when they had notes from lectures and worksheets to study from when preparing for tests. However, the students who still felt like the PBL units prepared them for assessments felt very strongly about this method. The student quoted above also stated that they “noticed a significant increase in my quiz and test scores when using the PBL method.” Whereas another student stated that “for our presentation to get a good grade you needed to know the information for the presentation and your repost so it stuck in your head.”

The results from two tests and one quiz were used for comparison between the previous year and present year biology classes. A t-test was performed on the results for each set of students and each assessment. When comparing the 2014/2015 and 2015/2016 students, results from the Mendelian Genetics test did not show any statistical difference, t(97) = 0.8439, p = 0.4038. The structure of DNA quiz produced a similar
comparison as the t-test again did not show any significant difference, \( t(96) = 0.1886, p = 0.8514 \). The only test results showing a significant difference was the Molecular Genetics test. Students from the 2014/2015 school year had a mean test score of 78% with a standard deviation of 4.4 (n=45) whereas students from the 2015/2016 school year had a mean test score of 73% with a standard deviation of 4.6 (n=58). The completed t-test showed a statistically significant difference, \( t(102) = 2.0368, p = 0.0477 \). While these results do not show that PBL is a more effective method of improving student assessment scores, they do show that it is just as effective as traditional instructional practices.

While the data does not show a statistical improvement from one school year to the next there were some interesting results when assessment results from the second quarter of the 2015/2016 were compared with those from the third quarter of the same school year. Up until the beginning of the action research project, students in my biology classes were taught using traditional classroom practices such as lectures, one day laboratory activities, worksheets, notes, and similar assignments. During the third quarter of the school year, students were instructed using the PBL model. Three biology classes participated in two PBL units and two out of the three classes showed an improvement in their mean assessment average from the second to the third quarter. One class in particular showed significant gains as the overall mean assessment average increased by 5% from the second to third quarter. This class in particular is my largest, most difficult class and behavior is a problem on a day to day basis. However, students in this class made the largest gains during the PBL units and seemed to really respond to the hands-
on, real-world activities. A student from this particular class stated that with traditional one day lessons she is often confused whereas with the PBL units she felt like she was constantly reviewing the material and was able to develop a deeper understanding. Another student from this class who is frequently absent stated that “it was kind of hard to follow through if you had an absence, but it was good because it made you want and have to come to school more often.”

**Student attitudes towards science coursework increased**

The first question on the Likert-style pre and post surveys asked students if they liked going to science class and then asked them to elaborate on their answer. A t-test was used to analyze student responses and data collected from this question. The Likert scale average from question one for the pre and post-unit surveys did not show any statistical difference. Students were then asked to explain their answer to this question. Several themes in student response presented themselves upon closer examination. With the pre-survey, students who agreed or were neutral with the statement made up 65% of the students whereas only 6% of the students strongly disagreed with the statement. Further reading of the student explanations showed that students who ranked themselves either three or four on the Likert scale stated that they were “not comfortable” with the subject area or that they just didn’t understand biology. One student shared that they “enjoy the class itself but no matter how hard I study or focus on the material, I never fully grasp the content, which is frustrating and makes it less enjoyable.” The few students who rated themselves a five just didn’t like science or stated that they thought the class was boring.
While no statistical difference was seen between the pre and post-survey Likert scale responses, the explanations students gave provided some interesting information about changes in their attitudes towards science during the PBL units. Upon examination, 64% of students clearly stated that they liked coming to class more during PBL units. One student even remarked that “I was actually excited to come to class and work with my PBL group.” This sentiment was reiterated by another student who said that “I was having more fun with the PBL during science class. It made me wonder what we are going to do next.” Some of the reasons that students listed as to why they enjoyed lessons more during the PBL units were that “everything was planned out and organized. There was no confusion about what and when things were due and we were given dates for every assignment, presentation, and test/quiz.” Students also stated that they liked the independent aspect of PBL in that they “could just walk in and know what we were supposed to do” and “had more control over the content I was producing, which caused me to enjoy going to class more than a traditional lesson.” The independent aspect of PBL provided a creative aspect that was appealing to students. One student’s response to this question stated that “It was more fun to be able to express our creativity and work with other people instead of doing a project by ourselves. It made me genuinely enjoy this class more than I usually do.”

Not all comments were positive though as several students expressed a level of stress or confusion with the PBL units. Out of fifty-eight students, 24% disagreed or strongly disagreed with the statement “I liked coming to science class more during the Project-Based Learning (PBL) units.” Twelve students or 21% also included words like
stress, anxiety, worried, and other related phrases in their explanations for their Likert scale responses. These two percentages did not have exact cross over between students as some students who agreed with the statement also expressed feeling stressed. However, closer examination revealed that students who stated they felt “stressed” or “worried” during the PBL units usually had problems related to group dynamics or disorganization. A high performing student in my class stated that “it really depended on the day” as to whether or not she liked coming to class more during PBL units. On days we did hands-on activities she looked forward to coming to class but then on other days she realized, “I had to work with my group and everyone had issues and I had to explain everything and do everything and gahhhh.” Another student shared that they liked to be “self-dependent so that if I receive a bad grade on something, I know it was my fault. Working in groups forces me to trust that my teammates have done the work assigned and that is not always true. PBL gives me constant anxiety and stress.”

Whether or not students were organized was definitely a determining factor in ranking on the Likert scale survey. The responses and Likert scale rankings of two students validated my observation on the effect of disorganization. The first student stated that “I don’t like to come to class on certain days, such as when I am not organized and don’t know what is due, but on other days when I have all of my work done, it is ok.” The second student reiterated this same idea when they said that “depending on the day on which I was coming to class. If we were unprepared for the class then I didn’t enjoy coming, however when we were prepared it wasn’t too bad.”

Initial implementation of a project-based learning unit has its challenges
As a teacher, I enjoy attempting new instructional strategies in hopes that they will increase student understanding and enjoyment. This was one of the driving reasons I chose to focus on PBL as part of my research. Unfortunately, no instructional method is 100% accurate, especially on the first attempt at implementation. A teacher must enter any new endeavor with an open mind and be prepared to fail. This was a common trend in the implementation of PBL in my classroom.

As I have never implemented a PBL unit in my classroom before, everything about this type of instruction was new to me. Three things stood out as major problems during the implementation of PBL: preparation time, group dynamics, and the level of freedom awarded during lessons of this type. The amount of preparation it takes to effectively conduct a PBL unit became evident from the beginning of my classroom research project as the very first post in my teacher journal reads:

Lots of prep time required and I am still looking for a PBL for my second unit as I had to change my timeline. I think that I will have to make my own PBL which is doable but a lot more work. I think I will feel better after I implement this first PBL.

My first unit was modified from a PBL created by another teacher. I had to alter some of the assignments but it was a great option for implementing this type of learning in my classroom for the first time. For the Mendelian Genetics PBL unit, I followed approximately 90% of the assignments/instructions from the PBL however, it became clear very early on in the process that some of the methods would not work in my classroom. I strive to be as organized as possible for my ninth grade biology classes as
the students are already disorganized so I had to stay one step ahead of my students. Because of this, I tried to get every document related to our PBL uploaded onto our learning management system, Schoology, as quickly as possible so that it was accessible to students. This ended up being one of the problems students mentioned in their surveys and interviews. During our mid-point survey one student suggested that I “should put up a guide for how to get to all of the assignments and how we should do them, at least for the first time we do an assignment.” A PBL station was set up in my room and many documents were printed, photocopied, and filed at this station for easy access. However, some students were confused about what was already printed off, what was on Schoology, and what documents should be printed. The initial disorganization of Schoology was also reiterated by the special education teacher’s aide I interviewed. This aide is present in two of my biology classes that have a higher number of students with individualized education plans (IEP). She shared that

It would be helpful to organize Schoology folders and label them with assignment checklist that was given to the students. I know some of them had trouble finding the information especially if they missed a day of class.

While this seems like a minute problem it ended up being very frustrating for students in that they couldn’t find what they needed and frustrating for me as I had to answer the same questions over and over again. Reorganizing the folders for the second PBL unit aided in fixing the confusion over the location of documents. Students also had an easier time determining which documents were already printed and those that they could access electronically.
The second PBL unit that was implemented was also from another teacher but had to be modified even more than the first. However, as I had already implemented one PBL I knew what did and did not work in my classroom and for my students so the set up was not as painful. Even though the amount of preparation time for PBL’s was large in comparison to a lesson in a traditional classroom I felt as though my classroom ran smoother. Rather than lecturing at the front of the room PBL allowed me to check in with students as to their group’s progress and have more in depth conversations about the concepts we were learning. At first I was not totally comfortable with this type of instruction as I like to know exactly what is going on with each and every student, which is easier if you are standing at the front of the room as one would during traditional instruction. In my teacher journal I discussed the problems I encountered with this shift in instruction.

When I have everyone together as a class working on the same assignment I am more aware of what is going on at each table. With PBL they could be working on anything. I’ve noticed that I sometimes don’t catch students who are struggling as much as what I would in a teacher centered classroom. I think it’s good because it is making the students advocate for themselves but they don’t always do a good job of this.

Luckily, my teacher’s aide assisted in pinpointing students who were struggling and we both adapted to this new type of instruction. At the end of the PBL units she commented that
Throughout the PBL unit it allows students who would normally fall behind to make connections and fill in gaps of missing or misunderstood concepts. It also allows traditional students who would pick up concepts easily an opportunity to be challenged and rise up in leadership roles.

The second major issue in implementing PBL for the first time was group dynamics. This was a problem throughout both PBL units and was frequently mentioned in my teacher journal. For both PBL units I did not allow students to pick their own groups. Groups were organized based on interests surveys completed before the first PBL, grades from the second quarter, and student requests to not work with specific classmates due to various reasons. Early on in my project group dynamics is mentioned as an issue.

Group dynamics are starting to come into play. Several groups have one student who is not contributing as much as they should be to their group. I also had several students get suspended so I had to ensure that the groups collaborated even in their absence. It’s also hard to explain to parents why you can’t just tell them what their child should be working on with PBL.

This was also a problem mentioned on student’s survey responses. A theme that was evident in their explanation was that students who liked their group also like PBL units whereas students who had problems with their group members did not like the PBL model. One student shared that “If the group is good and everyone works together and does their work it is more enjoyable but if the group doesn’t do their work and one person is doing all the work then it is not enjoyable.” A similar response was expressed by
another student who stated that “I enjoy coming to a group and knowing the entire load is not on me but I still have a significant role however, if my group slacks then I don’t enjoy it and feels as if everything is put on me.” One student even offered a suggestion for how to improve the group dynamics problem. In her post-unit survey response she suggested that students could “write why we think a proposed group would work and then get it approved that would prevent group conflicts.”

As a teacher, the group dynamics aspect of PBL was also stressful for me. One idea I had was to take lower performing students who don’t want to do any work and place them in a group containing a member who possessed a strong personality. In one class this tactic was very effective and a student who had done very little work the first half of the year gave a wonderful presentation of his artifact at the end of the unit and improved his grade. Unfortunately, this same tactic did not work as well in another class where a low performing student sunk even lower as his personality clashed with the strong personality of his group leader. Student groups were changed for each PBL which helped to alleviate problems that had appeared during the first PBL but new problems in this area arose in the second PBL as well. However, the group dynamics issue also had some positive aspects and produced some interesting results based on the group composition. While observing students during a group activity I noted that

A lot of students responded positively. It was fun watching them blow on the coins for luck so that their baby wouldn’t have a unibrow. It also brought up a good real life example about how a parent loves their baby no matter what traits they are born with. We also talked about how you can’t choose your baby’s traits.
Some students really enjoyed the group aspect and commented that “I personally learn more when I work in a group so I much rather do that then listen to a lecture” while others stated that they “like that in PBL we work in groups and we are independent.”

Another interesting aspect was seeing how student attitude and performance in class changed based on their group. Three young ladies who worked together on the second PBL unit were all in separate groups during the first unit. Each student performs at an average level in my class and continued this level of performance during the first PBL. They contributed to their groups but were not really leaders in the group. During the second PBL unit the three students were combined together in a group. As a group, their test scores rose an average of 20% from our previous PBL unit and the grade on their PBL artifact rose an average of 10% from the first PBL. On the day they gave their presentation for the Molecular Genetics PBL they were almost giddy coming back to the classroom as they were so proud of the work they had accomplished.

An increase in the amount of freedom given to students is something most teachers assume would be a welcome change but this proved to be one of the stressful aspects of PBL. For the first PBL I attempted to leave the learning more open-ended and individual assignments on a checklist were not given a specific due date. Students were told to assign their own homework and manage their group. All assignments leading up the final PBL artifact presentation were due by the end of the unit. My original plan was to periodically check assignments throughout the unit and mark off assignments on the student checklist when they were finished. This tactic was not effective and was noted in my teacher journal
I have not been checking off assignments on the checklist the way that I would like. For the next PBL I plan to come up with a new checklist format and way to ensure grading is finished.

This problem was also noted by a student I interviewed at the mid-point of the classroom research project as she noted that she thought that “there could have been due dates of some things and you could walk around and check to see how people were doing and tell them they might need to start doing things.” My students were not used to managing their education and were too used to teachers telling them exactly how and when to do everything. When they had to think logically and problem solve as to how they would attack a large assignment they lacked the necessary skills. This inability of students to manage their time and collaboratively plan with their group is explained by John Sweller who states that

Despite the alleged advantages of unguided environments to help students to derive meaning from learning materials, cognitive load theory suggests that the free exploration of a highly complex environment may generate a heavy working memory load that is detrimental to learning. This suggestion is particularly important in the case of novice learners, who lack proper schemas to integrate the new information with their prior knowledge (Kirschner et. al, 2006)

This problem was especially true of special education students. One student interviewed said that she really struggled with the PBL units and “preferred traditional units because they presented a small piece of information.” She needed to digest that small piece of
information and then move on to the next piece of information rather than looking at what she considered to be a large daunting assignment.

At the end of the first PBL students filled out a questionnaire where they were asked to give suggestions on how I could improve this particular unit if I was to complete it in the future. The one suggestion that showed up repeatedly on student questionnaires was that they wanted more firm due dates to help hold them accountable. Per their suggestions, I added due dates for groups of assignments to assist students in not becoming overwhelmed by the PBL unit. Due date implementation for the second PBL was a success as one student mentioned that “the first PBL wasn’t as effective as this past one we did.” When asked if the implementation of due dates was helping them 100% of the students in all three classes as well as the special education teacher’s aide said that it was an improvement to our PBL unit. When interviewed, the teacher’s aide also offered some insight as to how we could limit the amount of students struggling. She stated that it would be best to start PBL at the beginning of the school year. By the end of the year students would be more familiar and comfortable with the process.

However, in spite of their apprehension with PBL students overall still seemed to prefer that method of instruction over traditional, teacher-centered methods. Question seven and eight on the post-unit survey compared the effectiveness of traditional and PBL methods for learning about science. Question seven focused on the effectiveness of traditional instruction methods and had a Likert scale average of 2.98 with a standard deviation of 1.02 (n = 58). Question eight contained identical wording as question seven but responses dealt with the efficacy of PBL as an instructional method. This question
had a Likert scale average of 2.33 with a standard deviation of 0.94 (n = 58). A t-test of these results showed a statistical difference where t(57) = 3.7841, p = 0.0004. This shows an extremely significant difference in how students felt about the effectiveness of PBL.

When looking the data as a whole the Likert-scale surveys did not provide as much data as I had hoped in regards to the scaled answers. On the other hand, student explanations for their Likert-scale rankings were very telling and provided valuable information when analyzing the data. In examining their responses it was evident that they preferred learning via PBL as it provided more hands-on activities, related to their real life, and allowed them to share their work with people outside our classroom.

Interview responses from the teacher’s aide and my teacher journal also showed that PBL allowed students to step into leadership roles and help motivate students who would usually fall behind and lack understanding.

**INTERPRETATION AND CONCLUSION**

By implementing project-based learning units in my classroom I wanted to prove that this type of instruction was capable of increasing the academic achievement level of my students. While the data collected showed that PBL is not necessarily a more effective method it did prove to be just as effective as traditional instruction methods. This was evidenced by the many positive comments made by students as well the teacher’s aide and other adults who served as evaluators for final presentations.

Students felt that instruction via PBL made it “easier to grasp concepts and retain the information” learned during the two PBL units. They also commented that the PBL units were “more enjoyable, more entertaining, and fun” as students enjoyed the hands-on
aspect of the PBL lessons. Question two of the post-survey asked if students “enjoyed learning new science concepts” through PBL. Only eight of 58 students disagreed or strongly disagreed with the statement whereas 33 students or 57% agreed or strongly agreed with the statement. In their explanation for their Likert-scale ranking for question two, one student commented

I enjoyed learning new science concepts through the Project-Based Learning model because it was a combination of being taught the information and then us having to conduct independent research. The information we were taught gave us the basic understanding of the topics and the research allowed us to take the next step and further our knowledge about the topic at our own pace in order to complete the assignments given.

The flexibility to work at their own pace was another positive aspect mentioned by many students throughout this process as well as the teacher’s aide. In a traditional, teacher centered classroom, all students are doing the same thing at the same time. With this form of instruction all students are expected to finish assignments at the same time so that the class may move forward. This is not always an effective tactic as most classrooms are a mixture of students who have varying levels of understanding for that particular activity. My teacher’s aide commented that she felt PBL was more effective because if “any information was not understood with one activity, the students had time to process the information and make connections.” This idea was reiterated by one of my higher performing students who was interviewed. She stated that
The part I enjoyed most about the PBL process was that although there were certain due dates that had to be met, most of the assignments were self-paced. If you didn’t understand a concept, you could take your time and find an explanation that makes sense to you rather than having about an hour and thirty minutes to grasp the information and complete an assignment.

This same student stated that she felt the PBL method was more effective for her because it allowed her to “learn topics in a way that works for me, but maybe not for the teacher.” While many students loved the idea of having the entire unit planned out from day one others were overwhelmed by this idea. When implementing future PBL units I plan to make specific accommodations for students with IEP’s. Several of my special education students stated that they felt lost or overwhelmed and would have preferred to receive a small chunk of information in worksheet. One student I interviewed stated that she had trouble “processing the large chunk of information” and wanted to do more traditional assignments like worksheets as she could understand those more easily.

Group dynamics was one of the difficult aspects of implementing a PBL for the first time however, it also ended up being one of the things that students enjoyed the most about PBL and produced many real-life teaching moments. One student commented that they “really liked learning science because if you’re placed with people who can grasp it better it’s a lot easier when they help you especially when they’re always there.” Students also expressed that they liked learning from others and teaching concepts to classmates. One student stated that they “learned information from others instead of learning it myself, which I liked for some reason.” Students also commented that they
“learned a lot after watching other people’s presentations” Overall I feel like the group aspect of PBL really helped some students excel. Students who previously stayed in the background were able to share their knowledge and step up as leaders in their group. One student’s simple explanation really solidified what I think is the main idea of PBL, he stated that “this is all PBL does, it gives you a question to answer and while looking for the answer, you learn.” Placing students in an effective group was the hardest aspect of implementing PBL. Students often wanted to pick their own groups or keep the same group for both PBL units. One student suggested that a way they could choose their own groups is to “write why we think the group would work then get it approved and that would prevent several group conflicts.” The group dynamics aspect of PBL is definitely something that a person implementing this type of instruction should be prepared for ahead of time.

VALUE

Using project-based learning in my classroom was an eye opening experience. Implementation of this instructional method was beneficial to my students as well as me. PBL allowed students to collaborate in peer groups, present a final product to community members, and learn better time management skills. As a teacher, PBL forced me to think about how lessons should be implemented in my classroom and what instructional methods work best for my students. In the past, feedback in my classroom has only been given to students who requested it or after a final assessment/project had already been submitted. With PBL, my students were able to get feedback throughout each unit from myself as well as their peers.
The collection and analysis of data to support my research was a fulfilling experience. Many teachers are so accustomed to using the quantitative data produced from student scores on assessments or overall grades. Classroom research allows a teacher to look at different forms of data and then use the information from this data to shape instruction in their classroom. Qualitative data analysis was one of the pieces I was concerned about when completing this project. Would I be able to find any themes amongst this data and would it be a reliable data source? The answer to both of these questions is yes. The qualitative data I collected in the form of student interview responses and the follow-up questions on the Likert-style pre and post-unit surveys actually provided more data than the quantitative data produced from assessment scores and Likert-scale averages. By analyzing the qualitative data I was able to get a clearer picture of exactly what my students thought about project-based learning instruction.

The process of using data to investigate instruction in my classroom showed me the shortcomings in my current method of instruction as well as the positive aspects. PBL is a more authentic instructional method and my students greatly benefited from the implementation of this project. It was evident that they gained confidence in their public speaking skills, they enjoyed sharing their knowledge with classmates, and while many of them may not be doctors or scientists, they are now better prepared to explain science occurrences in their everyday lives. As a teacher, I also gained insight into what my students are capable of when I just go with the flow and focus on being a facilitator more than a teacher. In my opinion, that’s when true learning can begin.
REFERENCES CITED
REFERENCES CITED


APPENDIX A

STUDENT SURVEY PRE-TREATMENT
**Student Survey – pre-treatment**  
(Adapted from Sloan, 2013)

**Directions:**
This survey contains a number of statements about science and the way in which you learn in science classrooms. You will be asked what you think about these statements. There are no right or wrong answers. Your response should be your opinion, not what you think I want to hear. Participation in this research is voluntary. Whether or not you participate will not affect your grade or standing in this class in any way.

Use the following scale when answering each question in this survey:

<table>
<thead>
<tr>
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<th>1</th>
<th>2</th>
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<tr>
<td></td>
<td>Strongly Agree with the statement</td>
<td>Agree with the statement</td>
<td>Neutral (you don’t agree or disagree with the statement)</td>
<td>Disagree with the statement</td>
<td>Strongly Disagree with the statement</td>
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</table>

1. I like going to science class.  
*Follow-up question:* Please explain your selection for question # 1:

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<th>SA</th>
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2. I enjoy learning new science concepts.  
*Follow-up question:* Please explain your selection for question # 2:

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3. I enjoy science laboratory experiences.  
*Follow-up question:* Please describe your typical laboratory experience in middle school? Explain the aspects of the process you liked as well as those you disliked.

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4. I enjoy hands on activities like experiments more than book activities.  

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5. Doing experiments is not as good as finding out information from teachers.  

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</table>

6. I would rather learn biology concepts through laboratory experiences than by reading about the topics.  

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7. The traditional learning process (textbook reading, lectures, and labs) is an effective method for learning science concepts.

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<td>8. The traditional learning process (textbook reading, lectures, and labs) prepares me well for science tests/assessments.</td>
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<td>9. A basic understanding of science is needed for everyday life activities.</td>
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<td>10. I can use science to explain things that happen in my everyday life.</td>
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<tr>
<td><strong>Follow-up question:</strong> Can you give a specific example of something from your everyday life that you are able to explain using science.</td>
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<td>11. The traditional high school science laboratory experience helps develop critical thinking skills.</td>
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<tr>
<td>12. High school laboratory experiences should have a set procedure to follow.</td>
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<tr>
<td>13. The information in a high school science textbook is absolute/concrete knowledge.</td>
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<tr>
<td>14. The traditional high school science laboratory experience is full of complexity.</td>
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<tr>
<td>15. The same data can result in multiple solutions.</td>
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<tr>
<td>16. Science research should only have one variable.</td>
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<tr>
<td>17. Science concepts can be learned through the use of laboratory experiences.</td>
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<tr>
<td>18. High school laboratory experiences should have a more open-ended procedure.</td>
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</tbody>
</table>
APPENDIX B

STUDENT SURVEY POST-TREATMENT
**Directions:**

This survey contains a number of statements about science and the way in which you learn in science classrooms. You will be asked what you think about these statements. There are no right or wrong answers. Your response should be your opinion, not what you think I want to hear. Participation in this research is voluntary. Whether or not you participate will not affect your grade or standing in this class in any way.

**What class period are you in?**

- [ ] Blue 2
- [ ] Blue 4
- [ ] Red 8

**What are the last four digits in your ID number?** ____________________________

*(Note: this will ONLY be used to track responses from the pre- to the post-survey)*

Use the following scale when answering each question in this survey:

<table>
<thead>
<tr>
<th>Strongly Agree with the statement</th>
<th>Agree with the statement</th>
<th>Neutral (you don’t agree or disagree with the statement)</th>
<th>Disagree with the statement</th>
<th>Strongly Disagree with the statement</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>2</td>
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<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

1. I liked coming to science class more during the Project-Based Learning (PBL) units (Mendelian Genetics and Evolution).

Follow-up question: Please explain your selection for question # 1:

2. I enjoyed learning new science concepts through the Project-Based Learning (PBL) model.

Follow-up question: Please explain your selection for question # 2:

3. I enjoy the one-day science laboratory experiences (that are typical of the traditional learning model lab experience).

4. I enjoy hands-on activities more than book activities.

5. I enjoyed the hands-on Project-Based Learning (PBL) model experience.

6. I would rather learn biology concepts through PBL experiences than by reading about the topics.
7. The traditional learning process (textbook reading, lectures, and one-day labs) is an effective method for learning science concepts.

8. The PBL learning process (using big picture problems/questions) is an effective method for learning science concepts.

9. Science concepts can be learned thoroughly by trying to solve real problems.

10. The traditional learning process (textbook reading, lectures, and one-day labs) prepares me well for science tests/assessments.

11. The Project-Based Learning (PBL) process prepared me well for science tests/assessments.

**Follow-up question:** Please explain which process—traditional or PBL—prepared you better for assessments:

12. The PBL process helps develop critical thinking skills better than traditional high school science laboratory experience.

13. High school laboratory experiences should have a set procedure to follow.

14. The traditional high school science laboratory experience is full of complexity.

15. The PBL learning experience is full of complexity.

16. I prefer the open-ended procedure of the PBL model.

17. The information in a high school science textbook is absolute/concrete knowledge.

18. The PBL process helps me to explain the science behind things that happen in my everyday life.

**Follow-up question:** Please explain which process—traditional or PBL—better prepared you to explain the science behind things that happen in my everyday life.
<p>| | | | | | |</p>
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</thead>
<tbody>
<tr>
<td>19. I would like to continue learning biology concepts using a Project-Based Learning (PBL) model in the future?</td>
<td>1</td>
<td>2</td>
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<td>4</td>
<td>5</td>
</tr>
<tr>
<td>20. The PBL learning process (using big picture problems/questions) is an effective method for learning science concepts.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>21. Science concepts can be learned thoroughly by trying to solve real problems.</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>5</td>
</tr>
</tbody>
</table>
APPENDIX C

MID-POINT STUDENT INTERVIEW QUESTIONS
Mid-Point Student Interview Questions  
(Adapted from Sloan, 2013)

**Your participation in this interview process is voluntary. Whether or not you participate will not affect your grade or standing in this class.**

1. How do you feel about project-based learning (PBL)?  
   A. What did you like the most about the PBL process? Please explain your response.  
   B. What do you like the least about the PBL process? Please explain your response.

2. Do you like attending science class? Please explain your response.

3. Which type of lessons, traditional (lecture notes, worksheets, and single class day labs) or PBL helped you to understand concepts better? Please explain your response.

4. Did the PBL lessons prepare you for the quizzes/test?

5. Do you think it’s important to be able to explain experiences in your life using scientific concepts? Please explain your reasoning.

6. Which learning method, PBL or traditional, helps you to explain experiences in your everyday life using scientific concepts?

7. Do you prefer traditional labs (usually occurring on a single day) or the PBL process? Why?

8. How do you think I could improve the PBL process in the future?

9. Would you like to add anything else?
APPENDIX D

END OF PROJECT STUDENT INTERVIEW QUESTIONS
End of Project Student Interview Questions

Your participation in this interview process is voluntary. Whether or not you participate will not affect your grade or standing in this class in any way.

1. Which method of learning science is more effective for you, traditional or PBL? Please explain.

2. What are your impressions of the Project-Based Learning (PBL) process? 
   A. Would you like to learn concepts using the PBL model again? Please explain.

3. Which type of lessons, traditional (lecture notes, worksheets, and single class day labs) or PBL helped you to understand concepts better? Please explain your response.
   A. Which process do you think will allow you to recall concepts better in the future?

4. Which method, traditional or PBL, better prepared you for the quizzes/test?

5. How do you feel about having to create a PBL artifact?
   A. What differences do you see between how our PBL artifact was produced in comparison to a regular project we would complete during a traditional lesson?

6. Do you think it’s important to be able to explain experiences in your life using scientific concepts? Please explain your reasoning.

7. Which learning method, PBL or traditional, helps you to best explain experiences in your everyday life using scientific concepts?

8. Do you prefer traditional one-day labs or the PBL process? Why?

9. How do you think I could improve the PBL process in the future?

10. Would you like to add anything else?
APPENDIX E

TEACHER OBSERVATION JOURNAL PROMPTS
Teacher Journal Prompts
Teacher observations will be recorded informally in a composition notebook on a day to day basis as necessary. These observations will include quick, short thoughts about important aspects of the lesson related to the research questions.

Three times a week, the quick, informal observation notes will be transcribed into a formal record of teacher observations on Google Docs. Each day of formal observations will begin with a brief summary of the focus of the lessons from the previous couple days. The remainder of each formal observation will include answers to the questions in the table below. This table is the template that will be used to complete observations each day.

<table>
<thead>
<tr>
<th>DATE:</th>
<th>SUMMARY:</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUESTION:</td>
<td>RESPONSE:</td>
</tr>
<tr>
<td>What were the positive aspects of the lessons from the past couple days?</td>
<td></td>
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<tr>
<td>What problems did you face as a teacher related to implementing a project-based learning unit?</td>
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<tr>
<td>Were there any unique situations, anecdotes, stories, or other interesting events to report on today?</td>
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<tr>
<td>• Any students in particular who responded positively or negatively to the lesson format?</td>
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<tr>
<td>• Changes in student attitude?</td>
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<tr>
<td>• Connections made to everyday life?</td>
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<tr>
<td>Any other important pieces of information to report?</td>
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</tbody>
</table>
APPENDIX F

TEACHER’S AIDE INTERVIEW QUESTIONS
Teacher Interview – Special Education Teacher’s Aide

1. What are your impressions of Problem-Based Learning (PBL)?
   A. What do you like most about the PBL process? Please explain your reasoning.
   B. What do you like least about the PBL process? Please explain your reasoning.

2. Which learning method, traditional (i.e. textbook reading, lectures, and one-day labs) or PBL, do you feel helped the students to understand concepts better? Why do you think that is?

3. Which learning method, traditional or PBL, required more time for students to understand concepts? Why do you think that is?

4. Did the PBL process do a good job of preparing students for a quiz/test?

5. Do you think that the production of the PBL artifact is a more authentic assessment than the traditional types of projects you have seen? What differences do you see between how our PBL artifact was produced in comparison to a regular project we would complete during a traditional lesson?

6. Do you think that the PBL method helps students to better explain experiences in their everyday lives using science?

7. How do you think I could improve the PBL process in the future?

8. Would you like to add anything else?
62

APPENDIX G

SUBJECT CONSENT FORM
SUBJECT CONSENT FORM FOR PARTICIPATION IN HUMAN RESEARCH AT MONTANA STATE UNIVERSITY

Project Title: The Effect of Project-Based Learning on Academic Achievement in the Classroom
Investigator: Alyson Darconte

Your child is being asked to participate in a research study on the use of project-based learning in the classroom. This research will give me a better understanding of what learning strategies work best with my students. Your child was selected for this research study as they are a member of one of my three biology classes at Bitburg Middle-High School.

Participation is voluntary. If you agree that your child may participate they will be asked to complete a survey at the beginning and end of the project. Nine students will also be selected to participate in an interview at the mid-point and end of the research project. Participation is voluntary and the students can choose to not answer any questions they do not want to answer and/or stop at any time. Participation or non-participation will not affect the student’s grade or class standing.

Surveys and interview questions will be administered via Google forms and will take approximately 10 minutes to complete. The first survey will be conducted in January, 2016 and the second survey will be conducted the end of March/beginning of April 2016. Interviewees will also meet for no more than 20 minutes during seminar to discuss their answers to the questions on Google forms. The group interview session data will be collected via audio recording and transcribed into print. Interviewees will answer questions and meet the middle of February, 2016 and again at the end of March/beginning of April 2016. There are no foreseen risks to participating in this research project.

All personally identifiable information will be kept confidential during the surveys and interviews as well as in the final research paper. The last four digits of your student’s school ID number will only be used to compare surveys administered at the beginning and end of the project and interviews administered at the mid and end point of the project.

If you have any questions regarding the research project please contact Alyson Darconte at: Alyson.daronte@eu.dodea.edu or 06561 94810 ext. 2735
If you have additional questions about the rights of human subjects you can also contact the Chair of the Institutional Review Board, Mark Quinn at: mquinn@montana.edu or (406) 994-4707
"AUTHORIZATION: I have read the above and understand the discomforts, inconvenience and risk of this study. I, _________________________________ (name of parent or guardian), related to the subject as _________________ (relationship), agree to the participation of _________________________________ (student name) in this research. I understand that the subject or I may later refuse participation in this research and that the subject, through his/her own action or mine, may withdraw from the research study at any time. I have received a copy of this consent form for my own records.

Parent or Guardian Signature: _________________________________
Child's Name: _________________________________
Investigator: Alyson L. Darconte, Biology Teacher
Date: _________________________________
APPENDIX H

MENDELIAN GENETICS PBL UNIT INTRODUCTORY LETTER
January 13, 2016

Biology Classes
Bitburg Middle-High School
Bitburg, DE 54634

Dear Biology Class,

In February, “The Gary Spranger Show” would like to air a program featuring an unusual situation where identical twins have married identical twins. They are now concerned as future parents about the genetic makeup of the children that would result from their union. Will these children be identical twins as well, even if they are cousins? Will they look like each other and have no individually or unique characteristics?

Your team has been commissioned to create a resource for our local afternoon program “The Gary Spranger Show” that interprets the significance of predicting the genetic makeup involved in the children of identical twin females who have married identical twin males. Using charts, graphics, and photos, show your analysis (supported by your own data as well as historical data) of the genetic analysis that would be used to explain how these children could be different or how these children could be alike.

Your team must first identify genetic laws that will be used to explain the predicted results. The traits in these results must be described, illustrated, and researched. Each team member is responsible for documentation of at least one segment of the multimedia presentation. (See individual responsibilities.) Each team must decide on a theme or focus for its project.

The final team product should be a multimedia presentation that can be shared before a panel of evaluators. It must showcase possible genetic situations that control inheritance of traits, make predictions, and explain how genetic predictions relate to probability. Possible formats include video, PowerPoint®, Prezi, PowToon, or any other multimedia presentation. The multimedia presentation that is determined to be the best by the evaluation panel will appear on this program as a resource.

Good luck. We anxiously await your production.

Sincerely,
Matt B. Thereforyou
CEO, AFM Television Channel 1
MB_There4U@afm.af.mil
APPENDIX I

GENETICS COUNSELING SESSION REPORT RUBRIC
## Genetic Report Analysis Rubric

**Student(s) __________________**

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>UNSATISFACTORY (Below performance standards)</th>
<th>PROFICIENT (Minimal criteria)</th>
<th>ADVANCED (Demonstrates exceptional performance)</th>
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<tbody>
<tr>
<td><strong>Content</strong></td>
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</table>
| 1. The report contains a brief summary in which LESS THAN 3 of the following pieces of information that has been provided about the couples are discussed.  
- genetic disorder  
- affected family members  
- non-affected family members  
- genotypes of affected and non-affected family members. | 1. The report contains a brief summary which discusses ALL of the information that has been provided about the couples.  
- genetic disorder  
- affected family members  
- non-affected family members  
- genotypes of affected and non-affected family members. | IN ADDITION to the minimal criteria… |
| 2. The report provides a brief background regarding LESS THAN 3 of the following about the genetic disorder.  
- symptoms of genetic disorder  
- dominant or recessive  
- homozygous or heterozygous  
- sex-linked or non-sex-linked  
- treatment | 2. The report provides a brief background regarding ALL of the following about the genetic disorder.  
- symptoms of genetic disorder  
- dominant or recessive  
- homozygous or heterozygous  
- sex-linked or non-sex-linked  
- treatment | 1. The report layout is easy to read and understand. |
| 3. The report contains a pedigree which illustrates the family members that have been affected but NOT the possible carriers of the genetic disorder OR members who are not affected. | 3. The report contains a pedigree which illustrates the family members that have been affected or are possible carriers of the genetic disorder as well members who are not affected. | 2. The report contains a karyotype which indicates the affected, extra or missing chromosome. |
| 4. The report contains punnet squares that indicate the potential genotypes of the children the couple are planning to have. | 4. The report contains punnet squares that indicate the potential genotypes and phenotypes of the children the couple are planning to have. | 3. The report contains numerical predictions of the percentage of the couple’s children each acquiring the genetic disorder. |

| Score | 0 | 35 | 69 | 70 | 80 | 90 | 91 | 95 | 100 |

*Modified from Mrs. Kelly Yonce  
*Designer Babies Project, LearnNC.org*