THE EFFECT OF A HIGH SCHOOL SCIENCE RESEARCH TRIP EXPERIENCE ON LEARNING, MOTIVATION, AND FUTURE PATHWAYS

by

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

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DEDICATION

Being outdoors and part of nature has been a central part of my life and who I am. For me, it has been an important part of learning and an important part of just being. I wouldn’t have had such a close connection to nature or to learning if it weren’t for my mother, Evelyn, and my grandmother, Mathilda. My mother made sure that we had opportunities to get outside and to go camping as much as possible. She worked hard to make that happen and for it to be carefree. I’m sure she would be happier if I didn’t like bears quite so much, but I guess that’s what happens when you hang out with them every summer. My grandmother refused to stay in. When she wasn’t able travel as much anymore, we stayed in a cabin she built in her backyard. Education was the foundation and a cherished prize to achieve. Though formal education was important, being outside provided learning time as well. This project was about bringing both of those pieces together, being outside and learning. This time, the focus was to pass this tradition on to others. I’m very grateful for the gifts both women have given me for so long. Thank you.
ACKNOWLEDGMENT

I would like to thank the staff, students, families, and alumni of Bishop O’Dowd High School who helped to made this graduate experience a reality. The enduring interest and passion for learning in an outdoor environment have enriched the experiences we provide today. I would also like to thank many of the core personnel of the MSSE program for making this the most amazing educational experience. I wish you were here to see this, Peggy Taylor, you were a special gift to me as I began this degree. I am grateful to Diana Paterson who seems to have ceaseless positive energy and has been willing to help me with absolutely everything. I so appreciate the support and guidance that Walt Woolbaugh has generously provided throughout this capstone process. He kept this project always moving in a strong direction with wonderful support and feedback.

Thank you to my readers who never had much time to pull off their part, but did it anyway. I do appreciate the helpful feedback and push for excellence on this project from my science reader, Louise Mead. For the critique, suggestions, and ideas, thanks to my friends Laura Goslee and Dorothy Lubin. Thank you to my sister, Kim Langenborg, who is my ultimate support from every angle. I am grateful for the generous time, energy, advise and ultimately late nights put in by Zosha Adam to help this capstone get completed. This wouldn’t be the project that it was without the help of everyone.

Finally, I’d like to thank Ecology Project International (EPI) for the wonderful years we have been working together with students and for extending their resources and expertise to make these experiences a reality. A deep thank you, specifically, to Kyle Watson for her immeasurable assistance with our trips and for this capstone.
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ABSTRACT

Experiences in nature are often positive events. These important educational opportunities are frequently downplayed for a variety of reasons. Field research enhances high school students’ passion for science and nature through real-life application, and a tangible connection with the natural world. This study investigated the effects that students experienced, both educationally and personally, after participating on a science research trip. Student learning and retention of main concepts as well as student motivation following a field research experience were explored. The impact on future academic studies, career, and life choices were also examined. Both current and former students were evaluated using assessments, surveys, interviews, and observations. The results indicated that these trips were beneficial. They enabled students to learn and retain important content while building confidence in their skills as scientists. Students learned to connect with and care for the environment. The investigation also revealed that trip experiences have positively impacted future life choices. Research trips are valuable experiences for both educational development and personal growth.
INTRODUCTION AND BACKGROUND

Students often study biology either mostly or completely isolated from the natural world. Consequently, they are left to study from a book, learn from a lecture, participate in laboratory activities, and perhaps view examples in a video. Without experiences in nature, there is a disconnect. An understanding of these interrelationships impacting components and processes in the natural world is key to critical thinking and making useful applications. Some students come to high school with prior out-of-doors experiences through family vacations, programs offered in elementary, middle school, or summer programs. However, there seem to be fewer students who interact with nature.

For many years, I have taken students on science research trips to experience the natural world directly. I have witnessed a level of excitement and transformation from the returning students revealing a zeal for what they have learned and experienced in the field; a new-founded determination to make a positive impact in the world. After going on a research trip, students retain this enthusiasm for learning about science even after returning to the classroom environment. These students now have a ready resource of field-based applications, enabling them to grasp and apply concepts much more easily. These trips influence students well beyond high school. I receive numerous correspondences from former students now in college and even well after college explaining how their research trip impacted the direction of their life and choices they made.

The purpose of this research project was to investigate the impact that science research trip experiences have on students in three major areas: knowledge acquisition
regarding major science concepts, motivation toward learning science, and the impact on future decisions. There are many obstacles to overcome for research trips to become a reality in a high school. There are financial and space limitations as well as safety concerns. However, persisting trepidation by parents and administrators lies in the judging of the value. Do the merits outweigh the inherent obstacles? Evidence of the educational and fundamental benefits these trips provide currently for students, as well as the possible impact on their futures, will hopefully promote and perpetuate this type of experiential education. This may also help to increase the number of trips available to a broader population of students. I also hope to generate more opportunities for financial assistance or sponsorships making these trips more inclusive within the school community.

My past experience participating in and organizing these research trips guided my primary focus question, what is the impact of a science research trip experience on student learning, motivation, and future pathways? To further delve into this issue, the following sub-questions were addressed in this study, 1) What is the effect of a science research trip experience on learning, application, and retention of main evolution and ecology concepts? 2) What is the effect of the science research trip experience on instilling confidence to do field science and to motivate students toward learning science? 3) What is the impact of the science research trip experience on a student’s personal connection with science and the natural world as well as influence their future educational or career pathway choices? 4) What value does this research project have for my own classroom teaching as well as the direction and focus of future research trips?
CONCEPTUAL FRAMEWORK

E.O. Wilson (1996) stated, “The manifold ways by which human beings are tied to the remainder of life are very poorly understood, crying for new scientific inquiry and bold aesthetic interpretation” (p. 178). Connecting and learning from the natural environment is essential for students. I grew up connected to nature. Every moment possible was spent outside with dirt, rocks, plants, and animals. I was fortunate that my parents chose to spend family time camping and visiting national parks. However, as a teacher, I am witnessing a growing disconnect in the “manifold” that my students have with the natural world around them. Even those who are avid supporters of various environmental movements have very little personal experience beyond their video screen. My connection on campus with the natural world was, and continues to be, an essential part of my learning experience. I strive to promote the discovery of real-world applications and conceptual understandings of how things work with all students.

Outdoor experiences in nature create an important connection between the natural world and each person. Louv (2008) and Stebbins (2012) stress that the bond between children and the natural world can promote physiological, social and psychological health that should be nurtured and encouraged. The affective reward associated with outdoor experiences in education can boost student engagement and an interest in learning science (Cachelin, Paisley, & Blanchard, 2009; Sener, Turk, & Tas, 2015). A study by the California Department of Education looked at the effects of Environment-Based Education programs in 60 different schools. The results showed an “increased engagement and enthusiasm for learning” (Lieberman, Hoody, & Lieberman, 2000).
Prokop, Tuncer, & Kvasničák (2007) suggested that even students who already show an interest in the natural world will exhibit an increase in this interest following enrolling in an outdoor education program.

If student engagement increases through participation in outdoor education programs, then perhaps students will also feel more confident in science classes and may even consider a future in science. Prokop et al. (2007) studied how a one-day field trip would affect both attitude toward learning biology and content knowledge. The increase in attitude and content knowledge was significant. Included in the attitude survey was a career parameter. Prior to the field course, students indicated a negative level of interest toward choosing a career in biology. After the treatment, the experimental group rated a career in biology as neutral as compared to the control group which still rated this as negative. Though improving from low to neutral does not sound monumental, especially in a group of sixth graders, it is a documented change in attitude in a positive direction following outdoor education. Griset (2010) also noted that students began to consider future careers related to science fields after creating a new field ecology class. She discovered that her field course improved the confidence level of her students: “Many comment that their world view has shifted from apathy to action, and from mild interest to a passion for the study for the natural world around them” (Griset 2010, p. 46).

In terms of content acquisition, there is a strong connection between outdoor learning and an increase in content knowledge. In as short as a one-day field trip, Prokop et al. (2007) showed that sixth graders improved their biology knowledge between a pre- and posttest than the control group who conducted the lesson in the classroom. In an
ecosystem drawing assessment, most students ignored major abiotic factors such as sunlight and water in the pretest. After participating in the field, most field students included them on the posttest drawings as important components of the ecosystem. Significant improvements on the multiple-choice posttest were also noted. A different study of 139 fourth graders also indicated a boost in science knowledge by students who had lessons in the field versus solely in the classroom. The study noted that the initial lesson was taught in the classroom to both groups prior to the treatment. Nevertheless, the level of learning was enhanced significantly by the replication of the material outdoors rather than in the classroom (Plaza, Rabinal & Delgado, 2012).

Retention of knowledge becomes most effective as students progress to discovering and applying observed associations. One of the most significant and quantitative studies connecting outdoor learning and retention was done by the California Department of Education (American Institutes for Research, 2005). In an investigation on sixth graders who participated in a one-week outdoor school, they found those who attended improved standardized scores by 27 percent between the pre to post surveys as compared to those who did not attend. Retention was measured by using a delayed evaluation. In this case, the post surveys were given six to ten weeks after the students returned from the outdoor school. In another study on retention the researchers waited one year to administer a delayed, open-ended interview to see how much content fourth graders remembered from a program in Smoky Mountain National Park. The results showed that “Fourteen of the 15 students discussed ecological and environmental tangibles that were derived from the program” (Farmer, Knapp, & Benton, 2007, p. 40).
From a constructivist’s viewpoint, students learn best when given the opportunity to connect what they already know and understand to new information they discover themselves (Crowther, 1997). “Real-world” scenarios are most effective and may elicit many possible hypotheses based on student observations rather than just one correct answer (Doran, Chan, Tamir & Lenhart, 2002). The authentic nature of discovery and inquiry in the outdoor environment ties in closely with the design of the three spheres of activity supported by the National Research Council (NRC, 2012); the integration of investigation, evaluation, and explanation. Any of those three components can be accomplished in any order. There is no prescribed progression or fixed, rigid scientific method. When discussing the use of science and engineering practices, the NRC states,

They (students) also need experiences that help them recognize that the laboratory is not the sole domain for legitimate scientific inquiry and that, for many scientists (e.g., earth scientists, ethologists, ecologists), the “laboratory” is the natural world where experiments are conducted and data are collected in the field (2012, p. 60).

In 2009, the National Research Council published a report on Learning Science in Informal Environments. “Informal environments” - most anything outside of the classroom, including field trips and outdoor events - are also the primary learning environment for the future of each person as they move beyond school (NRC, 2009). Experiencing and learning in the natural world can be considered an “informal environment” and can provide an authentic and long-lasting educational experience. Students can experience the world in a way that is novel for them, especially in new locations. They will discover that in the natural world it may not be possible to control all variables as you might be able to do in a laboratory setting (NRC, 2012).
science presents opportunities to easily employ all eight Science and Engineering Practices from the Next Generation Science Standards from questioning as they wonder about unusual phenomena to designing an investigation to test their ideas, to argumentation as they create claims related to their observations that differ from others, to communication as they present what they now know and understand (NRC, 2012).

There are three major areas identified for data collection for this project: knowledge acquisition regarding major science concepts, motivation toward learning science, and impact toward future decisions. There are several techniques that have been used to assess these areas. Attitude and motivation can be assessed through pre- and post-surveys (Griset, 2010). Farmer, Knapp, and Benson (2007) used open-ended and unstructured interviews. They asked students what they remembered about their trip and then used a phenomenological analysis to look for common themes in their responses. This provided a method for quantifying the information from an open-ended interview. Swank (2013) used a pre- and post-test to look for any changes in content knowledge. She also used a delayed test to evaluate retention. In terms of the effect of trip experiences on future career choices, Prokop et al. (2007) included questions to address this on their pre- and post-surveys with sixth graders.

Based on this review of literature, outdoor education holds many strengths. It largely holds the attention of the participating students and heightens their interest in what they are learning. As compared to classroom situations, the outdoor learning environment along with the associated activities show a greater level of learning and retention of that material. Field learning can even boost student confidence and general
attitudes toward science. These are all great assets and certainly consistent with anecdotal evidence I have seen while on science research trips. One issue is rather puzzling. Most of the research available on outdoor learning when it includes an academic component is directed toward elementary school children (10 to 12 year olds). The academic rigors of a high school curriculum are much different, even when compared with middle school.

**METHODOLOGY**

The purpose of this study was to determine the effectiveness of a science research trip experience on student learning, motivation, and future pathways. In order for students to participate on one of the science research trips, they first had to be recommended by a science teacher. Teachers recommend students who not only perform well in class but have demonstrated a genuine interest in science. Recommended students received an invitation to apply for a position on a trip. Applicants are then considered based on the teacher’s evaluation, a statement of purpose, and if necessary, the time and date they submitted the application. Our school population in 2017-2018 was 1200; 43 percent European American, 22 percent African American, 12 percent Asian American or Pacific Islander, 9 percent Hispanic or Latino, and 14 percent other. The breakdown for the spring trips was 47 percent European American, 13 percent African American, 15 percent Asian American/Pacific Islander, 11 percent Hispanic or Latino, and 14 percent other (Bishop O’Dowd, 2018). The school had just over 30 percent of the students on financial assistance in 2017-2018. Some financial assistance
was made available to help these students with the cost of the trip, but, unfortunately, the majority of the expense was the responsibility of each family.

The treatment for this project was designed to provide a way for students to connect their experiences in the field with important academic concepts. This experiential reinforcement would encourage students to find original applications of science concepts in the real-world, generate their own examples to support those concepts, and generate new questions to investigate through data collection and/or research. Beyond the inherent content, the treatment was designed to increase student motivation, provide a sense of accomplishment, and enhance curiosity. The intention was that these experiences would translate back to the classroom and potentially impact choices students made in the future.

The treatment was implemented before and throughout each research trip. I have been taking students to various countries for science research trips with a nonprofit educational organization - Ecology Project International (EPI) - for the last 16 years. In March of 2018, there were four separate student research trips. Every year, the same trips are available to students based on their year in school. Freshman journey to Belize for nine days. They study coral reef and jungle ecology. Sophomores travel to Costa Rica for nine days. They work with the critically endangered leatherback turtle population as well as study the differences between primary and secondary rainforests. Juniors and seniors venture to either Ecuador for nine days or to the Galapagos Islands for twelve days. In Ecuador, students investigate differences in the ecosystems between the Amazon region and the high-altitude Andes. They also track mountain tapirs and
spectacled bears to complete a population analysis. In the Galapagos, students work directly with the giant tortoises and study ecological differences between islands as well as human impact. The basic treatment was structured so that students prepared for the experience before each trip and were guided to function as a field scientist while on location (Table 1). The research design for this study received an exemption by Montana State University’s Internal Review Board and compliance was maintained throughout this project (Appendix A).

Table 1

<table>
<thead>
<tr>
<th>Timing</th>
<th>Tools/Activities</th>
<th>Content Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-trip meetings</td>
<td>Short video – specific to research site</td>
<td>Biotic and abiotic factors</td>
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<tr>
<td></td>
<td>Student presentations on local organisms</td>
<td>Organisms and relationships</td>
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<tr>
<td></td>
<td>Journal writing</td>
<td>Content vocabulary</td>
</tr>
<tr>
<td></td>
<td>Data collection practice</td>
<td>Spanish vocabulary</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Evolution and ecology review</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Data collection competence</td>
</tr>
<tr>
<td>During the trip</td>
<td>Data collection and observations</td>
<td>Data collection skills</td>
</tr>
<tr>
<td></td>
<td>Data review and analysis</td>
<td>Data accuracy</td>
</tr>
<tr>
<td></td>
<td>Journal writing</td>
<td>Collaboration skills</td>
</tr>
<tr>
<td></td>
<td>Lessons in the field and on hikes</td>
<td>Communication skills</td>
</tr>
<tr>
<td></td>
<td>Focused games and activities</td>
<td>Real-world experience</td>
</tr>
<tr>
<td></td>
<td>Small group interview of a researcher</td>
<td>Evolution content application</td>
</tr>
<tr>
<td></td>
<td>Group presentation of research</td>
<td>Ecology content application</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Future pathway possibilities</td>
</tr>
</tbody>
</table>

The first phase of the treatment took place between January and March during pre-course meetings. The focus was adapted to relate specifically to each trip. During the pre-course meetings, students revisited major evolution and ecology concepts learned in their freshman and/or sophomore science course relating to the local flora and fauna of their intended research site. A short video was used to document and introduce specifics of the ecosystem. Students were given prompts for journal entries and practiced
identifying examples of key vocabulary terms, organismal relationships, and important environmental factors shown in the video. The meetings allowed students to revisit previously learned concepts and learn more details about the specific research focus of their trip. Good teamwork was promoted within the group by practicing field work skills to enhance the upcoming experience in the field. An example from the Costa Rica pre-trip material used for this part of the treatment can be viewed in Appendix B.

The second phase of the treatment consisted of the events and learning experiences students participated in during the research trip. In the field, students worked with the two teachers from our high school and at least two Ecology Project International instructors, as well as scientists at each location. Students participated in lessons and games throughout the trip to help them learn the field skills needed for the research and to solidify and apply important science concepts. To better facilitate this learning process, students were supplied with a printed journal specific for each trip which included drawings, science content, and definitions for reference as well as data tables and questions/prompts to be filled out by students. There were also blank pages in the journal for more in depth observations. Students worked in these journals every day as they collected and analyzed field data. Students were assisted by the instructors and teachers in making observations and connecting those observations to content they had learned. In small groups, students developed their own research question based on some of their observations. They researched information about their topic, collected and analyzed field data, and created a poster to present their findings. Poster presentations were made to a larger audience and when possible, students presented to other field scientists and to
students from local schools close to the research site who had also been involved in research with EPI.

The third phase of the treatment involved the students interviewing one of the scientists and/or instructors on the trip. Students conducted the interviews in small groups using some suggested questions, along with questions that the students developed themselves (Appendix C). The purpose of this interview was to allow students to find out how each scientist became interested in the research they are currently doing and the background they had to get to that position. Since most professionals take a rather diverse, convoluted, and sometimes surprising pathway to get to their current position, it often inspires a lot of curiosity from students. After interviewing in small groups, the students convened with the other student groups to share what they had learned.

For this project, data were collected from two main areas of focus. The primary focus was on the students who traveled to each of the four research sites in March of 2018. The data were analyzed to detect changes in student understanding of major biological concepts in ecology and evolution and their motivation toward learning. It was also noted if the trip experiences had influenced choices students were making for their future pathways in college and/or career. The secondary focus of this study was to document how these experiences may have impacted the life choices of participants from previous trips.

A variety of data collection methods were used to answer the main focus question and sub-questions for this action research project. Both qualitative and quantitative methods were employed to provide meaningful and comparable data. To achieve
triangulation for the data collection, several instruments were used to address each question (Table 2).

Table 2  
*Research Matrix Showing Correspondence Between Research Question and Data Collected*

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Data Sources</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Assessment</td>
</tr>
<tr>
<td>Focus Question: Student learning, motivation, and future pathway?</td>
<td>3 4 5 2 1 2 5 1 2</td>
</tr>
<tr>
<td>Sub-Question 1: Understanding, inter-connecting, and applying main evolution and ecology concepts?</td>
<td>3 4 5 2</td>
</tr>
<tr>
<td>Sub-Question 2: Confidence in doing field science and motivation toward learning science?</td>
<td>2 1 2 5 1 2</td>
</tr>
<tr>
<td>Sub-Question 3: Personal connection with science and the natural world and future pathway choices?</td>
<td>1 2 5 1 2</td>
</tr>
<tr>
<td>Sub-Question 4: Value on classroom teaching and the direction of the focus for future research trips?</td>
<td>3 4 5 2 1 2 5 1 2</td>
</tr>
</tbody>
</table>

Note.  
1 Data show student expectations and motivation prior to treatment  
2 Data show observations/opinions of treatment, response and outcome  
3 Data show baseline academic content prior to treatment  
4 Data show academic progress following treatment  
5 Data reflect the long-term value of the treatment

Along with assessments and surveys, three students were randomly selected from each trip to be interviewed before and after each trip (Appendix D and E). Responses were analyzed for changes between the pre- and post-trip interviews, then triangulated.
with data from the pre- and the post-trip surveys. To help with consistency in the interview process, and to confirm open-ended data interpretation, another teacher with previous experience, both as a student and as a teacher on these trips, was present for each interview. All interviews were digitally recorded for accuracy and review. In addition to collecting data on current students, the Past Student Survey was made available using a Google form to all Bishop O’Dowd graduates of science research trips between 2002 and 2017 (Appendix F). The survey was modified from one used by the Marshall REU in Scientific Computing (2012). The data from respondents were collected automatically into an electronic spreadsheet generated directly from the survey. Names were used only for pattern analysis and demographics.

The instruments used for data collection on the 2018 trips were developed to address the main research questions for this project and to provide validity and reliability when administered. There were two pre-trip surveys created for this project. EPI has generated a pre-trip survey for every course they operate over the last several years (Appendix G). The post-survey used by EPI is the same as the pre-survey. The School Pre-Trip Survey was created in order to survey students more specifically on the research sub-questions and to triangulate with the results from the EPI Surveys (Appendix H). The areas addressed in the school survey related directly to motivation, confidence as a field scientist, connection to the natural world, value of outdoor learning, and thoughts about future integration of science. The School Post-Survey maintained most of the same statements found in the School Pre-Survey with two added statements specific to the EPI trip (Appendix I). Both the School Pre- and Post-Trip Surveys had open-ended
statements to provide a qualitative aspect – again for triangulation of evidence. In refining the School Surveys, both surveys were reviewed for content by two other science teachers and tested on an EPI course in January of 2018.

The pre-, post-, and delayed assessments were developed to evaluate science content knowledge acquisition and retention (Appendix J). Both the ecology and evolution sections of the assessments corresponded to the content and experiences relevant to each specific location. The overall assessment content was the same but reflected the unique ecosystem and research focus of each trip. The ecology section included five questions and was developed and tested by EPI on previous student trips. The evolution portion included four questions that I developed using information from prior experiences on each trip and collaborating with EPI on the current curriculum. The content and question structure on each assessment was reviewed beforehand by two additional science teachers and then tested on a separate EPI trip in January.

The administration of all surveys and assessments was supervised by either EPI instructors, Bishop O’Dowd teachers, or both. Students were not informed about any of the assessments ahead of time. Students were informed that there were no time limits for completion and no consequences for the assessment results. Students were not given feedback on their answers or given correct responses to the questions after the assessments. Due to research and time constraints on the trips, the instruments had to be administered in a variety of locations. The Pre-Trip School Survey was given during a pre-trip meeting and supervised by two Bishop O’Dowd teachers. The Post-Trip School Survey was taken at the airport during a layover on the way home. This was supervised
by the two Bishop O’Dowd teachers on each course. The Pre-Trip EPI Survey and Pre-Trip Assessment were taken by students when they first arrived at the trip location. This was administered by the EPI instructors and two Bishop O’Dowd teachers. The Post-Trip EPI Survey and Post-Trip Assessment was accomplished at the very end of the trip and was supervised by the EPI instructors and both Bishop O’Dowd teachers. To evaluate the retention of knowledge acquisition, the delayed assessment was given two weeks after returning to school. Students completed this assessment in the library under the supervision of a Bishop O’Dowd teacher.

DATA AND ANALYSIS

Data from each instrument were quantitatively and qualitatively analyzed based on the research question addressed. Triangulation was used to provide more evidence regarding each project component.

Learning and Retention

Students were assessed for understanding of both ecology and evolution concepts as they applied to each trip’s research location and specific ecosystem. For the ecology portion, the results indicated that student scores improved from a mean of 76.73% on the pre-assessment to 84.36% on the post-assessment ($N=55$). Using a t-test to analyze the results, the p-value was 0.01, thus the null hypothesis is rejected. This indicates that the difference between the pre- and post-assessment results for ecology content acquisition was significant. However, there was an increase in the standard deviation from the pre-to post-assessment from 13.75 to 15.72, respectively, indicating a larger spread in the overall scores on this portion of the post-assessment. The statistical analysis of the
evolution section also revealed a statistical significance between the pre- and post-assessment with a p-value of 0.0005. Contrary to the ecology section, the standard deviation in the evolution section narrowed from 20.58 to 15.60 from the pre- to post-assessment. The complete assessment, including both ecology and evolution together, showed a mean increase from 69.55% to 78.80% (Figure 1). The standard deviation decreased from 14.8 to 12.5. The p-value was 0.0005. Thus the null hypothesis was rejected and the value of the treatment in terms of content knowledge for ecology and evolution was shown to be statistically significant. The decrease in standard deviation in the post-assessment showed that student scores were closer to the mean as a whole.

![Figure 1](image_url)

*Figure 1.* Mean scores and standard deviations for the pre- and post-assessments for ecology and evolution combined, (N=55).

The data from the pre- and post-assessments were compared to the delayed assessment results taken two weeks after students returned from each research site. Students demonstrated good retention of both ecology and evolution content between the post- and delayed assessment. There was a slight change in the mean scores in the post-
assessment as compared to the delayed assessment from 78.80 to 79.36 respectively. However, the t-test results gave a p-value of 0.81. This indicates that the null hypothesis is accepted, so there is no significant difference between the post- and delayed assessment results. A summary of scores for pre-, post- and delayed assessments are shown in Figure 2.

![Score distributions for pre-assessment, post-assessment and delayed assessment for each trip as well as a summary of scores for all trips, (N=55).](image)

**Figure 2.** Score distributions for the pre-assessment, post-assessment and delayed assessment for each trip as well as a summary of scores for all trips, (N=55).

**Confidence and Motivation**

Students responded to twelve Likert-based statements on the pre- and post-trip surveys regarding their ability and confidence to be a field scientist. The survey statements asked students to rate their confidence on skills in the field, and on the analysis and presentation of research. The students’ confidence levels for functioning as a field scientist rose significantly between the pre-trip survey and the post-trip survey (Figure 3). Using a t-test, I was able to verify the significance of the increase between the pre- and post-survey with a p-value less than 0.0001. Thus, the null hypothesis is
rejected and the difference between the pre- and post-survey responses is significant.

When students were asked an open-ended question on the pre-trip survey about when they felt they had performed best as a scientist, 44 percent of the students mentioned field science work with in-class inquiry having the next highest number of responses. Though 14 of the 55 students had traveled with EPI before, most of the examples given were not based on a previous trip experience. The treatment designed for the 2018 trips was much more focused than in past years. Observations and data collection made in the high school Living Laboratory (outdoor lab space) were credited by several students. When asked on the post-trip survey which skill learned they felt confident to teach to others, 71% mentioned either field data collection or field research design (N=55). One student said, “I think being able to just formulate an experiment using the tools and environment around me is a skill I definitely gained on this trip and could teach to someone.”

![Bar chart](chart.png)

**Figure 3.** Pre- and post-trip survey results for statements related to functioning as a field scientist, (N=55).

Observations from teachers further highlight the change in field work confidence. 

One teacher mentioned in his trip journal entry that students were becoming better
scientists as the trip proceeded: “Students are becoming much more aware of their surroundings and are noticeably better observers.” On a different trip in the Galapagos Islands, another teacher pointed out how meticulous those students were while investigating invasive species. The teacher noted that the students were especially engaged when asked to predict how many seeds, and of what type, they would expect to find in the tortoise feces. “Students were performing real science work and they knew it was important, so they took it very seriously.”

Motivation for learning science was addressed in three of the pre- and post-trip survey statements. Students on all trips showed a marked increase in this area. Looking at all students, the increase in those who strongly agreed with the motivation statements as compared to before the trip was just over 22 percent. The significance of the difference in the mean due to the treatment was supported with a p-value very close to zero using a t-test. The null hypothesis was rejected by this analysis. The results from the open-ended questions on the pre-trip survey indicated that more than 50 percent of the students claim their main motivation for learning is derived from personal interest. Though other motivators were mentioned, such as teachers/mentors, future possibilities, and enjoying hands-on type activities, no other category was acknowledged nearly as much. One student wrote, “I really like knowing how aspects of the natural world are interconnected and when that intersects with science, I’m super interested and motivated to learn.”

There were various ways students showed their intensifying motivation for learning while on the trip. One student on the Belize trip was overheard telling another
student that he thought the bird observations were going to be really boring. Later in the trip, after observing birds with the group, the same student asked his friend if he wanted to get up early the next day to do some more observations of birds on their own. In yet another anecdote, instructors noticed student interest was dramatically increased when encouraged to formulate and pursue their own research questions. On the post-trip survey, one of the students who traveled to Costa Rica said, “In Tirimbina, when we were asked to come up with our own experiment, it was hard at first, but working with our instructors helped me to understand how to control variables and be successful in my research. It was really fun.”

Student motivation was positively impacted by direct connections with organisms, access to enthusiastic instructors, and the application of specific science research with real-world relevance. One student completed in an open-ended response with, “We discussed how aggressive and damaging invasive species were to ecosystems so when we saw how tortoise feces led to its mass spread, I was very engaged.” Another student mentioned that the passion of her instructors about the importance of conservation made topics much more interesting. Some students wanted to take their inspiration from their trip to the next level. A student from the Costa Rica trip wrote, “Being on this trip has really opened my eyes on what nature has to offer. I plan to be more connected with the outside and educate others on what I have learned.” Another student showed the pride and interest he had in his research when he said during the post-trip interview, “I really enjoyed getting to do research about what we chose to learn about. I still have our poster in my backpack. I didn’t want to take a chance that it would get lost with my luggage.”
His urgency to retain the scientific information learned was evident and particularly poignant.

Students responded to five survey statements regarding learning and retaining information in an outside environment as compared to a classroom. Two of the survey statements leaned in favor of an outdoor learning environment whereas three statements supported a classroom environment. On a pre-trip survey, students clearly agreed that they were more interested in learning outside (65%) than in a classroom (18%) but indicated some concern over possible distractions. One student wrote on the open-ended portion of the survey, “Our teacher led us outside to learn about adaptations of flies. Although I observed and recorded the data, I could not necessarily focus due to the distractions of the wind and the other students.” During a pre-trip interview, a student who was about to travel to Ecuador said,

There are good reasons for learning both inside and outside. When you’re outside, you are part of the ecosystem and get to interpret things yourself. When you’re inside it is practical, safe, and easier to make an analysis. Also, not everyone is comfortable outside.

A t-test was used to see if the change in responses between the pre- and post-surveys were statistically significant. The results indicated that students preferred learning outdoors and felt they retained more of the content. The mean rose from 3.85 on a Likert scale to 45.33 but more importantly the p-value was near zero. This evidence rejects the null hypothesis and indicates a difference following treatment (Figure 4). Conversely, the questions focused toward the advantage of a classroom environment for learning showed a similar trend. In this case the post-survey mean was less than the pre-survey mean pointing toward a change in attitude away from the classroom environment
for learning. This is supported by the statistical data from the t-test as the p-value was near zero. This rejects the null hypothesis showing that the change due to the treatment was significant (Figure 4). In further support of the trend toward a favorable outside learning environment, a freshman from the Belize trip said during the post-trip interview, “I found that I learn more by interacting with nature.” A student from the Costa Rica trip stated, “Physically being out in the field helped me retain the information in my mind and I will never forget this experience and the information about sea turtles.” A teacher on the Costa Rica trip noticed that when students were participating in lessons similar to a classroom-type lesson that they were less engaged even though the content was necessary to the subsequent work in the field.

![Figure 4](image-url)

*Figure 4.* Pre- and post-trip survey responses regarding learning in a classroom as compared to an outside environment, (*N*=55).

To further look at learning and retention, students responded to two separate statements on the post-trip survey where they could reflect on their recent trip experience. Seventy-six percent of the students agreed or strongly agreed that learning science
concepts while on this trip were easier to grasp than if learned in a classroom. Ninety-five percent agreed or strongly agreed that they felt they would retain much of the science information learned while on the trip.

**Connection with Science and Nature**

Both surveys and interviews assessed student experiences outdoors and their interest in science. Out of twelve students interviewed, ten actively engage in many outdoor activities with family and friends. One of the students who did not participate in outdoor activities with family said, “I’m the only one in my family who is even interested.” In the pre- and post-trip surveys, five statements related to this topic to help determine the effect of the trips. In looking at the results, there was a shift in scores toward agreement for every statement, however to differing degrees. Students’ perceptions of the importance of science for understanding the world and for giving them the necessary skills that are important to integrate in life showed a significant increase between the pre and post-trip survey. Using a t-test to analyze the significance of the increase in the means between pre- and post-surveys, the p-value for both the importance of science in understanding the world and the importance of science skills was near zero. The null hypothesis is rejected for both statements which demonstrates the significance of the increase. When asked about why science was important in a pre-trip interview, one student said, “It’s about life. You can understand how things work.” In contrast, another student voiced his one trepidation with science stating “there is a lot of foundational knowledge you need to have in order to understand anything.”
On the statement regarding student interest in science-related activities, there is a noticeable shift in responses on the graph indicating a positive change after the trips (Figure 5). However, the p-value was 0.057 which is larger than the 0.05 significance value. In this case, the null hypothesis is supported and the change between pre- and post-treatment is not valued as significant. The twelve students interviewed were asked about their science-related activities and many were not sure what would classify as a science-related activity. This could be a contributing reason for the lack of change after the treatment.

![Figure 5. Likert responses to the pre- and post-trip survey statements regarding a connection to science and nature, (N=55).](image)

The data show that students’ value of their time in nature clearly increased after going on their respective trips. The p-value was calculated at 0.0005. This indicates a statistical significance between the pre- and post-trip results as the null hypothesis is rejected. One teacher wrote that students were beginning to spot species that they had been researching and never had seen before in the wild. She said, “They were so excited
to find, identify, and teach others about their animal.” There was also a statistical difference in the responses regarding the interdependence and equal importance of life forms. The p-value was 0.01 which rejects the null hypothesis. There is evidence from the responses during the post-trip interviews, that students had made good connections between organisms and other environmental factors. One student from the Galapagos trip said, “It is shocking the amount of invasive species and how fast it happens.” A student from the Costa Rica trip expressed, “I realize how my actions can relate to different animals such as how using plastic bags can affect turtles.”

Two of the statements in the Post-Trip Survey ask for each student’s opinion on how the trip experience had enhanced his/her connection with the natural world and how interested they are in maintaining a connection with the natural world. Fifty-three of the 55 students strongly agreed or agreed that their science research trip experience had enhanced their connection to the natural world. Only two students were neutral about that statement. One student said about his memorable experience, “For me, it was being on turtle patrol. Just to be out in the middle of the night on a beach and working with turtles. I loved being out there.” Another student said, “I really enjoyed being in the rainforest. The noise was so amazing.” There was also an overwhelming response to the statement about wanting to maintain their connection with the natural world with 54 students saying they agreed or strongly agreed. In the post-trip interviews, I noted an amazing sense of pride exhibited by students regarding the research they had done and the overall importance of the research to the natural world. These trips clearly influenced
students in terms of wanting to bring back what they have learned, teach others (including family and friends) and help to conserve the planet.

Future Pathways

Data were collected from both current students who traveled on trips this year ($N=55$) and former students from as far back as 2002 ($N=141$) to see if research trips influence future educational or career pathways. Current students were asked to respond on a Likert scale to two statements. The data from the first statement regarded their thoughts on learning science as being valuable for their future. The second statement on the survey was to check if they were considering science as a possible career choice at this point. Though the mean did increase in for both importance of science in their future and for a science career pathway, there are some interesting considerations (Figure 6). On a t-test for the value of science in their future, the p-value near zero. This is classified as significant, but I noted that the standard deviation for the pre-test was 1.24 and the post-test was 1.16. Even though the null hypothesis was rejected, the wide spread standard deviation indicates a rather broad range of data within the set. This means there was a lot of variation in the answers given. In terms of science as a career pathway, the p-value was 0.03. Though this shows a that there is a significant difference after the treatment, but at 0.03 it is rather close to the significance level of 0.05.

Some responses outside of the survey did indicate some students had changed their thoughts about future pathway plans based on their trip experience. One student was overheard telling another student that this trip had made her enjoy science again and that she is now considering pursuing science in college. Several of the students who I
interviewed had already considered science as their future pathway, but there were even greater changes in their responses at the post-trip interview. One student who was unsure in the pre-trip interview later said, “Doing field research solidified my interest and surprised me that I felt I could do that in my future.” A senior who was emphatic about becoming a biotechnology engineer for her career changed her mind in the second interview and now wanted to teach students in the field and maybe work for EPI. She said, “I think I would really love to teach and if I could be in wonderful places and still teach, that would be the best.” She was so excited to tell me of her career plan change.

**Figure 6.** Pre- and post-survey responses regarding future pathways, \((N=55)\).

The Interview a Scientist activity was designed to introduce students to science pathways so they could see how scientists in the field had either reached their desired goal or were in progress. Students relayed some very positive reactions to this activity. The teachers on all four trips said that students were very engaged and asked lots of questions of the scientist they interviewed. One instructor said, “Students began to ask spontaneous questions and became so interested that they stopped taking notes.” Some of the students interviewed scientists from the country they were visiting and had to do their
interview in Spanish. Some of the comments from students in my post-interview showed how surprised they were to find out that the scientists took varied pathways to get where they are now, and that some were still in progress to reaching their goals. One student was surprised that the scientist did not really think he was going to go into biology originally. One of the seniors I interviewed was amazed that the scientist she spoke with had many difficulties and changes in his pathway. She said, “You never really know about people’s struggles. He (the scientist) was just like me. He was going through what I am going through.”

Data were collected from former Bishop O’Dowd students who traveled on EPI research trips when they were in high school. One hundred forty-one people responded to the online survey. The results indicated that the trip influence on focus/direction/major in college or a career was quite mixed with data, however, being split almost equally between agree, disagree, and neutral (Figure 7). Many students indicated on the open response how the trip had influenced their lives. Some of them were in fact inspired to pursue science because of their EPI. One person wrote, “I clearly remember being awed by the sea turtle work in Costa Rica. I didn’t want to leave Costa Rica and that trip made me realize that I wanted to work with wildlife in my career.” Another wrote, “Not only was it a great experience to foster my curiosity in science and about the environment, it also strengthened my interest in veterinary medicine which is the field I plan to pursue after college.” Other former students wrote about how the trip influenced them in other ways outside of science. One person stated, “I attribute my love for new experiences, environments, and topics to EPI. It gave me an opportunity to place myself in a new
place with new people, to trust others and open myself to experiences I might normally be afraid of.”

Two of the other survey statements showed a strong influence from the trip experience. In terms of former students feeling that the trip impacted their interest in science, 92 percent responded that they agreed or strongly agreed. Some majored in science or followed a pathway that included science and others did not. One former student stated, “While I have many interests and am not pursuing a career in science, I can still love the study of it, and care for the environment.” Still others have moved in a science-bound direction. One person said, “I truly believe that this trip helped shape my interest in studying science and pursuing a career in marine biology.” Eighty-seven percent of the respondents marked agreed or strongly agreed that the trip influenced their care/concern for the environment. One person wrote, “The EPI trip made me more environmentally conscious, more in tune to my everyday impact here on planet earth and more hope filled.”
The goal of this research project was to evaluate the effectiveness of science research trips in terms of learning, motivation and influence on future academic and career decisions. My hypothesis was that students could benefit on many unique, individual levels by engaging in outdoor education opportunities and participating as field scientists. Many different data collection methods were used, both quantitative and qualitative, to gather evidence and gauge the value of this outdoor learning experience.

**Learning and Retention**

The pre-, post- and delayed assessments were used primarily to evaluate the impact of trips on learning and retention of content. Qualitative observations from teacher journals were applied when available but were not necessarily specific to the exact content from the assessments. The results from both content areas, evolution and
ecology, revealed growth in student knowledge of specific and applicable content. This was true across all grade levels. The average score increased by almost 10 percent while the standard deviation dropped by almost two percent. I was somewhat surprised that all grades levels showed improvement on the assessments which for me, illustrates the value of the research trip experience. Based on the differences between grade levels, I thought there might be a large discrepancy in the results of assessments from different trips. For example, our freshmen take a year of an integrated science course before taking biology. Many of the seniors have not had biology for a couple of years. However, no notable differences were evident. There were indications students were thinking critically, applying the information they were learning. One teacher who has chaperoned several EPI trips in the past, noted in his journal that students were asking great questions regarding science and specifically about ecology.

I also attempted to measure retention, beyond the initial content mastery. The delayed assessment was employed as a comparison to the post-assessment results. In this case the null hypothesis was supported by the results of the paired t-test which indicated there was no statistically significant difference between the two scores. Students had clearly retained the information they learned on the trip to the same level as the post-test. Though the questions were the same as on the pre- and post-assessments, students had not received any feedback from previous sessions nor were they aware they would be tested again.
Confidence and Motivation

Many of our students have some experience with field science, both with data collection and analysis, from the large outdoor laboratory at Bishop O’Dowd. The research trips take the process further, from start to finish, by teaching the skills needed for the specific focus. Students develop their own questions, implement an investigation, collect and analyze data, and ultimately present the results. Both pre- and post-trip surveys, as well as pre- and post-trip interviews were used to evaluate the effectiveness of the trip experience on student confidence as a field scientist. Instructor observations were used as support. Overall there was a 28% increase in the students who strongly agreed that they felt confident as a field scientist by the end of the trip ($N=55$). The biggest shift was in the results from the Ecuador trip which had an increase of 53% ($N=12$). This was somewhat unexpected since these students were juniors, already well-immersed in the science curriculum, and all had been recommended by their science teachers. The quotes from students and teachers indicated that the students understood their research had real value. In the post-interviews I noted an overall confidence exhibited by students in their conversations when asked about their research and presentations. One student mentioned she now felt prepared to present her final biology project in May. A student enrolled in Mandarin, expressed her concern about presenting her research in Spanish during the pre-interview. She later told me the presentation was not a problem. A former student summarized, “The EPI trip was easily one of the best experiences of high school. You learn teamwork and research methods in a real world environment. The experience is
more practical than just classroom learning.” Students demonstrated confidence about their research and knew how to function in the field as a research scientist.

From the pre- and post-survey results, as well as support from the open-ended questions and interviews, it was clear that student motivation is primarily guided by personal interest. It is not surprising that students who are recommended for a science trip would, in fact, be interested in science, but that is not always the case. In the pre-trip interview, very few mentioned science as their primary reason for wanting to go on the trip. In fact, the freshman who were interviewed just wanted to explore another country. The older students had a better idea of what a science research trip entailed. The quantitative results showed a 22% shift toward a greater motivation after the trip. The most dramatic change was the depth of motivation.

Open-ended comments from the survey, the post-trip interview, and notes made by teachers in their journals depicted students who enjoyed the research process and were motivated to make changes in the world. This became more apparent when interviewed the student who had completely changed her career plans because of her trip experience. She was extremely surprised and almost embarrassed to say she had been absorbed completely by picking through tortoise feces to collect invasive plant species seed data. The overall passion exuded from 11 of the 12 students interviewed as they recounted their trip experiences was overpowering. Their hunger to learn more, combined with their aspirations to make a difference on this planet were palpable. One student from the Ecuador trip expressed, “I, as well as a few other students who attended this trip am
planning on organizing a Lake Merritt clean-up. We are examining the most effective method to get others involved.”

The opportunity to experience science outside on a research trip, rather than learning primarily in a classroom appeared to be a strong motivator. There was a significant difference between the pre-trip and post-trip results, even taking into account that these students had all been recommended. This speaks to the powerful effect of the trip experience – a transformative experience for these students. Even the students that I interviewed before the trip who were strong advocates of outdoor education came back much more enthusiastic. This was supported by the data. Students who were very quiet and reserved before the trip, returned more confident. One of the timid students only politely answered questions during the pre-interview but was telling me stories upon stories during the post-trip interview. He was visibly much more self-assured and his excitement was contagious. Another student could not wait to tell me about turtle patrol. He said, “The turtle was crazy! It was so big, bigger than me if I laid down. I even watched it lay eggs!”

**Connection with Science and Nature**

Students showed an increased connection to the natural world and a greater recognition of the importance of science and science skills after the research trips. This is supported by the data from the pre- and post-surveys where the difference between the two sets of data was shown to be significant using t-test. Only one survey statement did not show a significant difference; the statement about interest in science-related activities. Students apparently did not understand what a science-related activity might be. The
question was meant to be open ended and could include museums, zoos, or even college fairs. When I asked if they participated in science-related activities with their families, all twelve students I interviewed asked what a science-related activity might be. After I gave them some very specific examples, they all claimed that they did those activities. I also noticed that my suggestions of science-related activities did not spark any new or different ideas from the students.

Based on post-trip surveys, students showed they now had a significant connection with nature. The same was true regarding the student desire to maintain that connection to the natural world. Students had a variety of ways they planned to accomplish that goal. Some expressed their desire to go on another EPI trip. Others intended to find ways to connect with organizations locally. Still others were considering doing some independent research to discover more about animals and ecosystems of interest. Many of the students mentioned they want to inspire and educate family and friends about nature and science.

**Future Pathways**

Information about the effect of the trips on future decisions for college or a career was gathered through the surveys, interviews, and through observations made by instructors in the field. The “Interview a Scientist” activity seemed to be beneficial to students on all the trips as well as contributing valuable data for my research. The feedback from instructors showed that students were interested in the interviews, came up with good questions (beyond the prompt questions), and were even surprised by what they were learning. Student responses in the post-interview echoed those observations.
When asked how the Interview a Scientist activity went, for them, 10 of the 12 students answered exuberantly. They not only remembered the activity with no prompt other than the name, but they had a lot of stories to tell me about “their person.” Many of the students I interviewed were surprised that the scientist had not always planned or dreamed of being a scientist. Other revelations were the struggles they endured to get to their current position or challenges yet ahead. Lastly, students never considered that many of the scientists had future plans beyond their current position. A few teachers wrote in their journals that this particular activity seemed to improve and solidify a connection between the students and the scientists for the remainder of the trip. For some of the younger students, this opened a door for them to think about science, especially field science, as a potential future pathway. For some of the older students, including seniors who had just been accepted to college, they were rethinking some of their expected choices. Though this was not part of this particular survey, one former student encapsulated the impact of this trip on her pathway: “I came home and told my mom I wanted to be a marine biologist. Now I am an instructor in outdoor marine education hoping to provide students with the same hands on science experience EPI gave me.”

Current students who showed an interest in a future in science did show some increase between pre- and post-surveys. What was difficult to measure is how students will continue to involve science in their future without a college major or career in science. As discussed previously, the term “science-related activities” was not meaningful to students. More specific statements/prompts would elicit better responses. There are other positive attributes, beyond science, that students take away from these
trip experiences; value for education, career, leisure, or personal significance. Testimonies from former students highlight this point. Many did not follow a science pathway in college or as a career yet gained rewards from their trip experience. Former students specifically mentioned other transformative experiences from EPI trips such as a love of travel, exposure to different cultures and language, learning to ask big questions, becoming a leader, and developing life skills.

The information from former students is evidence of the more comprehensive impact of these research trips (N=141). The data indicate a very strong correlation between the trip experience and their interest in science (92%) as well as their care and concern for the environment (87%). The trips definitely influenced some in terms of their choices for college majors (43%) or career emphasis (43%). Only one former student of the 141, wrote that she had a terrible experience on her trip. I assume there could have been others who had a similar experience but did not respond to the survey. However, for the majority of those who responded, there was a bigger message in terms of the overall lasting value of these trips. One hundred and forty of the 141 respondents ascribed overall value, far reaching positive effects, and lasting memories to the EPI trips in which they participated.

VALUE

For many years I have witnessed how students are favorably affected by their experiences on science research trips. Students often exhibit how much they value this field work in very subjective, difficult to quantify ways; through storytelling and an exuberance – sparkle – that was not evident beforehand. Often, these same students will
channel their new-found enthusiasm into participation in Living Lab events on campus, involvement in ecology clubs at school or in the community, or enrollment in more research trips and challenging science classes. They continue to make connections between what they observed and learned in the field, with current classroom curriculum. The educational and personal advantages gained through the research trip experiences has always been evident to me but only through anecdotal observations. This research project connected the necessary data enabling me to adapt and hone my own teaching techniques, as well as crafting more research trips to benefit future students.

Motivation to learn is certainly an open road to greater learning at any age. Based on my research, it is clear that outdoor learning is a component that breeds interest and that students value as real. Designing outdoor lessons and monitoring student progress can be challenging, but finding ways to integrate science outdoors can help to breed greater motivation that positively impacts learning. Research outdoors is also less perfect. Variables cannot be realistically controlled as they might in a lab. Failure is a greater possibility, but both those factors, variables and potential failure, are also part of what makes science outside more real. One student told me during her post-trip interview, “I can see that science in the field could be very time consuming and you may not get the data.” She’s right, and that can be frustrating for both teachers and students. Bishop O’Dowd’s Living Lab can accommodate several science classes to use the area for field studies at any one time. We are currently trying to expand the curriculum to include more field components to promote the type of motivation that can be derived
from that experience. Consequently, curricular content and a true experience in nature could be accomplished without the cost and logistics of traveling.

Another important aspect that can be combined with additional field experience is offering research possibilities for students. They could choose a topic of interest to study, then take the investigation from the initial design, to data collection, analysis and eventually presentation. The data collected in this project showed that students were extremely proud of their field research work when allowed to choose their own topic and question to investigate. This sparked even more interest and motivated some students to take their projects to the next level. During one post-trip interview, a student told me his group was so intent on research regarding turtle nest location, that they spent their own free time, over several evenings, looking at all available data at the research station. One teacher on the Costa Rica trip was asked by multiple students if we did the same kind of activities in the Living Lab that the group was doing on the trip.

Getting students into the field presents hurdles that do not exist in the classroom. Sometimes there is added equipment or skill training needed for students and teachers, and both can be quite expensive. There can also be significant safety concerns. The benefit is that more students have the opportunity to discover the advantages unique to research trips. Based on the data from this project, students demonstrated they can learn and retain important concepts through the lessons and research completed in the field. Incorporating those on-site opportunities with a heightened level of motivation to learn would be a wonderful combination. Beyond that, students would gain a proficiency in field science skills, and realistically good science skills in general. A full investigative
process in the field could cover all eight Science and Engineering Practices mapped out by the Next Generation Science Standards in one project.

One overarching theme generated by the results from this project is that science research trips need to continue. As a high school teacher, I am seeing that there are fewer students having experiences outdoors, and thus, having less opportunities to connect with nature. This study has confirmed the multiple advantages for connecting and learning outdoors. Beyond our Living Lab, this is one of very few opportunities students have to engage in outdoor education, and also work side by side with scientists in the field. These trips are an immersion into an entire ecosystem rather than just a short isolated moment in time every other day.

There are three major problems that should be addressed for these trips to grow and continue. One issue is the perceived lack of educational value for each trip. I am hoping that the data put forth from this project provide support and validation for the many exceptional advantages to be gained from these experiences. The second issue is the lack of funding for families who cannot afford to participate. Though financial aid is available, it has been difficult to accommodate enough families in need. My intention is to create a financial source to help students to go on research trips. Some of our past alumnae may be a good resource for getting this started. The school definitely uses these research trips for marketing purposes, so they have a vested interest in helping them to flourish. Finally, as more students choose to participate, more spaces need to be made available. There are a limited number of trips and a limit on the teachers who can or are willing to travel with students. This might be a challenging issue and limiting factor.
The overall results from this project have shown that science research trips do impact learning and motivation. They also strongly influence future choices that students are making. Though the pathways can be quite diverse, and perhaps may not ultimately be science related, they all lead to important personal growth. Though I am a fervent supporter of the numerous attributes of the science research trips, it was eye-opening to hear the feedback from current students. It was also amazing to hear from the many former students who found time to answer a survey and reflect on how a trip may have truly influenced their lives. Both former and current students acknowledged that academic, career, and life pathways can change. Anticipated directions may take surprising turns. It was equally affirming to hear of other attributes from the trips beyond science. One former student noted that participating on a research trip allowed students to break away from normal routines and expand their circle of personal friends. Many new friendships formed that still persist well beyond the trips. In moving forward, continued feedback and data collection from all stakeholders will continue to be important. This includes the close working relationship I have with EPI. Their continued interest in offering the quality educational experience that we have been a part of for the last sixteen years is pivotal. Learning opportunities in the natural world are extremely critical and virtually unreproducible in the classroom. They can literally transform a student’s life. To continue these educational experiences while expanding those opportunities will be of paramount importance.


Griset, O. (2010). Meeting outside: a field ecology course to engage all students in exploring environmental issues. The Science Teacher, 2, 41-46


APPENDICES
APPENDIX A

INSTITUTIONAL REVIEW BOARD EXEMPTION
MEMORANDUM

TO: Timothy Newman and Wall Woolbaugh
FROM: Mark Quinn
Chair, Institutional Review Board for the Protection of Human Subjects
DATE: October 30, 2017
RE: "The Effect of a Science Research Trip Experience on Student Learning, Motivation, and Ongoing Connection with Nature" [TN103017-EX]

The above research, described in your submission of October 30, 2017, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

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

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

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

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

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

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

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

SAMPLE PRE-TRIP MATERIAL (COSTA RICA)
Costa Rica Research Trip 2018

Do you have a current passport?  Yes  No

If no, have you applied for one?  Yes  No

When do you expect to have it?  __________

Are you a citizen of the United States?  Yes  No

Have you traveled outside of California?  Yes  No

Have you traveled outside of the USA?  Yes  No

Is English your first language?  Yes  No

If not, what is your first language?  __________

What other language(s) have you studied?  __________

If you have studied another language, what level are you in?  1  2  3  4

How would you rate your swimming ability?  Poor  Fair  Good  Excellent

How would you rate your comfort level with being in water?  (Mark on the scale below)

<p>| |</p>
<table>
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<tbody>
<tr>
<td>extremely</td>
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<tr>
<td>extremely unpliable  comfort</td>
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<tr>
<td>extremely comfort</td>
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</table>

Have you been on a hike?  Yes  No

If yes, approximately how far was your longest hike?  __________

Have you ever been camping?  Yes  No

If yes, where was the last place you camped?  __________
Have you camped without your family  
Yes  
No  

Have you ever had a bug bite?  
Yes  
No  

How would you rate your comfort level with insects? (Mark on the scale below)

extremely uncomfortable  
comfortable

How would you rate your comfort level with spiders? (Mark on the scale below)

extremely uncomfortable  
comfortable

How would you rate your comfort level with snakes? (Mark on the scale below)

extremely uncomfortable  
comfortable

How would you rate your comfort level with other animals in general?

extremely uncomfortable  
comfortable

Do you have any food issues?

Describe your most challenging adventure experience so far.
Turtle Measurements

Field Measurements – Leatherback Turtles

- **Largo**  The length of the turtle carapace
- **Ancho**  The widest distance found on the turtle carapace

Be sure all of your measurements are recorded in centimeters
APPENDIX C

INTERVIEW A SCIENTIST ACTIVITY
Interview a Scientist - EPI 2018
Your group will have a very special opportunity today to find out more about one of the scientists you are working in the field with this week. Many times, people take an indirect pathway to reach their goals. Before you interview your scientist, you should think about what kind of information you want to find out. Below are some questions to get you started. You may choose to use some of these questions, but should think about developing some of your own.

Early Years
- Where did you grow up?
- When you were in high school, what did you think you wanted to do with your life?

Education
- How did you choose the college you went to?
- What was your major in college? Was that a good choice for you?
- Have you pursued education after your undergraduate degree?

Work and Future
- How did you acquire the job you have now? What kind of skills were required to get this job?
- What are your career plans? What will it take to get there?
APPENDIX D

PRE-TRIP INTERVIEW QUESTIONS
Pre-Trip Student Interview Questions

Participation in this research is voluntary. Grades and class standing will not be affected.

1. Approximately how much time do you spend outdoors each week?
   Probe: What do you generally do outdoors? What kind of things do you do? Do your parents encourage outdoor activities?

2. Have you engaged in science or nature-type activities outside of school (sports camps, relaxing, camp, walk, etc)?
   Probe: Can you give examples and who they were with? Would you like to do more or less of those activities? Have you ever spent significant time unplugged?

3. What were your reasons for wanting to go on this trip?
   Probe: What do you think will be the most difficult part of going on this trip? What will be the most rewarding part?

4. How would you rate your overall interest in science on a scale of 1 to 5? (1 is very low, 5 is very high)
   Probe: What do you like the most about science? What do you dislike the most about science?

5. Do you have experience learning science outdoors?
   Probe: What would you say are the advantages of learning science outside? What would you say are the advantages of learning science in a classroom?

6. What science classes do you plan to take after your required classes are satisfied?

7. Do you want to pursue something related to science after high school?
   Probe: What would you like to do? (science or other) What do you think it would take to get there?
APPENDIX E

POST-TRIP INTERVIEW QUESTIONS
Post-Trip Student Interview Questions

Participation in this research is voluntary. Grades and class standing will not be affected.

8. Opener - Did you have a good time on the trip?

9. What was your biggest take-away from this trip?
   
   **Probe:** What was your most memorable experience? 
   What lesson would you say was most effective? What made it the best? 
   What did the instructor/chaperone do to help you learn about this topic?

10. Now that you’ve completed the EPI course, is there anything that you view differently than before the trip?
   
   **Probe:** If so, how might this impact your life?

11. Has your interest in science changed or stayed the same? How would you rate your overall interest in science on a scale of 1 to 5? (1 is very low, 5 is very high?)
   
   **Probe:** Will you continue to seek out experiences connected to science? 
   What kinds of things do you think you will do or avoid?

12. Now that you’ve been on this trip, how would you compare learning in an outdoor environment as compared to learning in a classroom?
   
   **Probe:** Can you give some examples? 
   How could a classroom science teacher help to improve a classroom teaching experience to achieve the same learning goal?

13. How was your experience being unplugged during this trip? Positives/negatives?

14. Did you learn anything interesting when you interviewed the scientist on the trip?
   
   **Probe:** Who did you interview? (Researcher, EPI instructor) 
   Do you feel you may be interested in pursuing a science major or career? 
   Did this trip impact that in any way?

15. Anything else you learned or impacted you related to this trip that I haven’t asked?
APPENDIX F

FORMER STUDENT SURVEY
Former Student - EPI Participation Survey

Participation in this survey is voluntary. Names will only be used to connect with the participant and analyze collected data; names will not be published.

* Required

1. Name (First and Last) *

2. Gender *
   Mark only one oval.
   - Female
   - Male
   - Other:

3. What is your current occupation? *
   Check all that apply.
   - Student
   - Employed
   - Other:

4. If you are employed, what do you do?

5. Date of your latest EPI research trip *
   Mark only one oval.
   - 0-3 years ago
   - 4-6 years ago
   - 7-9 years ago
   - 10-12 years ago
   - more than 12 years ago
6. Location of the EPI trip(s) you attended? *
Check all that apply.
☐ Costa Rica
☐ Galapagos
☐ Mexico
☐ Belize
☐ Ecuador - Andes/Amazon
☐ Montana

7. How well do you remember your EPI trip experience?
Mark only one oval.

1 2 3 4 5
Poorly ■ ■ ■ ■ ■ Very clearly

8. What do you remember the most about your EPI trip(s)?


9. Which of the following have you done since attending an EPI research trip? 
Check all that apply.
☐ Started college
☐ Completed a bachelor's degree
☐ Started postgraduate studies
☐ Completed a postgraduate degree
☐ Obtained a full-time job
☐ Other:

10. How did your participation on an EPI trip impact your interest in science?
Mark only one oval.

1 2 3 4 5
Negative impact ■ ■ ■ ■ ■ Positive impact
11. How did your participation on an EPI trip influence your chosen focus or major or direction in college?
   Mark only one oval.

   1  2  3  4  5
   No influence MOOTH STRONG influence

12. If you have attended or are attending college, what is/was your chosen focus or major?

13. How did your participation on an EPI trip influence your decision about what career you would like to or did pursue?
   Mark only one oval.

   1  2  3  4  5
   No influence MOOTH STRONG influence

14. How did your participation on an EPI trip influence your care/concern for the environment?
   Mark only one oval.

   1  2  3  4  5
   No influence MOOTH STRONG influence

15. How has your participation on an EPI trip changed the amount of free time you spend doing science or nature-related activities?
   Mark only one oval.

   1  2  3  4  5
   Decreased the amount of time ooth increased the amount of time

16. What further comments do you have about how your EPI experience has influenced you?
APPENDIX G

EPI PRE- AND POST-TRIP SURVEY
### EPI Student Survey

#### Field Science Skills

<table>
<thead>
<tr>
<th>Statement</th>
<th>5 Strongly Agree</th>
<th>4 Agree</th>
<th>3 Not Sure</th>
<th>2 Disagree</th>
<th>1 Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can ask questions that can be answered through field research and the collection of data</td>
<td></td>
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<tr>
<td>I am able to design a methodology to collect data that allows me to answer a question I have created</td>
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<tr>
<td>I am able to use data I have collected to create graphs and tables that demonstrate my results</td>
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<tr>
<td>I am able to construct conclusions and explanations using graphics, charts, and tables</td>
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<tr>
<td>I am able to create a poster or presentation that communicates results and my conclusions</td>
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<tr>
<td>I am able to defend my arguments and findings to others</td>
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<tr>
<td>I feel comfortable orally presenting my conclusions</td>
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</tbody>
</table>

#### Connection and Integration of the Natural World

<table>
<thead>
<tr>
<th>Statement</th>
<th>5 Strongly Agree</th>
<th>4 Agree</th>
<th>3 Not Sure</th>
<th>2 Disagree</th>
<th>1 Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I value the time I spend being outside in nature</td>
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<tr>
<td>I appreciate the interdependence and equal importance of all life forms</td>
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</tbody>
</table>
APPENDIX H

SCHOOL PRE-TRIP SURVEY
**Science Research Pre-Trip Survey**

Participation in this research is voluntary and participation or non-participation will not affect a student’s grade or class standing in any way. No names will be included in the final presentation of this research.

**Directions:** Please respond to the following by placing an X in the box that most closely matches your outlook regarding each statement.

<table>
<thead>
<tr>
<th>Future Integration of Science in Life</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel that learning science will help me to be successful in my future.</td>
<td></td>
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<tr>
<td>I plan to include science as a career option.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Field Science Skills</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am familiar with what a science field researcher does.</td>
<td></td>
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<tr>
<td>I feel confident in my skills to collect data for an investigation out in the field.</td>
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<td>I feel confident in my ability to organize scientific data that has been collected.</td>
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<tr>
<td>I think that I have the basic skills to be a field research scientist.</td>
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<tr>
<td>Give an example of one situation where you have performed your best as a scientist. Explain what were you doing and the outcome.</td>
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</table>
### Connection and Integration of the Natural World

<table>
<thead>
<tr>
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<th>5</th>
<th>4</th>
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<tr>
<td>I consider the results from scientific investigations to be important for understanding how the world works.</td>
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<td>I feel that science skills are important to integrate into my everyday life.</td>
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<tr>
<td>I enjoy visiting science-related museums, displays, or presentations.</td>
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</table>

### Motivation in Science

<table>
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<tr>
<th>Statement</th>
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<td>I find that the things I learn in science are relevant and useful to my experiences in my life.</td>
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<td>I find that learning science is interesting</td>
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<td>Science is one of my favorite subjects in school.</td>
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<tr>
<td>Give an example of the best motivator for you in terms of learning science. Explain why this is most effective for you.</td>
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<tr>
<td>Value of Outdoor Learning</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
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<td>Give an example of a lesson that you were taught outside the classroom. Explain what you learned and how effective it was for you to learn that content outside versus inside a classroom.</td>
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APPENDIX I

SCHOOL POST-TRIP SURVEY
Science Research Post-Trip Survey

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<td>Give an example of one skill you learned on this course that you feel confident enough to teach to others.</td>
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</table>
### Connection and Integration of the Natural World

<table>
<thead>
<tr>
<th>Agree Level</th>
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<tr>
<td>After going on this EPI trip, I think I may look to visit more science-related museums, displays, or presentations.</td>
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<tr>
<td>Going on this EPI course has enhanced my connection to the natural world.</td>
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<tr>
<td>I would like to maintain my feeling of connection with the natural world when I get home.</td>
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### Motivation in Science

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</tr>
<tr>
<td>Give an example of one topic you were exposed to while on this EPI course where learning was the most engaging for you. Explain what it was about this topic or how it was presented that made this the most engaging for you.</td>
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</tbody>
</table>
After being on this EPI course, I am excited to learn more about _______.

Explain how you plan to learn more about that topic.

___________________________________  (topic)

Explanation:

<table>
<thead>
<tr>
<th>Value of Outdoor Learning</th>
<th>5 Strongly Agree</th>
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<th>3 Not Sure</th>
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<td></td>
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</tr>
<tr>
<td>I found that learning science information on this EPI course was generally easier to grasp than if I learned this content in a classroom.</td>
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APPENDIX J

PRE-, POST- AND DELAYED ASSESSMENTS
Belize Assessment

1. Why is lionfish considered an invasive species?
   A. It exists outside of its natural range
   B. It competes with native species for resources
   C. They are depleting the populations of other native fish in the reef
   D. Its reproductive biology allows it to spread over a large area very fast
   E. All of the above

2. What is blue carbon?
   A. It’s a type of carbon only found in the atmosphere
   B. It’s the color of carbon in the oceans
   C. It’s the carbon stored and captured by coastal ecosystems in coastal and marine ecosystems
   D. It’s the process that describes how carbon is released in the atmosphere
   E. All of the above

3. In nature there are various types of symbiotic relationships, for example, mutualism, commensalism, and parasitism. What is an example of strict mutualism?
   A. Coral and zooxanthella
   B. Mangroves and palm trees
   C. Lionfish and parrotfish
   D. Rays and lobster
   E. Seagrass and humans

4. What are some of the ecological goods and services that mangroves provide?
   A. Sequester carbon
   B. Support fisheries, tourism and recreation activities
   C. Provide habitat, spawning and nursery grounds for economically important fish species
   D. Protect coastlines from storms and erosion
   E. All of the above

5. Coral reefs and marine ecosystems are highly threatened. What is the main human activity that is provoking more frequent coral bleaching?
   A. Coastal deforestation
   B. Climate change
   C. Careless tourism
   D. Microplastics
   E. Excessive fishing
6. In the rainforests of Belize, the prey species of the jaguar have declined due to deforestation. Which would be true about jaguars in Belize?
   A. When prey is scarce, some jaguars may be unable to obtain what they need to survive.
   B. When prey is limited, the jaguars will find other food to eat, so there is always enough.
   C. When prey is scarce, the jaguars all eat and drink less so that all survive.
   D. There will always be plenty of prey in the forests of Belize to meet the jaguar’s needs.

7. Both crocodiles and bottlenose dolphins have essentially the same genetic code. Which statement would be true about the crocodiles and dolphins?
   A. Both crocodiles and dolphins evolved in the same area and live in the same habitat.
   B. Both crocodiles and dolphins eat similar diets.
   C. Crocodiles and dolphins are related.
   D. Crocodiles and dolphins can interbreed successfully.

8. What caused populations of bottlenose dolphins to develop air sacs for communication rather than the vocal cords found in other marine mammals?
   A. Some happened to have air sacs that used the movement of air to create sound. They reproduced more offspring than others.
   B. All marine mammals are essentially alike, so there is no real variation in methods of communication. Bottlenose dolphins have vocal cords beneath their blowhole.
   C. Individual dolphins gradually developed air sacs based on their need to communicate without opening their mouth.
   D. The dolphins with more air sacs are stronger so more of them survive.

9. The lionfish found off the coast of Belize is very brightly colored with flashy fins. Lionfish are slow-moving and their bright colors and flashy fins could easily attract predators. What explains the presence of these traits since they could potentially affect the survival of the lionfish?
   A. The bright color and flashiness have no function today; they are leftover from the past.
   B. Bright color and flashiness are used today for camouflage, but had a different purpose before.
   C. Due to overfishing, only the brightest and flashiest lionfish remain since they are easier to avoid with nets.
   D. The bright colors and flashy fins warn predators of the lionfish’s toxic spines which improves their chances of survival.
Costa Rica Assessment

1. When a tree in the forest falls to the ground naturally, where does the organic matter stored in its leaves, branches, and trunk go?
   A. Nothing happens. Once the tree dies, the organic matter is lost
   B. The organisms that break down the tree (fungi, termites, etc.) use that organic matter
   C. It is used by plants growing on the trunk and herbivores
   D. It is destroyed by solar radiation
   E. It is used by organisms that decompose the tree (fungi, termites, etc.) herbivores and plants growing on the trunk of the fallen tree.

2. Many rainforest plants are pollinated and dispersed by different species of bats. What kind of relationship exists between the bat and the plant?
   A. One benefits and the other one doesn’t. The bat benefits because it feeds on pollen and the fruits of the plants. Plants don’t benefit.
   B. One benefits and the other is negatively affected. The plant benefits from the bat because it disperses its pollen and seeds. The bat is not significantly benefited because it requires a very large energy investment to visit many plants.
   C. There is mutual benefit for both species
   D. Neither of them benefits
   E. There is no relationship between the bat and the plant.

3. If we didn’t take measures to recover the population of Leatherback turtles in the world and they disappeared permanently, would their disappearance negatively affect other species?
   A. It would affect populations of jellyfish, fish, and humans, among many other species
   B. It would only affect animal populations that feed on them
   C. It would not affect other species
   D. It would only affect jellyfish populations
   E. It would only affect fish stocks
4. There are 7 species of sea turtles in the world. If we compare them by appearance, the leatherback turtle is the most different. For example, its shell is soft, flexible and has no rigid plates like other species. It also has more fat on its body and is larger in size. What do you think are the main reasons for these differences?
   A. Leatherback turtles live in the open sea and make long migrations to places other species do not
   B. The temperatures of their migration routes are different than the other species of sea turtles
   C. Due to their feeding preferences, Leatherbacks must submerge to greater depths
   D. All of the above
   E. There is no main reason; it is just the way it is

5. Leatherback turtles have populated the planet for more than 110 million years. However, it has been estimated that in the last 20 years, the population has decreased by more than 80%, and it is vulnerable to extinction. What are the main factors that have affected their population decline?
   A. An increase in the population of Leatherback’s natural predators
   B. Human factors such as consumption of eggs, as well as accidental industrial fishing
   C. The influence of the climatic phenomenon called “El Niño” in the marine currents
   D. A drastic decline in the world’s jellyfish population
   E. Vehicle traffic on nesting beaches

6. Leatherback turtles in the Caribbean Sea primarily eat jellyfish in the ocean. Which is true about leatherbacks living in the Caribbean?
   A. When jellyfish are scarce, some leatherbacks may be unable to obtain what they need to survive.
   B. When jellyfish are limited, the leatherbacks will find other food to eat, so there is always enough.
   C. When jellyfish are scarce, the leatherbacks all eat and drink less so that all survive.
   D. There will always be plenty of jellyfish in the ocean to meet the leatherback’s needs.

7. Both 3-toed sloths and howler monkeys have essentially the same genetic code. Which statement would be true about the sloths and monkeys?
   A. Both sloths and monkeys evolved in the same area and live in the same habitat.
   B. Both sloths and monkeys eat similar diets.
   C. Sloths and monkeys are related.
   D. Sloths and monkeys can interbreed successfully.
8. What caused populations of Leatherback turtles to have a leathery shell instead of a bony shell as found in other sea turtles?
   A. Some sea turtles happened to have a leathery shell that was best suited for diving deep in the ocean to find food. They reproduced more offspring than others.
   B. All sea turtles are essentially alike, so there are not really different variations in shells. Leatherbacks have a bony shell beneath the leathery skin.
   C. Individual turtles gradually developed the leathery shell based on their need to dive deep.
   D. The turtles with the biggest shells are stronger so more of them survive.

9. The male plumed basalisk lizards found in Costa Rica have three crests – one each on the head, body and tail. Having three crests represents a large investment of energy and materials to maintain. It could also attract predators. What explains the presence of the three crests since they could compromise the survival of male basalisk?
   A. The 3 crests have no function today; they are left over from the past.
   B. The 3 crests are used today, but have a different purpose than before.
   C. Due to centuries of hunting, humans have killed all except the basalisks with large crests.
   D. Through competition and female choice, having 3 crests improve the reproductive success of male basalisks.
Ecuador Assessment

1. In a healthy ecosystem how do energy, water and nutrients flow in a balanced manner?
   A. There isn’t a natural order in which energy, water and nutrients are transferred between organisms
   B. Animals capture energy directly through sun exposure and then they capture nutrients and water separately
   C. Energy, water, and nutrients don’t have any relationship with the organisms
   D. Decomposers are the only ones in charge of recycling all organic and inorganic matter
   E. Plants store solar energy, accumulate water and soil nutrients and this is transferred to herbivores and then passed on to carnivores

2. What is a good example of a parasitic relationship between two organisms in the rainforest?
   A. Bromeliads and orchids attached to trees
   B. Hummingbird drinking the nectar of flowers
   C. Ticks who extract blood in the fur of bears and tapirs
   D. Lichen attached to tree trunks
   E. Night birds and bats competing to feed on insects at night

3. The Andean bear and the Andean tapir can share the same habitat. In terms of competition for resources which statement is correct?
   A. They have distinct diets but can sometimes overlap for resources like fruits and seeds
   B. The Andean bear is a strict carnivore and hunts other smaller mammals
   C. Competition is fierce because they are both generalist eaters
   D. They can be carnivores and can help regulate populations of pests
   E. They are both scavengers and help break down decaying matter

4. The concept of adaptation can be widely seen in nature. What is NOT an example of adaptation found in Ecuadorian forests?
   A. Bat’s ability to use sound waves to navigate at night
   B. The rainforest vine branches and trunk that allows them to climb to the top in search of light
   C. The Andean tapir’s prehensile nose to grab vegetation that it eats
   D. The Spectacle bear’s strong claws to reach the treetops
   E. The ability of the air to stay humid in the cloud forest
5. In nature, old trees naturally die. However, through deforestation, the alteration of the rainforest can break the ecological cycles dramatically. Which response is NOT a result of deforestation?
   A. Loss of biodiversity
   B. Soil erosion
   C. Flooding or drought
   D. Increase in the abundance of animals
   E. Alteration of the water and nutrients cycle

6. Mountain tapirs living in the Andes require water to drink and specific plants to eat in the high altitude Páramo ecosystem. Which is true about mountain tapirs in the Andes?
   A. When plants and water are scarce, some tapirs may be unable to obtain what they need to survive.
   B. When food and water are limited, the tapirs will find other plants to eat, so there is always enough food.
   C. When food and water are scarce, the tapirs all eat and drink less so that all survive.
   D. There will always be plenty of food and water in the Andes to meet the tapir’s needs.

7. Both spectacled bears and mountain tapirs have essentially the same genetic code. Which statement would be true about the bears and tapirs?
   A. Both bears and tapirs evolved in the same area and live in the same habitat.
   B. Both bears and tapirs eat similar diets.
   C. Bears and tapirs are related.
   D. Bears and tapirs can interbreed successfully.

8. What caused different species of tapirs to have different length proboscises (noses)?
   A. Some tapirs happened to have a proboscis that was best suited for eating plants. They reproduced more offspring than others.
   B. All tapirs are essentially alike, so there are not really different variations in proboscises.
   C. Individual tapirs gradually developed the length of their proboscis based on their need to obtain food.
   D. The tapirs with the longest proboscises are stronger so more or them survive.
9. The male Blue Backed Manakin (bird) found in the Amazon region has a bright red cap on its head and is known for doing a very animated dance. Both the red feathers on its cap and the dance display represent a large investment of energy and materials. The cap and dance could also easily attract predators. What explains the presence of this cap and dance since it could potentially compromise the survival of male manakins?

A. Both features have no function today, but are traits left over from the bird’s past.
B. Both features are used today, but they both have a different purpose than before.
C. Due to centuries of hunting, humans have killed all except the manakins with bright red head feathers.
D. Through competition and female choice, brightly colored head feathers and the dance improve the reproductive success of male manakins.
Galapagos Assessment

1. A clear example of evolution is:
   A. Ornamental plants and fruit trees brought by people that have adapted to living in the archipelago.
   B. Marine iguanas that after a long time have adapted to be able to feed underwater and ended up differentiating themselves from their land ancestors
   C. The Galapagos goats are faster than the goats in the continent to find food
   D. None of these
   E. All of the above

2. An ecosystem can be defined as:
   A. A place where humans build houses
   B. The process of existence of living beings
   C. The relationship between biotic and abiotic factors in a determined area
   D. Marine and terrestrial natural areas
   E. All of the above

3. Giant tortoises from some islands including the tortoises from Santa Cruz perform great altitudinal migrations during the different seasons. How can this behavior change the ecosystem of Galapagos?
   A. They disperse seeds from the highlands to the lowlands
   B. Tortoises don’t affect the ecosystem in any way
   C. Tortoises are heavy animals and they can destroy the soil with their trampling
   D. Being herbivores, they control the growth of several plant species
   E. Tortoises are heavy animals and when they migrate they compact the soil.

4. Exotic organisms to Galapagos can also be called introduced species. Some of these species are invasive when:
   A. They cohabitate with the species in Galapagos without causing any impacts
   B. They are introduced intentionally
   C. Are not adapted to the ecosystems in Galapagos
   D. Endanger the ecosystem, human health and/or the economy in Galapagos
   E. None of these

5. The way in which we consume
   A. Has no relationship with the health of the planet
   B. Is directly related with the degradation of the resources we have on the planet
   C. Depends on the buying capacity of my family
   D. Does not affect or benefit the health of the planet
   E. None of the above
6. Tortoises on the Galapagos islands require food to eat and water to drink. Which is true about tortoises on the Galapagos Islands?
   A. When food and water are scarce, some tortoises may be unable to obtain what they need to survive.
   B. When food and water are limited, the tortoises will find other food sources, so there is always enough.
   C. When food and water are scarce, the tortoises all eat and drink less so that all survive.
   D. There will always be plenty of food and water on the Galapagos Islands to meet the tortoise’s needs.

7. Both Galapagos finches and Galapagos Tortoises have essentially the same genetic code. Which statement would be true about finches and tortoises?
   A. Both finches and tortoises evolved in the same area and live in the same habitat.
   B. Both finches and tortoises eat similar diets.
   C. Finches and tortoises are related.
   D. Finches and tortoises can interbreed successfully.

8. What caused populations of tortoises to have different carapace shapes and sizes?
   A. Some tortoises happened to have a carapace shape and size that was best suited for obtaining food in their habitat. They reproduced more offspring than others.
   B. All tortoises are essentially alike, so there are not really different subspecies in Galapagos.
   C. Individual tortoises gradually developed their current shape and size carapace based on their need to obtain food.
   D. The tortoises with the biggest carapaces are stronger so more of them survive.

9. The male Magnificent Frigatebird found in the Galapagos has a bright red, inflatable pouch under his throat. The pouch represents a large investment of energy and materials to maintain. It can also attract predators. What explains the presence of this pouch since it could potentially compromise the survival of male frigatebirds?
   A. The pouch has no function today, but is trait left over from the past.
   B. The pouch is used today, but has a different purpose than before.
   C. Due to centuries of hunting, humans have killed all except the frigatebirds with large, bright pouches.
   D. Through competition and female choice, brightly colored and large pouches improve the reproductive success of male frigatebird.