THE EFFECTS OF IMPLEMENTING PROJECT BASED LEARNING IN THE MIDDLE SCHOOL SCIENCE CLASSROOM

by

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DEDICATION, ACKNOWLEDGEMENTS

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TABLE OF CONTENTS

INTRODUCTION AND BACKGROUND 1

CONCEPTUAL FRAMEWORK 3

METHODOLOGY 9

DATA AND ANALYSIS 20

INTERPRETATION AND CONCLUSION 32

VALUE 33

REFERENCES CITED 36

APPENDICES 38

APPENDIX A: Science Opinion Survey 39
APPENDIX B: Student Interview Questions 42
APPENDIX C: Science Notebook Reflection Prompts 44
APPENDIX D: Terms For Concept Maps 46
APPENDIX E: Field Study Checklist 48
APPENDIX F: Summative Assessment 50
APPENDIX G: Flow Chart 55
APPENDIX H: Project Overview 57

LIST OF TABLES

1. Triangulation Matrix 18

2. Timeline 19

3. Science Survey Results 21

LIST OF FIGURES

1. Concept Map Results Pre and Post Instruction.....26

2. Examples of Student Ideal Habitat Drawings.....31

ABSTRACT

The purpose of this investigation was to find out if using project based learning in the middle school classroom is an effective method for teaching key concepts in science while engaging students in the practices of science. Traditional science teaching often seems removed from the work that "real" scientists do. By participating in project based learning, students had the opportunity to do the work of a scientist and then apply their learning to a real world problem. During a unit of study on evolution where the focus question was "Do humans affect the evolution of organisms?" students were presented with a scenario asking them to determine the impact humans are having on the natural environment. To accomplish this task, students learned how to do field studies focusing on biodiversity. Using birds as a focus, they took data on campus and at a nearby public park. Using their data, students evaluated the frequency of native birds species on campus and compared this to the frequency of bird species at a local park. Using their understanding of evolutionary concepts, students hypothesized about the reasons for the results of their data. Based on their conclusions, students made recommendations about how an open space on campus should be modified in order to better support the native bird population. The results of this study showed that project based learning is effective for teaching complex science concepts and promoting the learning and use of scientific practices.

INTRODUCTION AND BACKGROUND

Project Background

As a science teacher, I use a variety of teaching strategies to help my students develop an understanding of both science content and process. I have been able to integrate inquiry-based science into my teaching repertoire on a somewhat consistent basis. Within a unit of study I might ask students to design an experiment to answer a specific question which would require them to incorporate their understanding of content related material, science processes, and investigation skills to successfully accomplish the task. I know how to scaffold inquiry for students who have a limited understanding of how to design and carry out a scientific investigation. I use a variety of teaching strategies and am comfortable taking on the role of facilitator as students work to construct their understanding of science. That being said, I feel that the type of inquiry I do in the classroom, although engaging because it is hands-on and problem solving in nature, does not always result in the purposeful engagement and deep conceptual understanding of science I am targeting. I am especially concerned about students developing an understanding of foundational concepts in biology around the topics of evolution, natural selection, and adaptation while engaging in the practices of science. Project based learning is intriguing to me because, by its very nature, it creates a purpose for learning. For this reason, I have decided to investigate project based learning as a means for exploring how to more effectively engage students in learning the foundational concepts embedded in the study of evolution while carrying out scientific practices.

Teaching Environment and School Demographics

I teach in an urban middle school in the southern California coastal community of Santa Monica. Total school enrollment is 1000 students. The major demographic groups in the school include 13% Black or African American, 52% Hispanic or Latino, and 27% White (not Hispanic), and 8% other (Asian and Pacific Islander). Fifty percent fall into the socio-economically disadvantaged category; 12% are English language learners; and 13% are considered students with disabilities. The surrounding neighborhoods that the school draws students from vary significantly. On one side of the school is the poorest neighborhood in the city where crime and gang violence occur. On the other side of the school is a neighborhood made up of middle and upper income families. Within the school, there are a number of academic programs that students can participate in based on interest and academic achievement. One of these programs is the 7th and 8th grade Santa Monica Science Magnet.

My current teaching assignment includes five classes of seventh grade students for a total of 160 students. The average class size is 32. Three of my classes are made up of students in the Santa Monica Science Magnet. These are students who self select into the program by demonstrating a special interest in science. They choose to participate in after school science enrichment, achieve at least a C average, complete independent science projects, and attend special trips focused on science. In seventh grade, these students are grouped together as “magnet students” for their science classes. The other two classes I teach are made up of “regular” seventh grade science students. Our school follows a block schedule. I see each class for two 100-minute block periods and one 42-minute period during the week.

Focus Question

My desire to provide students with a purpose for engaging in science inquiry has led me to investigate project based learning (PBL). My primary question is: How effective is PBL for teaching middle school science? My sub-questions are: How does PBL affect student attitudes towards science? Does PBL promote understanding of complex concepts in science? To what extent does PBL promote the learning and use of scientific practices?

CONCEPTUAL FRAMEWORK

Project based learning is an instructional strategy where students engage in a student driven inquiry process to find answers to complex investigation questions. The context of the question provides the motivation to learn both science content and process. What distinguishes PBL from science inquiry is the application of the target understanding to a real world problem (Duschl, Schweingruber & Shouse, 2007). PBL incorporates scientific inquiry as advocated for in the National Science Education Standards (NRC, 2000). It also addresses the eight practices considered essential to learning science in the Framework of K-12 Science Education (NRC, 2012). These practices include: “Asking questions (for science) and defining problems (for engineering); developing and using models; planning and carrying out investigations; analyzing and interpreting data; using mathematics and computational thinking; constructing explanations (for science) and designing solutions (for engineering); engaging in argument from evidence; and obtaining, evaluating, and communicating information” (NRC, 2012, p.3). PBL is ideal for middle school students as they have a

high need for learning that allows for competence and achievement, positive social interaction with peers and adults, and meaningful contribution to their schools and communities (Swango & Boles Steward, 2003). The caveat to employing PBL is that it can require both teachers and students to fundamentally change their understanding of how instruction is carried out in the classroom.

Designing a project based learning experience generally follows a backwards-mapping format where one "begins with the end in mind" (Markham, 2003). A number of authors have deconstructed the design process they employed when developing and testing commercial project based learning curricula. In a large-scale study done by Krajcik, McNeill & Reiser (2007), they advocate for a learning-goals driven design model. This study included 870 seventh grade students from a variety of urban schools and was conducted in two phases over a three-year period. The purpose of the study was to describe a method for developing learning-goals driven curriculum called Questioning Our World Through Science and Technology (IQWST). The goal of developing this curriculum was to align standards with learning goals, instruction, and assessment using a project based teaching model. According to these authors, there are three important elements to keep in mind when designing project-based curriculum: The first is to specify goals for learning. This involves more than just a superficial unpacking of the standards; instead, it involves looking in-depth at what knowledge the standard implies. Next, specify the learning goals as learning performances. This involves replacing the word "understand" with a specific cognitive performance that students will have to demonstrate in order to show that they actually understand what they are learning. Lastly,

learning goals need to be aligned with tasks and assessments. This is often difficult to do and relies heavily on the previous two elements.

In another study by Barron et al. (1998) of 111 fifth grade students and 5 teachers from a Title I eligible middle school in metropolitan Nashville, Tennessee, the authors advocate “doing with understanding.” In order to accomplish this, they recommend following four principles when designing effective project-based learning. As with Krajcik et al. (2007), they start with identifying learning appropriate goals. Next, they recommend incorporating learning scaffolds up front, prior to students engaging in the project. These are in the form of short problem oriented tasks that require learning or applying a specific concept or skill that students will need to know or understand when they are engaged in the larger project. In order to do this effectively, the teacher needs to anticipate where students may get stuck and design the tasks accordingly. The third principle states that students should be provided with frequent opportunities for formative self-assessment and revision as they progress through PBL. By doing this, the teacher gains valuable feedback about how to best support students along the way rather than waiting until the end to find out students were confused about an aspect of the project. The fourth principle states the importance of developing social organization that promotes participation and a sense of ownership among students within the PBL experience. Although both of these were large-scale studies that were conducted over multiple years, they highlight important elements that individual teachers can take into consideration when planning PBL.

A third study, consisting of 12 teachers and 652 sixth through eighth grade students, attempted to answer the question “What motivates students to learn science

content?" (Kanter, 2010). The author states that it is important to create a need-to-know situation for science content when designing PBL units. The goal is to structure learning experiences that create motivation for the students to understand the science concepts. Certainly, applying the knowledge gained during a project-based unit of instruction to a real world problem is one way to address this recommendation.

In order for PBL to be effective, teachers need to make the shift from the traditional teacher-centered classroom to a student-centered classroom. According to Park Rogers, Cross, Gresalfi, Trauth-Nare & Buck (2011), teachers with a strong content and teacher-centered approach can have a difficult time making this change towards PBL. Teachers who emphasize process more than content tend to make the shift more readily. A teacher's values heavily influence the ease or difficulty they experience when shifting to PBL. Of note in this case study of three teachers implementing PBL in 9th grade science classrooms, is the finding that if a teacher relies on old teaching strategies when implementing PBL, there may not be a substantial change in the way they teach despite taking on a new curriculum. This study also notes that all teachers need quality professional development, structural support, and administrative backing in order to make the shift from a traditional teacher-centered model to a student-centered PBL model. The benefits outweigh the costs ultimately as the goal of PBL is to increase student engagement, student inquiry, and the ability of students to think and reason critically.

Another issue for teachers in undertaking this type of instruction in the classroom is the need to focus on developing a strong sense of community among the learners in order to foster successful collaboration during PBL. In a study by Crawford (1999), the author suggests that teachers play a "central role in facilitating collaboration" (p.720).

Teachers need to learn how much direction to give and how much responsibility to turn over to students. According to this study, the most effective types of teacher direction include clear project timelines as well as explicit descriptions of teacher expectations for student products. Also, student groups need to be allowed to make decisions on their own in order to develop group interdependency.

For students, the shift towards PBL may bring up other issues in the classroom. In traditional classrooms, students progress through learning experiences under the direction of the teacher. It is assumed that content knowledge is acquired along the way, and the student is tested on their knowledge towards the end of the learning experience. Because of the student-centered approach in PBL, students take on more of the responsibility for their learning when compared to traditional teaching. For students who are unused to this approach, issues may arise. Similar to Crawford (1999), Markham (2003), states that it is important to help students develop group skills, understand how to participate in cooperative learning experiences and use self monitoring techniques prior to initiating PBL in order to avoid negative outcomes early on in the process. The focus is on much more than just the content. Motivation to stay with the project may come up as students initially participate in PBL. A study by Lam, Cheng & Ma (2009) demonstrated the importance of instructional support on the part of the teacher. The results of this study suggest that if students perceive higher instructional support from the teacher, they experience higher intrinsic motivation during the course of the project. This points to the importance of attending to teacher – student interaction during PBL in order to improve learning and motivation.

In this era of high stakes testing in education, standards based instruction is an important consideration when contemplating the use of PBL. Neither process nor content take priority in PBL. However, for PBL to be an effective learning model there should be some assurance that content is learned. Strategically planning how to address science content from the very beginning is essential. Krajcik, et al (2007), recommends strict alignment of learning goals with tasks and assessments. Barron, et al (1998), recommends frequent opportunities for formative self-assessment and revision. Baumgartner and Zabin (2008) used concept inventories pre and post project to evaluate student understanding of subject matter. Of note in this two year study is that students showed a significant gain in self reported knowledge the first year of the study. In the second year of the study, when students participated in authentic fieldwork, they showed more achievement in content knowledge as measured by the concept inventories when compared with the first year cohort. This lends weight to the idea that purposeful participation in the practices of science reinforces the learning of science concepts. In a study by Geier, et al. (2008), the researchers examined the effects of PBL in the context of student performance on standardized tests in a large urban school district. Their results showed a statistically significant increase in standardized test scores with students who participated in PBL units of study. Their findings suggest that PBL can have a cumulative effect as students who had participated in PBL over multiple years had an overall higher average score in all five content and process categories measured by the standardized test regardless of which units the students had participated in. Carefully crafting learning experiences within PBL so that they align with standards is important. Markham (2003) acknowledges that PBL is not particularly effective when there are many topics to be

covered. He recommends that teachers deliberately choose which topics they want to teach in depth and which they are willing to just "cover" in the course of the year. The ones that they are interested in teaching in depth are the ones that lend themselves to PBL; the rest can be taught through more traditional means.

Embarking on PBL seems both exciting and daunting. On one hand, it is exciting because from the outside it looks like the perfect compliment to inquiry based learning in the science classroom. The structure of PBL appears to provide the motivation for students to apply the content knowledge they gain through science investigation to a real world problem. According to Markham (2003), it can bridge the gap between knowledge and thinking as students engage in "learning and practicing skills in problem-solving, communication, and self-management"(pg.6). PBL can set a very personal context for learning as students address concerns that matter to them. On the other hand, using PBL effectively seems like a daunting task initially. Developing a high quality PBL unit will take time and require a different set of teacher skills when compared to planning for traditional lessons. It will take time to build skills with students so that they are able to work independently, cooperatively, and maintain focus and motivation. Also, in a school that depends on more traditional teaching models, it will take effort to explain PBL and the justification for using it to both fellow teachers and administration. I am confident that these obstacles can be met and that, in the end, it will be worth the time and effort to employ PBL in my classroom.

METHODOLOGY

This action research project looked at out how student engagement and mastery of science content standards and practices is influenced by project based learning (PBL). The intervention took place over an eight-week period beginning in January 2013 and ending in March 2013. Both the treatment and non-treatment units focused on California Science Content Standards related to evolution. The non-treatment classes received instruction through more traditional science teaching methods and the treatment class learned the concepts within the context of a project based assignment. Specifically, this study examined the effect of PBL on student attitudes towards science, the ways in which PBL promotes the understanding of key concepts in science and the use of scientific practices.

Participants

The students in both the treatment and non-treatment classes were part of the science magnet program within the school. The demographics of these particular classes varied from those of the rest of the school: 24% of the students were Hispanic, 61% Caucasian, 12% African American, and 3% Asian. About 30% were socio-economically disadvantaged. In each of these classes, one to two students received special education services and none were classified as English language learners (ELL); however, three to four had been reclassified as English proficient. Thirty three students made up the treatment class and thirty four students made up the non-treatment class. As a group, these students were generally mid-range to high achieving, motivated, and easy to engage in science learning. I chose my period 2 and period 6 classes for this study because they were fairly closely matched in academic performance as evidenced by the result of a *t*-

test I ran on a summative assessment on photosynthesis and respiration that students in both groups had taken earlier in the year. The treatment class had a Mean raw score of 86.14 with a Standard Deviation 12.20 (n=33). The non-treatment class had a Mean raw score of 87.34 with a Standard Deviation of 10.19 (n=34). The difference between these two groups was not statistically significant, $t(66) = 0.4382$, $p = 0.6627$. In addition, I had flexibility in scheduling these two classes for trips off campus, and I wanted to get a handle on the teaching/learning issues around implementing PBL before bringing it to my lower performing classes. 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.

Comparison Unit

Students in my sixth period science magnet class comprised the non-treatment class. These students engaged in a series of learning experiences focusing on seventh grade science content standards related to evolution. The focus question for the unit was "Do humans affect the evolution of organisms?" Instruction consisted of a series of short lectures, hands-on activities that demonstrated concepts, investigations, writing assignments, quizzes, and readings. The curriculum used for this unit was taken from the newly adopted California Education and the Environment Initiative (EEI) titled "Shaping Natural Systems Through Evolution" (Hodder, Foss & Hayes, 2010). The focus of this curriculum is to integrate California Environmental Principles into science content instruction. This unit specifically addresses examples of how human activities and evolutionary processes intersect. Students kept a record of their learning experiences in their science notebooks. Writing assignments in their notebooks included asking

questions, reflecting on hands-on activities demonstrating evolutionary concepts, investigations, and researching an endangered species. Throughout the unit, students strove to make connections back to the focus question.

Treatment Unit

Students in my second period science magnet class participated in the treatment unit, which addressed California Science Content standards on evolution through the implementation of a project based learning assignment on biodiversity. The focus question for the unit was identical to the non-treatment unit: "Do humans affect the evolution of organisms?" At the heart of project based learning is a real world application of learning. In this spirit, the project began with a scenario that challenged students to address a current issue in our school:

> "A board of concerned citizens is interested in knowing more about the changes in the biodiversity of the John Adams Middle School campus. Our job, as a class, is to develop an understanding of the changes in biodiversity that have taken place and to specifically examine what impact humans have made on the wildlife found on campus. We will need to understand the ecology of the John Adams Middle School campus, learn about species that are being stressed due to environmental changes, and then make recommendations to the board about things that can be done to improve the situation at John Adams Middle School."

After the scenario was introduced, Phase I of treatment instruction began with introducing students to the skills they would need in order to successfully complete the field study portion of the project. Our focus was on our local bird population. Before they could gather data on birds, students needed to learn how to enter a study site quietly to

avoid scaring birds away, use binoculars effectively to spot and identify specific bird species, understand the data collection recording method, record accurate observations and map out the setting of our field sites. Using a field guide to identify plant and bird species was an additional skill that I wanted them to learn.

To create ownership for the study and have students self monitor their behavior during our field trips to the park, I had them create a "field study protocol." They identified the behaviors necessary to maintain safety while off campus and to facilitate successful bird watching. Students had the opportunity to practice the protocol on campus prior to our first trip to the park. The protocol and practice ahead of time set the tone and expectations for the field studies. The next challenge was to help students learn the different bird species they would likely see at the park. Because I am a novice bird watcher, I recruited a volunteer from the local chapter of the Audubon Society to help with this portion of instruction. Students participated in two activities in the classroom to help them become familiar with the most common bird species in our geographical area. In addition, the Audubon volunteer provided a class set of binoculars each time we did our field study. Students were instructed in the use of the binoculars prior to going on the first field study. Students were also instructed in data recording for both bird counts and habitat observations. The Audubon volunteer was invaluable in helping us accurately identify bird and shrub/tree species that make up the habitat at the park and on campus.

The treatment group spent five class periods outside collecting data on the local bird populations. Two of the periods were spent on the school campus. The other three periods were spent at a local park (Marine Park). Getting to and from the park required a 10-15 minute walk each way. Students recorded data on the number of individual birds

spotted, number of different species noted, and factors in the habitat that allowed the birds to meet their basic needs (food, water, shelter, and a place to raise young). On one day of the field study, we focused specifically on identifying and tallying native shrubs and trees. Through observation, students were able to speculate about which birds benefitted from which plants and why. During the field studies, there were multiple opportunities to bring up informal conversations about how humans might affect the evolution of birds.

Back in the classroom, students compared the bird data from the two locations (campus and park) and began to make some speculations about specific conditions that may be affecting local bird populations on campus. As students analyzed the field data, they began to formulate an answer to the question: “Are people having an impact on the evolution of our local bird population?” Students compiled their data and we entered it on ebird, an online bird data site. Instruction in the principles of evolution and biodiversity occurred in the classroom on the days students were not in the field. The main difference in this instruction when compared with the non-treatment group was that there were fewer classroom sessions and instruction was done within the context of the birds/habitats the students were experiencing during the field studies.

During Phase II of the project, I had planned to have students research a threatened or endangered bird species found in California. However, the study was gaining ground within the school. Much of the campus was under construction during the time of the study. I met with the principal at one point to inquire about the possibility of setting up a wildlife habitat on campus. I was thinking of something small near my classroom. She suggested that my students develop plans to transform a temporary

parking lot (approximately 100ft x 60ft) into our wildlife habitat. She had been struggling to find a real use for this area and money had already been set aside for landscaping. What was missing was a plan. She contacted the district architect and landscape architect and they then got involved with the project. This was a great opportunity for students to apply what they had learned during the field studies. But, I knew that we would not have enough time to do everything that I had originally planned. Fortunately, my students all had the same language arts teacher. She was more than willing to take over helping students complete the research paper as part of the language arts curriculum. That freed up the remaining science periods for students to work on the schoolyard wildlife habitat. Students researched native plants and their specific relationships with native bird species. They then created their own scale drawings of an "ideal" wildlife habitat with recommendations for specific plant species that would attract specific bird species. The goal here was for students to apply what they had learned about the biology/ecology of native and threatened species. Students analyzed their field data by evaluating what bird species tended to populate our campus and which were absent on campus but present at the park. They also used what they had learned about how birds meet their basic needs and the relationship between native plants and local bird species to help guide them. I wanted to incorporate an engineering focus to the project, so as a home assignment, students were asked to design and build a habitat modification to help support either a local native bird species or a threatened or endangered species.

For Phase III and the culmination of the project, students presented their ideal habitat design and their habitat modifications to each other and to members of our school community. Feedback was provided by the district architects, school administration, and

the Audubon volunteer in addition to other community members. During the presentations, students were able to answer the questions: What are the factors affecting the biodiversity of the bird population on our campus? What can we do to ensure that our native bird population can thrive on our campus?

Throughout the field study portion of the project, students were introduced to foundational concepts of evolution such as genetic variation, natural selection, and adaptation through lessons from the same curriculum as the non-treatment classes. The difference was that students were learning this within the context of their fieldwork and were asked to make connections between the two. This was when students were asked to directly answer the focus question "Do humans affect the evolution of organisms?" They came up with realistic scenarios explaining how their bird species might become endangered, remain neutral, or thrive as a result of human impact on the environment. As with the non-treatment group, classroom assessment techniques were used throughout the unit to keep tabs on how student understanding developed and address misconceptions that arose. In addition, both groups of students kept a record of their work in their science notebooks as mentioned above. An important facet of their science notebooks throughout the year was reflection. With each learning experience, students were asked to reflect and make connections back to the focus question.

Data Collection

A variety of data collection tools were used to answer the primary question. The specific tools used are outlined in Table 1 and are included in the Appendices. Both groups were given key terms (Appendix D) for the unit and asked to construct a concept map showing the relationship between the terms pre and post study. Student interviews

were held towards the end of the project and included representative students from the treatment group (See Appendix B for an outline of interview questions). A published test from the EEI unit “Shaping Natural Systems Through Evolution” (Appendix F) was used as the summative assessment for both groups and administered at the end of the study. During the field study experiences, a teacher checklist of skills and observations (Appendix E) was used to assess student data gathering techniques. Science notebook reflection prompts were presented to students on a weekly basis (these prompts can be found in Appendix C). Students completed a flow chart summarizing the results of their research and recommendations (See Appendix G). At the completion of the study, both the treatment and non-treatment groups completed the “Science Opinion Survey” (Appendix A).

Table 1
Data Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3
Primary Question: 1. How effective is PBL for teaching middle school science?			
Secondary Questions: 2. How does engaging in PBL affect student attitudes towards science?	Comparison of treatment and non-treatment results on the "Science Opinion Survey."	Midway and post project student interviews	Science notebook reflections
3. Does PBL promote understanding of key concepts in science?	Comparison of treatment and non-treatment summative test scores	Evaluation of concept maps employing key terms pre and post	Evaluation of flow chart of research results
4. To what extent does PBL promote the learning and use of scientific practices?	Teacher evaluation of student data gathering techniques during field work	Evaluation of science notebooks for types of questions students asked, data recording techniques, and data analysis	Evaluation of student use of data to support Phase III final class recommendations

Timeline

This study took place over an 8-week period beginning on January 28, 2013 and ending on March 22, 2013.

Table 2
Timeline of project targets and assessment tools

Weeks 1-9	Project Targets	AR Assessment Tools
Before week 1	Planning the project	Teacher journal of the planning process Students construct concept maps pre-project
Week 1 January 28- February 1	Intro to unit and project Practice on how to do a field survey (school yard) Initial pass at data tabulation	Teacher checklist of data gathering/recording techniques for baseline levels Science notebook reflection check Teacher journal
Week 2 February 4-8	Field trip to Marine Park for field survey I Data tabulation	Teacher checklist of data gathering/recording techniques Science notebook reflection and check Teacher journal
Week 3 February 11-15	Schoolyard field survey I Data tabulation	Teacher checklist of data gathering/recording techniques Science notebook reflection Teacher journal
Week 4 February 18-22	Field trip to Marine Park for field survey II Birds Data tabulation	Teacher checklist of data gathering/recording techniques Science notebook reflection and check *Student Interviews Teacher journal
Week 5 February 25- March 1	Schoolyard field survey II Birds Data tabulation	Teacher checklist of data gathering/recording techniques Science notebook reflection Teacher journal
Week 6 March 4-8	Field trip to Marine Park for field survey III Birds Data tabulation Start bird species research project	Teacher checklist of data gathering/recording techniques Science notebook reflection and check Teacher journal
Week 7 March 11-15	Schoolyard field survey III Birds	Teacher checklist of data gathering/recording

	Data tabulation	techniques Science notebook reflection Teacher journal
Week 8 March 18-22	Species research and group presentations due Presentation to administration and parent group about campus recommendations	Flow chart Teacher journal Summative test on evolution from EEI curriculum (Hodder, Foss & Hayes, 2010) Science Opinion Survey (Gibson, 2008) Final student interviews Teacher journal

DATA AND ANALYSIS

Using a project based learning approach, which incorporated a comparative field study on local bird biodiversity, had a neutral impact on student attitudes towards science when compared to the non-treatment group. Both the treatment and non-treatment groups had similar positive attitudes about science. The treatment group valued going out into the field and enjoyed the hands-on approach to learning. They also appreciated the tangible contribution they were able to make towards the design of an outdoor space on campus. More importantly, student understanding of key concepts of evolution was enhanced by engaging in PBL even though this group received less direct instruction from the teacher. By engaging in field studies as part of PBL, students developed new skills as they learned how to gather data in the field, analyze the data and apply it to a real world problem.

Student Attitudes

PBL learning supports positive student attitudes towards science. To evaluate this, I used the results from a survey designed to measure student attitudes about learning

science (Appendix A). The survey consisted of twenty-seven questions. Fourteen were worded to indicate a positive attitude towards science. An example of a positively worded question was: “I would like to learn more about science.” Thirteen were worded to indicate a negative attitude towards science. An example of this was: “I would dislike being a scientist after I leave school.” Students responded using a 1-5 Likert scale. A choice of 1 indicated “I strongly agree,” 2 indicated, “I agree,” 3 indicated, “I am not sure,” 4 indicated “I disagree” and 5 indicated, “I strongly disagree.” The mode of the responses for each question was used to compare the responses between the treatment and non-treatment classes. When a question had the same number of responses for different numbers on the Likert scale, the average of those numbers was considered the mode.

Results to all questions are shown in Table 3. Students in both the treatment and non-treatment groups had almost identical responses once responses were disaggregated to reveal attitudes. In both groups, students answered 19% of the questions with a neutral attitude. The treatment group answered 77% of the questions to indicate a positive attitude towards science and only 4% to indicate a negative attitude. Students in the non-treatment group answered 74% of the questions to indicate a positive attitude and 7% to indicate a negative attitude towards science. Overall, both groups demonstrated a very positive attitude towards learning science.

Table 3
Science Survey Results

Column1	Positive Attitude	Neutral Attitude	Negative Attitude
Treatment	77%	19%	4%
Non-treatment	74%	19%	7%

Another method for evaluating student attitudes towards science was through student interviews. Two focus group interviews took place during the last week of the project. The questions posed are noted in Appendix B. Group A consisted of three boys and two girls. All were mid range students in terms of achievement. They were chosen because they volunteered and were available during the scheduled interview time. Group B consisted of 4 boys and 2 girls. These students were chosen because they were more representative of the demographics in the class. In this group there was a range of high to mid achieving students, more boys than girls, and more representative of the ethnic groups within the school.

One theme that stood out during the interviews was the students' general enjoyment of the hands on nature of conducting a field study and being outside. Responses indicating a general enjoyment included: "I think it [doing the field studies] helped me admire what nature is and take in the beauty of things." Another student stated "But now that I've gone on the field studies, I've seen all these beautiful birds and it just got me feeling better; I just kind of have this relationship with birds now." And, "I thought it was fun going to the park and using the binoculars to look at the birds closer." Students also seemed to appreciate being out of the classroom as evidenced by the statement, "I liked the fact that we got to go to Marine Park because we actually got to do stuff. If we're in a classroom, we're just sitting there watching a screen." A response that I did not expect had to do with choice in learning. The conversation veered towards the differences between learning in the classroom and in the field. Students were discussing using videos in the classroom versus seeing something live. One student said "Sometimes you get to touch the food they eat [referring to plants seen during the field studies]. You

get a more up close feel and there is freedom to look at something else instead of what's on the screen. When you look at a screen, there's another person choosing what you look at." These multiple references to "looking at a screen" in the classroom made me want to rethink the way I structure classroom time and the delivery of instruction.

A second theme was student awareness that they were engaging in "real science" by learning specific field skills for data collection as evidenced by these comments: " It makes me feel like a real biologist [referring to data gathering during field studies] and spiked my interest in science." Another said, "I got better with taking in details when I was trying to figure out which bird was which." The only negative comment about engaging in the field studies at the park had to do with the walk back to school. This required a long uphill walk. Except for this, students had an overwhelmingly positive response to engaging in field studies both on and off campus.

A third source of data indicating student attitudes towards science were student written responses to reflective questions after each field study. The questions are noted in Appendix C. The responses reflected the same themes as student responses to interview questions. Students valued participating in field studies as evidenced by the following comments: "I've learned a lot about birds. I'm paying more attention to my surroundings and noticing the beauty around me" and "I learned that being a scientist isn't just sitting in a lab doing experiments. You can go outside and do research on many different things." Any finally, "I've learned that we get to experience nature instead of just learning about it." Student responses to doing the field studies were overwhelmingly positive and had a spill over effect towards student attitudes about science. Many students initially thought that all science was conducted in a lab setting by a person in a white

coat. By participating in this project, students broadened their perspective about science and displayed a positive outlook towards participating in field studies.

Understanding of Key Concepts

The second area of data analysis was whether or not project based learning promotes the understanding of key concepts in science. At the end of the field studies for the treatment class and the unit on evolution for the non-treatment class, students took a summative test (Appendix F) from the Education in the Environment (EEI) curriculum that I had used to teach concepts of evolution in both classes. Both classes scored relatively high on this test: The Mean score for the treatment class was 89.48 percent (n= 31) with a Standard Deviation of 10.30; the Mean score for the non-treatment class was 84.28 percent (n=33) with a Standard Deviation of 10.87. Although it appears at first glance that the treatment class performed better on this test when compared to the non-treatment class, *t*-test results showed that the difference in the results was not quite statistically significant, $t(62) = 1.96$, $p = 0.05$. What is interesting to note with these results is that I spent far less time teaching the treatment class the specific lessons from this curriculum when compared to the non-treatment class. Instead, the concepts of natural selection, adaptation, biodiversity, and genetic variation were discussed informally and within the context of the field studies. I was purposeful in starting these conversations during our field studies because I knew that we would not have enough class time to do the same activities as the non-treatment class. If performing well on this assessment is an indicator that students understand the concepts of evolution, then both classes showed this. Using a PBL learning approach did not negatively impact learning science content. In fact, the treatment class may have an advantage because they were

able to see the concepts in real life during the field studies instead of learning about them second hand.

Analyzing concept maps utilizing key terms in evolution that students created before and towards the end of project period gave me additional insight into how well each group was able to synthesize their understanding of the concepts of evolution. For both the before and after instruction maps, students were given the same list of terms (Appendix D). They were instructed to write each of the terms on a post-it and place them on a paper in a way that showed the relationships between the terms. Any terms they did not recognize could be placed at the bottom of the map. Students were then instructed to add connecting lines and words to clearly illustrate how the terms were related. Students in both classes had had the opportunity to practice making a concept map before they completed the ones related to the evolution unit. Students worked in groups of four to complete the concept maps. They worked with the same group of students on both the before and after maps. They were not shown their previous map before they created their final map.

I analyzed the results by tallying the number of connections made on each map and then rated the words used to explain each connection with a 1, 2 or 3. A 1 indicated the connection was weak, a 3 reflected a strong connection, and a 2 was in between. I then determined the percentage of each type of connection for each map and found the Mean for each type of connection on the before instruction maps and on the after instruction maps for each class. Table 3 shows the Mean percentages for each type of response for the treatment and non-treatment groups.

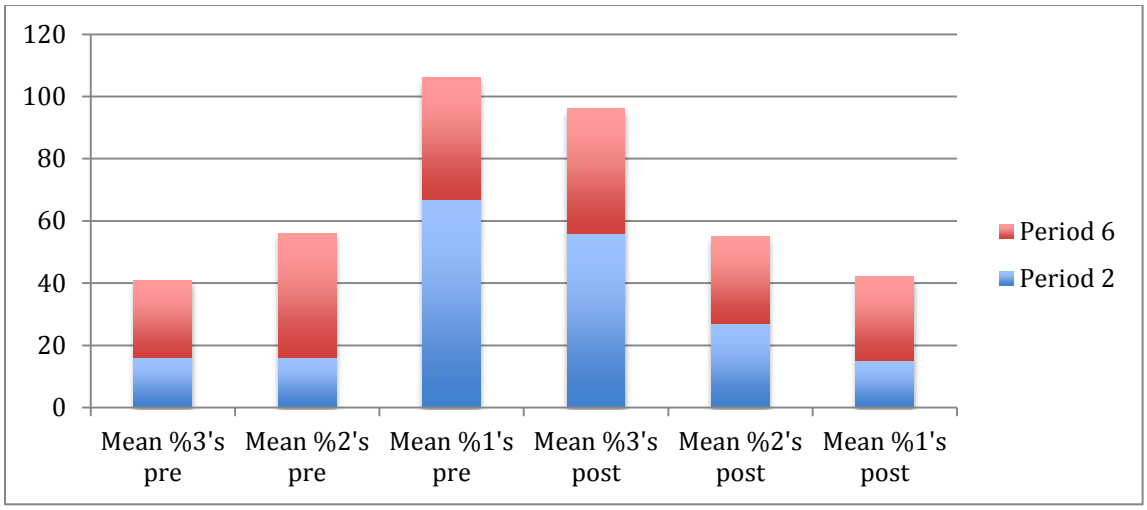


Figure 1. Concept map results pre and post instruction.

As you can see from Table 3, the non-treatment class (Period 6) started with a higher percentage (Mean of 25%) of Level 3 connections when compared to the treatment class (Mean of 16%), which may indicate that some students in the non-treatment class had more background knowledge about evolution when compared to the students in the treatment class. However, the treatment class had the biggest change between their before and after instruction concept maps. The percentage of Level 3 connections went from 16% to 56% demonstrating a 40% increase. The non-treatment class only showed a 15% increase in Level 3 connections when comparing the before and after concept maps. The treatment class showed 56% of level 3 responses on the after map compared with a total of 40% level 3 responses for the non-treatment after instruction map. Conversely, the treatment class decreased their Level 1 responses from 67% before instruction to 15% after instruction. This shows a 52% decrease in Level 1 responses. The non-treatment class only showed a 12% decrease in Level 1 responses. Although the non-treatment class started with more Level 3 responses and fewer Level 1 responses before instruction, they did not show nearly as much change in increasing the

Level 3 responses and decreasing the Level 1 responses after instruction. This is significant because creating concept maps requires higher order thinking skills. According to Webb's Cognitive Rigor Matrix (Hess, 2010), creating and justifying the connections between terms on a concept map would align with Depth of Knowledge Level 3 task: Strategic Thinking/Reasoning. In this case, it appears that students in the treatment class were able to do this to a greater degree than students in the non-treatment class.

A third source of data related to whether or not PBL promotes understanding of key concepts in science were the results from flow charts (Appendix G) students in both the treatment and non treatment classes completed the last week of the study. In order to complete the chart, students had to choose a threatened or endangered organism that they were familiar with. Students in the non-treatment class had done research reports and presentations on an endangered species the week before they were asked to complete the flow chart. Students in the treatment group had completed a research report on an endangered bird species found in California two weeks before working on the flow chart. In order to complete the flow chart, students had to recall information about a particular species, analyze the cause and effect relationships between human activities and the effects on the environment and the organism, and then draw conclusions about how human activity has affected the evolution of a species. Again, this was a task that required higher order cognitive reasoning (DOK-3). Similar to the concept maps, students received a score of 1 for weak or poorly supported statements, a 3 for strong or justified statements, and a 2 for responses that were in between. There were a total of five boxes: human activities, environment, chances of surviving and reproducing, variation, and

evolution. The Mean score for students in the non-treatment class was 75.63 percent (n=32) with a Standard Deviation of 17.49. The Mean score for students in the treatment class was 79.73 percent (n=30) with a Standard Deviation of 13.64. A *t*-test determined that the difference in scores was not statistically significant, $t(60) = 1.0264$, $p = 0.3088$. Both classes performed equally well on this measure of content knowledge related to evolution. This supports the assertion that PBL is as effective for promoting the understanding of key concepts in science when compared to more traditional approaches.

Scientific Practices

I looked at three sources of data to answer the final sub question "To what extent does PBL promote the learning and use of scientific practices?" The first source of data was a teacher checklist that I used on each of the field studies. My goal with the checklist was to monitor how well students were using the class constructed protocol and their level of engagement in taking data. Although our focus was on spotting, identifying, and counting birds, students were also instructed to notice and record specific elements in the environment that showed how birds were meeting their basic needs. With regard to the protocol, initially my data showed that 100% of the students followed the protocol on the first two field studies. I was specifically looking at how quietly students were able to approach and enter our field study site at the park so as not to scare the birds away. Students knew ahead of time that they would be spreading out along our observation corridor. It was amazing to see 33 twelve and thirteen year olds remain silent or talk in only a low whisper once they were at their observation stations.

On the last trip, I was less focused on the protocol and consequently I noticed more students talking as we entered the site. Only 76% were following the protocol

consistently at that point. There may have been two reasons for this: I was less focused on taking the data on this last trip, so I was not circulating among the students with my clipboard. I assumed (wrongly!) that they would follow the protocol because they had done so well on the previous two trips. The other may have been because we went to a different part of the park to watch a large flock of Cedar Waxwings. This caused a lot of excitement.

During our campus field studies, I noticed the same drop off in following the protocol as students became more familiar with what we were doing. We had spotted very few birds on campus. On our last campus field study, they seemed to have a preconceived notion about what they would see (or not see) and initially ignored the protocol. There was slightly less than half (48%) compliance at the beginning of our last field study on campus. I admonished them, and by the time we traveled to other end of campus most (85%) were following the protocol.

Throughout all of the field studies, students were actively engaged in recording data. They used tally marks on a bird chart for recording numbers and species of birds. On each field study, they were required to create a study site diagram showing the elements in the environment that were supporting birds' basic needs and elements that might hinder birds from meeting their basic needs. I saw dramatic improvement in the amount of detail and the accuracy of these illustrations. I gave students feedback each week on their illustrations and highlighted exemplars from the class. This seemed to motivate students to improve on this particular skill.

As expected, student bird data improved as they gained more experience using the binoculars and became familiar with the different species of birds. Initially, students were

able to count the number of total birds spotted but were unable to differentiate or name the birds unless they saw a gull or a crow. By our last trip to the park, the majority of students could reliably identify 4-6 species of birds (other than crows and gulls). A few were particularly adept and could differentiate and name 7-9 different species. Another source of data was identifying specific trees and shrubs that the birds were attracted to and speculating about the reason. Our Audubon volunteer happened to have a vast knowledge of native plants and taught the students why they were seeing specific types of birds in certain plants. This information laid the foundation for the students' ideal habitat projects.

As the final source of data, I was curious to know if the students would be able to evaluate their field data and apply what they had learned about birds and bird habitats in their final "create an ideal habitat" assignment. For this assignment, students used an 11x17 grid to construct a scale plan for the proposed schoolyard wildlife habitat. In it, they needed to include elements to both attract and support the basic needs of birds. The ideal habitats were evaluated by how well they focused on attracting specific local bird species, whether they paid attention to the use of scale, the layout, if they had accounted for sources of water, food, shelter, and a place to raise young, and if they included specific species of trees and shrubs that would meet the needs of specific local birds species of interest to the student. Figure 4 shows two examples of student work.

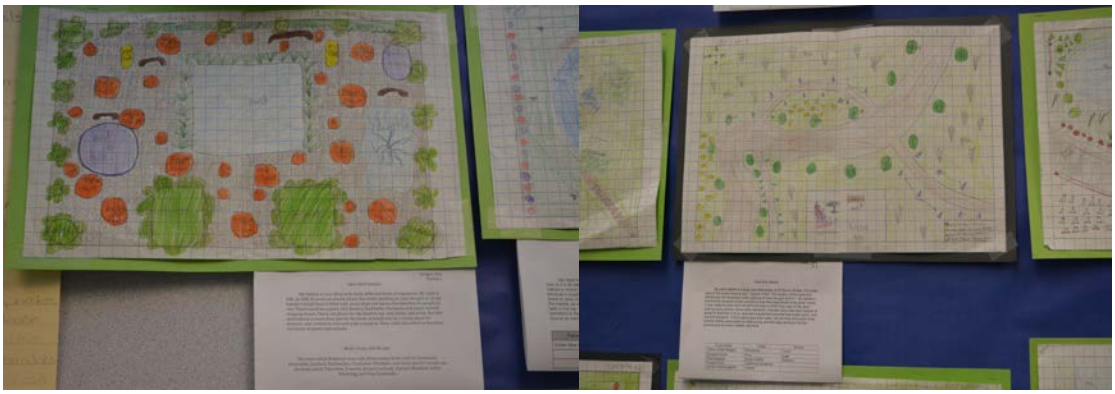


Figure 2. Examples of student ideal habitat drawings.

Students worked on this assignment in class for three class periods. As students were researching and designing, I was able to give them feedback on how they were progressing. All students were able to indicate why their garden would attract at least three species of birds. In thirteen out of thirty three (40%) of the plans, students were able to state why their plan would attract 5 or more species of birds. In these plans, students had gone into more detail about the specific species of trees and shrubs that they would include. For example, one student noted that his ideal habitat would attract Yellow-billed Magpies, Hooded Orioles, Phainopeplas, and Anna's Hummingbirds based on including Manzanita, Pine, Desert Willow, California Sycamore, and Juniper trees in the plan as well as Toyon, Sage and Elderberry shrubs.

The district architect sketched a number of student designs and gave feedback about the interesting design elements the students had included. He told them that he plans to incorporate their ideas into the final construction plan. Through creating the wildlife habitat designs, students utilized the data they had gathered in the field to inform their understanding and then create something novel. It also required them to utilize their mathematical understanding of scale and proportion and research skills to evaluate

information on native plant and bird species. This demonstrates both the use of scientific practices and higher-level cognitive reasoning.

INTERPRETATION AND CONCLUSION

This study provides evidence that project based learning in the middle school science classroom is an effective instructional approach. Specifically, PBL is valuable for promoting understanding of key concepts in science and for learning and using scientific practices. Although students voiced very positive attitudes towards doing field studies as part of their science instruction, there was not a significant difference in the results on a science attitude survey when compared to the non-treatment class. Both classes generally had very positive attitudes towards science.

Students who participated in project based learning for this study learned the major concepts of evolution within the meaningful context of a biodiversity field study. Principles of evolution are often difficult for students to understand and they frequently harbor the misconception that evolution was something that happened a long time ago but is no longer going on today. By closely observing the natural world around them and gaining the skills to record and analyze data on native bird species, students were able to construct their understanding of the ongoing process of evolution and the effect humans are having on the natural environment. From the student's viewpoint, this is a very different experience than reading about evolution in a book, doing simulation activities in the classroom, or watching a video about endangered species. These are all valid modes of instruction, but have so much more meaning for the student when they are paired with or replaced by engaging in the actual science. By gathering their own data and then using

that information to make a contribution to a real-life problem, students are drawing on a variety of skills from other disciplines and using higher order reasoning to accomplish the task. The feedback they received from the community validated their learning. By engaging in this project, the students experienced a sense of gratification as they realized that their ideas were valued and that they were actively involved in trying to make the world a better place.

VALUE

Designing and carrying out this study has made me realize the importance of creating as many opportunities as possible for students to engage in solving real world problems through their learning. The many advantages to this instructional approach include: contextualizing and establishing a purpose for learning, creating a shift in the teacher's role from being an expert to being the facilitator, and developing a stronger sense of classroom community. It also lays the foundation for future science inquiry.

I cannot overstate how important the field studies were in helping students understand how genetic variation, natural selection and adaptation work in the natural world. By observing birds in the wild, students were able to articulate what might happen to different species using evolutionary terms and connecting these ideas to real life scenarios. This context made the abstract more concrete and will provide a strong foundation for the students' future study of biology. Additionally, the "real world" application embedded within the project was equally as important for creating a purpose for the learning and keeping students engaged and motivated. When they come back as eighth graders next fall, they will see the space that they made plans for transformed into something they had a hand in creating.

My view of a teacher's role has shifted as a result of doing this study. First, I learned that I do not need to be the "expert" when embarking on a project, but that I can learn along with my students. I had a very clear idea of what I wanted them to learn about evolution and had mapped that out in advance of starting the project. However, I had little to no knowledge about bird watching, native bird species and the particulars of their local habitat prior to doing this project. Although it took some searching, I felt extremely lucky to come across such a willing and expert Audubon volunteer! This taught me the importance of bringing experts in the community into the classroom as well as the advantages of bringing my students out into the community.

Another important aspect that this study highlighted was the importance of teacher feedback in helping students to improve their skills and understanding as well as stay motivated. Students in the treatment group received feedback more often than I usually give because I wanted to keep close tabs on how well they were learning the concepts of evolution. I was worried that the other aspects of the study would distract them from the important learning outcomes I was expecting. The students' positive response to the feedback and improvement in the quality of their work reminded me of how effective frequent and timely feedback is for student learning.

This project had a positive effect on the development of the bonds within our classroom community. By engaging in the project, students had to work together in order to be successful at learning the field skills. They also collaborated with each other as they were designing their ideal habitats. This led to a shared ownership in the success of the project. As a result, there were fewer issues around discipline and work completion. Anyone who missed a day quickly worked to catch up to the rest of the class. Not only

were they encouraged and helped by their peers, they knew that their contribution was important and were motivated to make sure it was included.

Because of the value I found in doing this project, I plan to incorporate project based learning into my teaching in the future. Next year, I would like to do the bird biodiversity field study earlier in the year. The knowledge and skills that students will learn through doing this will lay the foundation for more advanced science inquiry later in the year. The bird data that was gathered this year will be the baseline data for future research. Students will be able to design their own experiments in an attempt to evaluate and improve on the effectiveness of the wildlife habitat on campus. My goal would be for students to publish the results of their research in student science publications such as *Classroom Bird Scope* through the Cornell Lab of Ornithology.

The process of researching, designing, implementing and analyzing an action research project helped me to reflect on my teaching in a more meaningful way. Instead of just going by my impressions of how effective a lesson or unit was in helping students learn certain concepts, I was actually able to see data to support or refute what I thought was going on with my students. Without the data, I would not have had the means to back up the assertion that project based learning is effective for teaching science. Now, with the experience of carrying out an effective project, I feel more confidence in my ability to design, implement and assess future projects. As I move forward as a teacher, I have the knowledge to test out other teaching methods and strategies that I am interested in through engaging in action research.

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APPENDICES

APPENDIX A

SCIENCE OPINION SURVEY

Science Opinion Survey (Gibson, 2008)

Read each statement. Circle the letter that most closely matches your opinion of the statement. There are no right or wrong answers-we just want your opinion.

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

I strongly agree	I agree	I am not sure	I disagree	I strongly disagree
A	B	C	D	E

1. Science lessons are fun

2. I would dislike being a scientist after I leave school

3. I would like to take more science courses

4. I dislike science lessons

5. When I leave school, I would like to work with people who make discoveries in science

6. I will be glad when I am done taking science classes

7. School should have more science lessons each week

8. I would like a job in a science laboratory after I leave school

9. I would like to learn more about science

10. Science lessons bore me

11. Working in a science laboratory would be an interesting way to earn living

12. I would be wasting my time if I took more science courses

13. Science is one of the most interesting school subjects

14. A career in science would be dull and boring

15. I will miss taking science courses in the future

16. Science lessons are a waste of time

17. I would like to teach science when I leave school

18. I do not want to take any more science classes

19. I really enjoy going to science lessons

20. A job as a scientist would be boring

21. Science courses I take in the future will be boring

22. I look forward to science lessons

23. I would dislike becoming a scientist because it needs too much education

24. Science classes I take in the future will be interesting

25. I would enjoy school more if there were no science lessons

26. I would like to be a scientist when I leave school

27. I do not need to learn more science

APPENDIX B

STUDENT INTERVIEW QUESTIONS

Before the interview begins, student will be reminded that participation in this research is voluntary and participation or non-participation will not affect a their grade or class standing in any way.

1. What do you think about the fieldwork we've been doing for the last few weeks?
    a. What's been the most enjoyable part?
    b. What's been the most difficult part?
    c. Do you have any questions about what we've been doing?

2. How closely do you think the fieldwork you've been doing resembles how biologists work in the field?

3. Do you think the fieldwork you are doing is important?
    a. If yes, how is it important?
    b. If no, why isn't it important?

4. What does the word conservation mean to you?

5. In what ways could your actions have a negative effect on the local bird population?

6. In what ways could your actions have a positive effect on the local bird population?

7. Why is biodiversity important?

**Added later:
What do you think the future effects of creating a schoolyard wildlife habitat on campus will be for the students who will come after you?

What role did our volunteers have in helping you participate in this study?

APPENDIX C

SCIENCE NOTEBOOK REFLECTION PROMPTS

Reflection Prompts for Science Notebooks

Week 1	What do you think about the project we are starting? Do you have any questions or concerns about the project? What new skills did you learn this week in science?
Week 2	In what ways does the fieldwork we are doing affect the way you think about science? What new skills did you learn this week in science?
Week 3-7	What do you know about birds that you didn't know before? What questions do you still have? What new skills did you learn this week in science?
Week 8	How have your ideas about science and scientists changed since we started the project?

APPENDIX D

TERMS FOR CONCEPT MAPS

Concept Map Terms

Adaptation	Evolution	Species
Natural selection	Habitat	Gene
Heritable	Variation	Mutation
Extinct (-tion)	Climate	Diversity

APPENDIX E

FIELD STUDY TEACHER CHECKLIST

Field Study Teacher Checklist: WEEK OF ___________________

Focus Skill #1 _______________________________________

Focus Skill #2 _______________________________________

STUDENT NAME	Rating for Focus Skill #1	Rating for Focus Skill #2

APPENDIX F

SUMMATIVE ASSESSMENT

Name: _____

Part 1

Instructions: Select the best answer and circle the correct letter. (2 points each)

1. Which sentence about natural selection is true?
   a. Natural selection only occurs in human populations.
   b. Variations of a single trait do not naturally exist in populations.
   c. Natural variations of a single trait exist in populations.
   d. Human activities do not alter natural selection.

2. Which of these sentences about evolution is true?
   a. When species evolve, they always become more complex.
   b. Evolutionary changes rarely occur.
   c. Evolution happened in the past, but does not happen in the present.
   d. Evolution results in change over time of the frequency of traits in a population.

3. Which of the following environmental factors can put pressure on species?
   a. changing climate
   b. the introduction of a new predator
   c. changing the chemistry of soil
   d. All of the above.

4. Which of these characteristics is an adaptation that allows pupfish to live in the desert?
   a. the ability to lay eggs when it is very hot
   b. bright stripes
   c. the ability to tolerate cold
   d. tails designed for fast swimming

5. Which of these sentences best describes the term "species"?
   a. All members of a species are genetically identical.
   b. Members of one species can mate with members of other species.
   c. Individuals are members of the same species if they can mate and produce fertile offspring.
   d. A single species cannot live in a variety of environments.

6. Which of these is not an inherited trait that would allow a species to survive or reproduce?
   a. the size of horn on bighorn sheep
   b. having access to more food
   c. the ability to sing songs to attract mates

Name: _____

Part 2

Instructions: Read the following paragraph and use the information to answer questions 7–10. (2 points each)

> Guppies are a kind of fish that live in streams on the island of Trinidad. In some pools, guppies are very colorful. In other pools, guppies are very drab and match the color of the bottom of the pool. Guppies that stand out are more likely to find mates. Guppies that blend in are less likely to be eaten by predators.

7. According to the reading, what trait varies for these guppies?
   a. length
   b. speed
   c. coloring
   d. egg-laying behavior

8. What kinds of guppies would you expect to find in a pool that contains many predators?
   a. mostly bright guppies
   b. mostly drab, colorless guppies
   c. an equal mixture of bright and drab guppies
   d. There is not enough information to make a prediction.

9. If you removed all the predators from a pool, how would natural selection proceed for the guppies?
   a. Bright guppies would be more likely to attract mates, so they would be more likely to reproduce. The bright-color gene's frequency would increase in future generations.
   b. Drab guppies would be more likely to survive, so they would be more likely to pass on their genes. The drab-color gene's frequency would increase in future generations.
   c. Without predators, the color of guppies would not matter for future generations. Some fish would be drab and some would be bright.
   d. Current guppies would be larger because more of their energy can now go into feeding instead of avoiding predators.

10. Which of the following statements is true if predators had a mutation that allowed them to see drab-colored guppies just as well as they could see bright-colored guppies?
    a. The guppies would need a new adaptation to avoid the predators, so they would develop one.
    b. Fewer guppies would be eaten.
    c. Being a bright-colored guppy has a lower survival rate than being drab colored.
    d. Being able to avoid predation is no longer a selective advantage for drab-colored guppies.

Name: _____

Part 3

Instructions: Select the best answer and circle the correct letter. (2 points each)

11. If a species does not have traits with much variation, and the environment changes, what might happen?
    a. The species may be at risk of extinction. It may not have any individuals with adaptations that help it cope with the new environment.
    b. The species can develop new adaptations on the spot, if it needs them.
    c. The species will be more successful, because all of its members can work together since they are so alike.
    d. The species will reproduce, and the new offspring will develop the adaptations needed to survive.

12. Which of the following environmental factors can influence how a species evolves?
    a. climate
    b. other kinds of plants and animals that live there
    c. geography
    d. all of the above

13. Humans have dramatically changed the environment in the San Joaquin Valley in California. In this region, 95% of the land has been altered for human use. These environmental changes have _____.
    a. led to more species diversity
    b. increased species' habitat range
    c. put several species at risk of extinction
    d. had little effect on species

Part 4

Instructions: Complete the following tasks in the spaces provided. (3 points each)

14. Give an example of an adaptation and the environment that it evolved in.

_____

_____

_____

Name: _____

15. Why does California have so many different kinds of species?

16. List three examples of human activities that have changed the environment.

17. Pick one of the examples above. How has this activity influenced the evolution of a species?

APPENDIX G

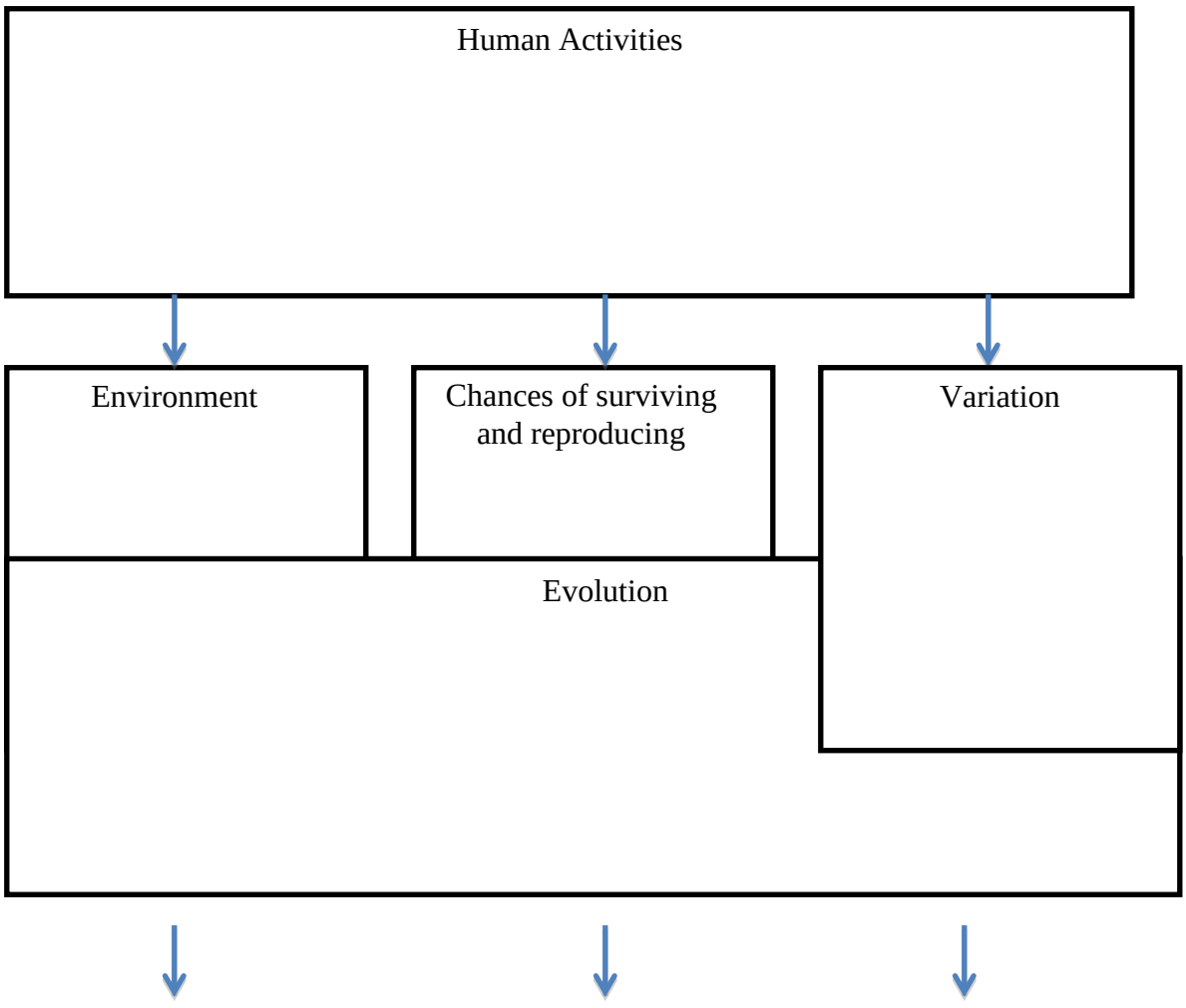
FLOW CHART

FLOW CHART

Adapted from EEI curriculum "Shaping Natural Systems Through Evolution" (Hodder, Foss & Hayes, 2010).

Instructions: Complete the flow chart below for an endangered species of your choosing.

- In "Human Activities" describe the kinds of human activities that have affected this species.
- In "Environment" describe how this species' environment has changed.
- In "Chances of surviving and reproducing" describe how the species' chances of surviving and reproducing have changed.
- In "Variations" describe the species level of genetic variation. If humans altered this level of variation, how did this happen?
- In "Evolution" summarize how human activity has affected the evolution of this species.



APPENDIX H

PROJECT OVERVIEW

PROJECT OVERVIEW (Buck Institute for Education, 2008)

Name of Project:	**EVOLUTION THROUGH THE LENS OF BIODIVERSITY**	**Duration: 9 weeks**
Subject/Course: 7th Grade Life Science	**Teacher(s): Dresher**	**Grade Level: 7**
Other subject areas to be included, if any:	**Math, Language Arts**	

Project Idea Summary of the issue, challenge, investigation, scenario, or problem:	Students will learn the concepts of evolution (genetic variation, natural selection, adaptation) by engaging in a study of biodiversity in two urban locations (school campus and local park). Students will evaluate the status of the local bird population by comparing numbers and species of birds in the two locations. They will research different bird species to better understand to ecology/biology of the individual species. Students will then draw conclusions about the health of individual populations on the school campus and make recommendations to the administration and parents about how to improve the conditions on campus to better support the bird population.
Driving Question	Do humans affect the evolution of organisms?
Content and Skills Standards to be addressed:	California Science Content Standards: 7.3 Biological evolution accounts for the diversity of species developed through gradual processes over many generations. 7.3a Students know both genetic variation and environmental factors are causes of evolution and diversity of organisms. California Environmental Principle III: Natural systems proceed through cycles that humans depend upon, benefit from and can alter.

		T+A	E		T+A	E
21st Century Skills to be explicitly *taught and assessed* (T+A) or that will be *encouraged* (E) by project work, but not taught or assessed:	Collaboration		x	Other: field data collection and recording techniques, data interpretation	x	
	Presentation	x		Research skills	x	
	Critical Thinking:	x				

			Presentation Audience:	
Culminating Products and Performances	**Group:**	Small group presentations on specific species of local birds. Whole class presentation of findings and recommendations for planting in new 8th grade area	Class:	x
			School:	
			Community:	x

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	Individual:	Bird species research report Science notebook	Experts:	
			Web:	
			Other:	

PROJECT OVERVIEW

Entry event to launch inquiry, engage students:	"A board of concerned citizens is interested in knowing more about the changes in the biodiversity of the John Adams Middle School campus. Our job, as a class, is to develop an understanding of the changes in biodiversity that have taken place and to specifically examine what impact humans have made on the flora and fauna. We will need to understand the ecology of the John Adams Middle School campus, learn about species that are being stressed due to environmental changes, and then make recommendations to the board about things that can be done to improve the situation at John Adams Middle School."				
Assessments	**Formative Assessments (During Project)**	Quizzes/Tests	X	Practice Presentations	
		Journal/Learning Log		Notes	
		Preliminary Plans/Outlines/Prototypes		Checklists	X
		Rough Drafts		Concept Maps	X
		Science Notebook Reflections	X	Other:	
	Summative Assessments (End of Project)	Written Product(s): Bird Research Report	X	Other Product(s) or Performance(s): Flow Chart	X
		Oral Presentation, with rubric Group presentation of findings on specific species		Peer Evaluation	
		Multiple Choice/Short Answer Test Summative EEI test	X	Self-Evaluation Reflection questions in science notebook	X
		Essay Test		Other:	
Resources	**On-site people, facilities:**	Principal, language arts teacher, math teacher, science magnet			

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Needed		parents
	Equipment:	binoculars, clipboards, field guides
	Materials:	Graph paper for scale drawings, colored pencils, rulers
	Community resources:	Ballona Land Trust, Santa Monica Audubon Society, District architect and landscape architect

Reflection Methods	**(Individual, Group, and/or Whole Class)**	Student self evaluation	x	Focus Group (student interviews)	x
		Whole-Class Discussion	x	Fishbowl Discussion	
		Survey	x	Other: Science notebook	x

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PROJECT TEACHING AND LEARNING GUIDE	
Project:	**Course/Semester:**
Knowledge and Skills Needed by Students to successfully complete culminating products and performances, and do well on summative assessments	**Scaffolding / Materials / Lessons to be Provided** by the project teacher, other teachers, experts, mentors, community members
Ability to conduct a schoolyard and park field survey using appropriate data collection and recording techniques ➔	Teacher: 1. Instruction in how collect data using either a transect line or quadrats. 2. Instruction on how to identify different categories of plant species.
Ability to conduct a bird biodiversity survey using appropriate data collection and recording techniques ➔	Teacher and bird specialists: Instruction on how to bird watch. Includes use of binoculars and field guides
Ability to evaluate data from surveys ➔	Teacher and math teacher: Instruction on how to tabulate data in order to compare conditions in the two study locations
Ability to collaborate with group members and exhibit appropriate behavior during surveys on campus and on field trips to Marine Park ➔	Teacher 1. Clear expectations for appropriate conduct during surveys. 2. Student self evaluation of collaboration skills
Research skills for evaluating bird species ➔	Teacher and Language Arts teacher

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