How can a science educator incorporate field study into their advanced high school science courses?

Michael Alexis Apffel
HOW CAN A SCIENCE EDUCATOR INCORPORATE FIELD STUDY INTO THEIR ADVANCED HIGH SCHOOL SCIENCE COURSES?

A Project
Presented to the
Faculty of
California State University,
San Bernardino

In Partial Fulfillment
of the Requirements for the Degree
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in
Education:
Science Education

by
Michael Alexis Apffel Jr.
September 2006
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ABSTRACT

The quality of science education since the 1970's at the high school level has slowly and continually declined. Most science classes, including advanced courses, lack the true nature of science. Due to high stakes testing and the focus on science content state standards, most science classes have used the traditional method of direct instruction including lecture, book work, occasional "cook book" labs lacking inquiry, with standardized testing to deliver the science curriculum. A crucial component of science education is the utilization of field studies to help students learn science content. There are vast amounts of information and opportunities for field science within the local community and throughout the world. This project organizes that information and categorizes it to inform the educator of the field study possibilities. In addition to providing this information, the project also helps educators overcome the many obstacles facing the implementation of field science into existing science courses. This author has provided several field study lesson plans and solutions to field study obstacles to aide the educator in incorporating field science into their science courses. All information and suggestions offered in this project are based on an in depth
literature review and personal experiences of science educators. This author has determined that all field studies can be placed into four categories: industrial/research, informal learning centers, expert related, and teacher/student directed. In addition, this author has also determined that the obstacles facing incorporation and utilization of field studies at the high school level can be placed into four categories: funding, litigation, lack of support and availability. In addition, this project makes suggestions that further research needs to be conducted on the effects of field science on standardized testing.
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CHAPTER ONE

INTRODUCTION TO THE PROJECT AND FIELD STUDY

In order to properly and effectively teach an all-encompassing science curriculum, science educators must use a variety of methods. One of these methods is currently underrepresented and neglected within science at the high school level. This method is field studies. Field study, can be conducted in a variety of manners. It can range from simple at-home experiments or studies to fully funded internships or apprenticeship at university or research facilities. Considering that this element of science education is not occurring on a regular basis in advanced science courses at the high school level, how can a science educator begin to implement field study into their current science classes?

There are a number of reasons why the science curriculum needs field study. Field study increases motivation in the student (Tilling 2004). As field studies help to increase interest and motivation in the student for science, it will ultimately increase the amount of success for that student (Glynn 2005). A field study brings real life experience to the student making it pertinent to their lives. Field studies are the essence of
the true nature of science. Field studies allow the student to collect information or data and test it. It uses direct and indirect methods of observation. Field studies can help a student learn a specific topic in science as well as understand the true nature of science. The National Science Teachers Association (NSTA) states in their position on the nature of science that, “Science is characterized by a systematic gathering of information...and the testing of this information by...experimentation” (NSTA 2000).

Under the federal legislation, No Child Left Behind Act of 2001 (NCLB), teacher and student accountability have increased dramatically. These effects may add enormous amounts of time consuming busy work for the teacher depending on their state and district’s interpretation of the legislation (Porter 2005). Some of these tasks include, but are not limited to, data compilation, statistic interpretation, content alignment and realignment to standards and sub-standards, pacing guides for common core curricula and other such tasks. With high stakes testing overshadowing teaching and influencing major funding to school districts, many teachers have chosen to ignore or leave out the crucial element of field study in the classroom and stick strictly
to direct instruction or lecture based instruction. This action suppresses the interest of science in students, limits the number of students choosing to enroll in science and ultimately lowers the pool of opportunity for developing future scientists in this country.

As a biology student in high school and a biology student in college, this author remembers the classes that incorporated field studies into their curriculum far more than the lecture-based courses. More was learned in these field oriented classes and interest peaked. These classes were enjoyable, which in turn increased motivation and enthusiasm for science. These types of courses, lecture and field oriented allowed for learning. However, the field courses better prepared this author for the future as an educator and researcher.

As a science instructor, this author has also seen the effectiveness of field studies incorporated into the classroom. Success and the motivation have increased in the students as they participated in various field studies. In addition, the constraints and pressures of California’s interpretation of NCLB have been felt. This researcher has had to spend hours on various software programs, crunching numbers and statistics for my classroom reports to the district office. In addition, the
difficulty of trying to teach effective science with little preparation time, short time frames, and limited budget have weighed heavily on this researcher. Many science educators have a true desire to teach the nature of science to their students via methods of field studies, labs, and other strategies. The planning required to participate and prepare for such instruction is time consuming. Time is a component of teaching that most educators do not have the luxury of having. As many other teachers, this author has looked for manuals and advice in incorporating previous developed lessons for field studies into the classroom. Some have been found but not many.

This lack of resources is the reason for developing this project. This project intends to provide a tool that other teachers can utilize in teaching effective science, specifically field studies. This project should be adaptable to any science course and require minimal preparation time on the teacher’s part. Not all suggestions in this project are manageable in all classes, but it is expected that if the desire and motivation exists to teach field studies, then this project would be of some help for any science teacher who truly wants to incorporate field studies into their class. This project will also address national and California state science
content standards, which is crucial in the current educational environment. Anything that is done in the classroom or in the educational environment must be connected to the standards as dictated by NCLB or the state and district’s interpretations. It is this author’s hope that educators will discover that through this project field studies can help the student to grasp the knowledge behind the content standards.

As mentioned, this project is to help aide the science educator in incorporating field studies into their current science classes, specifically advanced science courses. Advanced science classes, often times are considered science electives and may include such courses as Zoology, Botany, Marine Biology, Astronomy, Chemistry, Physics and Earth Sciences. Advanced Placement classes should also be included into this group. Although field studies need to be incorporated in all science courses, including introductory courses such as Life Science, Earth Science, Biology, Introduction to Biology, and Physical Science. This project concentrates on the advanced science courses. This reasoning is two fold.

First, the practicality of the situation; to attempt to design field science into all science courses would be a monumental task more appropriately designed for a much
larger study or project, reflecting that of a doctoral study. However, many of the examples, ideas and methods discussed in this project can be easily adapted to the basic courses also.

The second reason for choosing the advanced classes is the interests of students found in these classes. These students in general are interested in attending college and are more intrinsically motivated. Moreover, many of these students are interested in science and are pursuing a future in that field. Unfortunately, many advanced classes in the United States are lacking field study. If we as educators can incorporate more field studies into these courses, the students will be better prepared for their future studies and careers.

In addition, science can be introduced in a more inspiring and interesting light to the college bound student who may have other aspirations other than science. Many of these non-science students take these courses to fulfill a third year science course requirement to enter college. Many of them are not sure what they want to do in college. Incorporating field studies into these classes may open up an interest in these students who can better serve the scientific community with their ideas and newfound interest in science.
Although this project focuses on the advanced courses, it should be understood that all science classes should utilize field studies. Most students lose interest in the sciences during their introductory science courses, thus discouraging them from enrolling in more advanced science courses. There are a number of issues when dealing with introductory course students. Many of these students have major behavior problems, ranging from fighting and drugs to incarceration. Their academic ability is usually several grades below average and their overall ability to cooperate and perform are poor. These issues need to be addressed and resolved if a teacher desires to conduct field studies with them. The behavior problems in advanced science course students are minimal and their academics are usually up to grade level if not exceeding them. The advanced student is far more prepared for field studies then the introductory student. For this reason, this project focuses on the advanced student. It is suggested that as soon as a teacher becomes comfortable with field studies in the advanced classes, they can then begin to adapt it to the introductory courses.

In the 1950s and after the launch of Sputnik by the Soviet Union, the United States realized the importance of science and acted accordingly. Committees such as The
National Science Foundation (NSF), The Physical Science Study Committee (PSSC) and The Biological Sciences Curriculum Study (BSCS) were created and generously funded by the government of the United States. As the cold war progressed, the increase in funds to science increased. Numerous studies were conducted and development of technology thrived. Unfortunately, this federal support did not continue. The focus on science gradually came to an end with the Vietnam War and its aftermath. Educational goals and foci moved to the social sciences and reflected feelings and the individual rather than science and data.

The lack of focus for science is evident in the scores of United States students on such international comparative assessments as the Trends in International Mathematics and Science Study (TIMSS) and the Program for International Student Assessment (PISA). Although the United States has continued to score above average compared to a worldwide average, they have been scoring lower than many other industrialized countries similar to the United States on science and math (NCES 2003). A particular concern is the results from the PISA. Where TIMSS focuses on knowledge of science or math, PISA focuses on the application end of science and math. This is far more important. Knowledge is only valuable is it
can be used or applied. It is this application of science that has allowed the United States to surge forward in research and development, as well as leading the world on the scientific and technology front. This lack of application of scientific processes among American students has pushed companies within the United States to turn to other countries to find scientists rather than looking within their own country to continue the pursuit of science. This project can be used as a tool to help fight this downward trend in the quality of science education in the United States, by starting in the classroom.

This project will be significant in that it will not only help instructors to teach more effective science, but it will also motivate students in science. By motivating students and sparking their interests in the area of science we do a service to the science community in this country and the citizens within it. This project will be both informative and instructive. It will discuss the history of field science and the various issues addressed by this type of instruction. It will also contain a variety of activities that educators can adapt to their classroom.
Through an in depth literature review, and personal experience, this researcher will show the effectiveness of field studies in science classrooms and determine what has been effective in the past and what has been ineffective. The roadblocks and obstacles to incorporating field science into existing instruction will also be discussed and solutions will provided to these obstacles and roadblocks. Through an in depth literature review and personal observation and experience, this author create a product to help the current science educator to incorporate field studies into their existing courses. This project will also help educators to institute a new program into the science department in their respected school sites, if they so desire.

In conclusion, field study is another method of learning, which helps to increase student motivation, teach the nature of science, cover the content standards, and brings science to the everyday person. Field study is often left out of the science curriculum. They need to be incorporated in all science courses, particularly the advanced classes. NCLB has provided an environment in which teachers feel that direct instruction is the most effective method in relating huge amounts of information, without considering the depth of student understanding.
Therefore, in order help science educators use their time effectively and incorporate field science into their current advanced curriculum, this project has been created.
CHAPTER TWO

REVIEW OF RELATED LITERATURE REGARDING FIELD STUDIES

Field study can cover many topics and standards with in the various disciplines of science. They can be used in life sciences, Earth science and physical sciences alike. Field study can occur in a number of places outside of the classroom. From transect studies in ecology to nighttime observation with telescopes in astronomy. Field studies are an integral part of science. Field study can sometimes be informal learning if conducted outside of the school curriculum. It can occur in more permanent institutions such as museums, scientific research laboratories, nature centers, zoos and aquariums. Places of this nature often have guides and lesson plans to aide the instructor in conducting field study as part of the science curriculum. Other informal learning can occur at home with home-based laboratories or in local parks. Regardless of the location there are common elements in each of these situations. Such elements include inquiry, data collection and interpretation, hands on real life experience and other characteristics of the nature of science (Abraham 2002).
Advantages of Field Science

There are a number of advantages to using field study in the science curriculum. It increases student motivation and interest in science. It prepares students for the future and career choice. In a high stakes testing environment where standards are continually stressed, it allows a teacher to cover multiple standards within a given project. Field science can allow for various learning styles and address the multiple intelligences reaching all students including gifted students, resource and special education students, English language learners and other non-traditional students (NSTA 1999).

Motivation in Science

The lack of interest and motivation is evident in science by low enrollment numbers in both secondary and post secondary science courses (Khoon 1997). This is largely attributed to the method in which science is currently being taught. This method often termed "drill and kill" involves direct instruction, lecture based lessons, bookwork and worksheets created by textbook publishers. This method is a sure way to alienate most non-traditional students as well as many average mainstream students (Jorgenson 2002). Students do not connect with textbooks and the way it presents science as
isolated facts rather than a process that plays a crucial role in their life. Students have a difficult time understanding the relevance of science in their life, when taught traditionally.

There are a number of factors as to why educators have turned to the “drill and kill” method of teaching. Among them, the most prominent of reasons is due to high stakes testing and strict adherence to multiple content standards and sub standards. Teachers feel under pressure to cover all the “facts” rather than connect facts into a scientific process, because the high stakes tests are no more than fact based questions, rarely connecting to scientific processes (Cavanagh 2004). If students are introduced to science in elementary school, most of them are excited about it due to the hands on approach that elementary educators may use. However, students quickly lose interest in science during their middle school years as science goes from hands on to lecture based lessons. The students’ expectations of experiments and hands on instruction is met with or mismatched with the reality of few experiments, minimal hands on and more direct instruction (Skamp 2005). By high school, where advanced classes in science are taught, a majority of students have
associated bookwork, worksheets and lecture to science and therefore lost most if not all interest in science.

With a lack of interest in science, the level of motivation will drop dramatically. With little interest and poor motivation the student will show minimal performance in their science courses. Students will settle for average or below average in a science class as long as it is still passing. This attitude is seen not only in the non-college preparatory classes but the advanced class as well. A common response from parents of students who are performing poorly in science is that science was difficult for them when they were a student. If their child can simply pass the class to get high school credit then they are relieved. This attitude among parents reflects in their children as well. It is most likely that the parent associates science with the same negative characteristics that their student does. This negative view on science has been occurring since the late 1960’s, thus placing most of the parents of today’s students in a similar ineffective science courses when they were students (Jorgenson 2002).

Motivation is vital for student success. Some students who lack interest in science have other motives to still succeed in science. Those motivators may include a high school diploma, desire to attend college, praise
from parents or teachers, or some other intrinsic reward. However, compared to the overall enrollment of students in high school, this group of motivated students in science is small. This is evident in the low enrollment in science courses at both the high school and university levels (Lyons 2006). This low enrollment in turn limits the diversity of science classes offered.

The use of field study in the science curriculum can combat the negative image of science in the eyes of students and parents. It can renew an interest in science and make it available to more students. As students participate in projects outside the classroom, discovering and questioning various aspects of the project, they become empowered and begin to connect with science. For example, one non-traditional student from an urban field study project bragged to his fellow students that he was going to do “real science” as he walked down the school halls with equipment for the day’s study (Barnett 2006). This attitude is more likely to help the student succeed in his science course. As students discover answers to their questions, they become excited. Their self-esteem or self-image of themselves increases. Such factors are important to teenagers and oftentimes, their feeling of self-worth reflects in their academic achievement (Niiya
2004). As they feel these "good" feelings, they associate that emotion with science, creating a lasting effect or connection with science. The reinforcement between the affective and the cognitive domain help to bring about higher order learning (Smith 2004). In other words, as these connections continue to be constructed over the length of the field study, students perceive the feeling of success and accomplishment as status quo with the project and turn their focus to the project itself and the nature of science.

It has been suggested that fieldwork brings students into a cooperative learning environment. They must work together to succeed and accomplish their task. Students benefit from this fieldwork by building such life skills as teamwork, and self confidence (Smith 2004) Whether the student chooses to pursue science or not, these life skills can be transferred to other academic disciplines as well as every day life. Interest in science, motivation, self-image and life skills are all interconnected. As one develops the others do as well. Field study enhances these qualities, which ultimately lead to more success on the students' behalf.
The Role of Field Science in the Students’ Future

It is a lofty notion that students attend high school and college in order to further the pursuit of knowledge in their lives. The reality of the decision to attend school is the desire to be successful in life. Students attend school to better their life. They understand that a diploma and college degrees mean greater monetary increase in their life, which ultimately is success (Murnane 2000). Field study helps this goal to be achieved. Field study will train the students for the future, help them to gain employment with in the scientific field, foster life skills as mentioned before, teamwork and self confidence, and give the public a better understanding and appreciation for science.

Field study helps students prepare for the future whether it is in science or not. For the student interested in science, it can open doors to that student, they never knew existed. For example, one student mentioned “the research work further locked my goals into place. I know that I belong in a scientific field. My work on this expedition has helped me to set new goals and expectations for myself” (Abraham 2002). Other students mentioned that they did not realize the work involved in science and were surprised to see that science was not
simply facts in a textbook. In addition to opening doors to students in science, field study teaches students about the equipment used in science. A student working alongside a scientist in a research laboratory, during an internship, learns about the techniques and equipment used in that particular field. This gives the student advantage over other students who simply heard about the techniques and equipment. A student who has had true exposure to the physical part of research will have less to learn as they enter a career in science. Even the greatest instructor cannot provide this experience through lecture or direct instruction. Employers are far more interested in an applicant that can pick up the tools of the trade and get to work, than the applicant who has studied all the theoretical knowledge of the task, yet never stepped foot into the laboratory (Bayer 2005).

Science is not for all students. Students have many preferences and interests. To expect all students to enjoy science and pursue a career in this field would be absurd. However, it is beneficial for all people to have some science knowledge, appreciate it for the advances it has made to benefit humanity and respect it as a discipline of knowledge. Comments from students returning from a field study in North America, stated, “After my experience, I am
much more interested in archaeology, probably not enough to study it in college, but I will be much more likely to visit...archaeology related...sites on vacation." Or, "While I...will not pursue a career in anthropology, I would like to take part in a similar program as a volunteer" (Abraham 2002). Both of these statements show that both students have an appreciation for science even though they choose not to pursue it as a career. Simply exposing true science to people, we build a sense of understanding of science among the public, which can be a huge supporter for science and science education as these fields are constantly under attack by various special interest groups and politicians.

Field study can also help students to better choose a career other than science. They will be exposed to what real science is and make a determination if they want to stay in that field or not. Some students express the desire to go into the science field for employment until they participate in a field study program. For example, one student stated, "Before I left on this trip I wanted to do some science profession in the future. I realized doing research out in the field may not be the most interesting thing for me" (Abraham 2002). The experience of this student allowed him/her to change his/her mind in
what he/she chose to do in the future and what career to pursue. Although, field study pushed this student from the field of science it had a far more important use. The student was able to change their path to the future while they were still young. Many students go through high school and even college taking science with the desire to enter the research field. Unfortunately, as they enter the field they realize that they do not like the field and want to change careers. To change careers at this point in one’s life is costly, difficult and at times nearly impossible. If these individuals had been introduced to field science thorough out their educational career, they would have realized the needed change earlier in life, thus better preparing them for the future.

Field Science and Content Science

Rather than adhering to the National Science Education Standards which are all encompassing including: scientific content standards, science teaching standards, professional development standards, assessment standards, science education program standards and science education system standards, many states, such as California, have chosen to identify science standards that represent isolated facts (NSTA 2006). Many states have the philosophy of content as being, “a mile wide and an inch
The more content the course covers, the more information the student should learn. This is not the case. According to research, students learn better when they are given one or two main ideas with facts to reinforce the process compared to learning numerous facts and trying to piece together a process from too many details (Bybee 2002).

Some states' decisions to abide by trivial science facts has caused many science teachers to decide to teach science as individual isolated facts, rather than large concepts or processes (Cavanagh 2004). This mirrors the state exams at the end of the year, all facts and little process. With high stake testing and strict adherence to standards that are for the most part too specific, many teachers feel that the only way to deliver this vast amount of information is through direct instruction. Teachers feel that lecture is the quickest way to deliver the most amount of information (Cavanagh 2004). To further isolate science concepts into facts, many administrators suggest that teachers cover one sub standard at a time per day.

Field studies will help a teacher to adhere to both state and national content science standards. Though a field study, a number of standards can be addressed with
in one project. For example, the lesson plan termed transect study (See Appendix C) covers nearly all sub-standards with in the California State Standard: Ecology. It also addresses numerous national content science standards. Through field study a teacher can incorporate the nature of science, inquiry and state content standards, thus making a stronger connection for the students involved. It will help the students have a more firm grip on various scientific processes. For example, a student who had participated in a field study program gave a statement after their experience, "I learned more about photosynthesis in a half-hour...than I ever learned in my twelve years...in school" (Abraham, 2002).

Field Science and the Nature of Science

Another important component of teaching and learning science is to include the nature of science. Rarely are students exposed to the true nature of science. Many students, as well as some educators, confuse the so-called scientific method with the nature of science. Although the scientific method is part of the nature of science it is only one component and there is no universal uniform method to encompass the full nature of science. According to NSTA, the nature of science involves a "systematic
gathering of information” by using both direct and indirect observations (NSTA 2000). The nature of science is to produce knowledge that explains how nature works, governed by natural laws. Field study encourages students to gather information and develop explanations for natural events. This is the true nature of science. In addition, as students develop explanations they usually develop further questions that need to be researched. They begin to see the interrelatedness of various disciplines within science. Once they begin to experience the nature of science, educators can then explain the characteristics of the nature of science. Again, the student is discovering the information, while the teacher puts it into perspective, following the inquiry method of teaching. This method uses higher-level thinking and addresses the higher levels of Bloom’s taxonomy (Linn, 1995).

As mentioned, the nature of science involves data gathering and inquiry. The 5E’s method discussed by Roger Bybee in his text Learning Science and the Science of Learning, (2002) is an excellent model to encourage inquiry through field science. The 5E’s are discussed in The 5E/Inquiry Lesson Planning Model table (See Table 1). However, the basic premise of the method is to have the student complete tasks in order to discover scientific
principles on their own, under the direction and guidance of the teacher. As they create answers to questions, they remember the topic better and make a stronger connection (Bybee 2002).

Table 1. The 5E/Inquiry Lesson Planning Model

<table>
<thead>
<tr>
<th>Elements of 5E’s</th>
<th>Task of Teacher</th>
<th>Task of Student</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGAGE</td>
<td>Assesses learners’ prior knowledge. Identify conceptions and misconceptions of learner.</td>
<td>Develop a question about the major theme at hand</td>
</tr>
<tr>
<td>EXPLORE</td>
<td>Assign task to student that allows for student decision making and data gathering. Guide students in their “testing” of the main concept being taught.</td>
<td>Student “tests” their ideas with experience and gathers data.</td>
</tr>
<tr>
<td>EXPLAIN</td>
<td>Clarifies student understanding, introduces new vocabulary and formal language</td>
<td>Explain understanding of concept. Defend their results based on data gathered during the explore portion of the lesson.</td>
</tr>
<tr>
<td>EXTEND</td>
<td>Give students a situation in which they must apply the newly formed knowledge.</td>
<td>Learner applies knowledge learned to new situations. May elaborate on knowledge through additional exploration.</td>
</tr>
<tr>
<td>EVALUATE</td>
<td>Assessment of learner’s understanding of the topic being explored.</td>
<td>Metacognitive. Learner assesses own understanding of topic explored.</td>
</tr>
</tbody>
</table>

(Adapted from Bybee 2002)
Obstacles/Disadvantages to Field Science

There is not only one sure method of teaching that covers all students and delivers the content effectively. This is the reason for multiple teaching styles and methods. Some methods do not always fit the subject being covered at the moment. All methods face barriers and disadvantages. Field study is no exception. It is a tool to be used with other forms of teaching. There are a number of disadvantages or obstacles to teaching field studies.

**Funding and Field Science**

The largest concern of educators attempting to conduct field studies in their classroom is the cost (Smith 2004). Few school districts have the funds or are willing to release the funds for field trips and field related studies. The cost of doing a simple field study off campus can be rather large. For example, a zoology class at West Valley High School in Hemet, California chose to participate in a field study in San Diego, California (approximately 100 miles southwest of Hemet) to conduct research at an informal learning center. The total cost of the day-long excursion for 13 students was approximately $1500.00. Other excursions can cost even more if a teacher chooses to accomplish the study at an
established informal learning center such as aquariums, zoos or museums. Cost is always a concern when it comes to science. Science departments usually have one of the largest budgets on a high school campus, yet it is still usually too low to sustain a superb or viable program. In addition, the current atmosphere in education is to focus on math and English, resulting in any extra money being funneled into those programs (Schaefer 2004). However, this atmosphere can be taken advantage of. If an educator can connect their field science to other curricula, specifically math and English, then they have a better chance of persuading their administrator for approval.

There are a number of monetary issues that educators run into when attempting to participate in an off campus field study. If they choose to charge the students individually, the school risks law suits from those that cannot afford or choose not to pay for the excursion, as is indicated in the California Education Code 35330 & 35331 (CEC 2005). Some states make it illegal for academic classes to raise money for equipment or field study excursions. They feel it is the state and district’s responsibility to fund those types of trips and equipment. However, they seem to not have the money when the occasion is presented.
Litigation and Field Science

If an educator can overcome the cost barrier, the next concern that most instructors have is the fear of personal liability. In a litigation heavy society, there is always the fear of lawsuits when something goes wrong. Many districts and administrators have strong hesitations on allowing off campus activities due to the possibility of litigation against them. Districts take huge measures to insure the security of their students and themselves when off campus excursions occur. Students and parents sign waivers and other such paperwork to allow their child to go on a field trip. However, without fail, districts are constantly sued and suffer monetary damages when accidents occur on an off campus activity. Many teachers fear that they will lose their job if an activity goes bad or that the school district will forever associate that teacher with the mishap and “punish” the teacher throughout their career in that district. Whether these fears are unfounded and irrational or have merit, it is a perception that many educators fear (Smith 2002).

Other Barriers to Field Science

Another less formidable barrier as litigation and lack of funding is the availability or accessibility of field study locations. Many urban schools do not have the
luxury of having on campus areas that could work for field studies as some rural high schools may. Some teachers feel that there is no way to do a field study when skyscrapers and concrete are the only things available. This environment makes it more difficult to conduct a study; however, there are several possibilities available to the urban science teacher (Barnett 2006). These possibilities will be discussed in more detail in chapter four.

Another issue is the seasonal availability to conduct research (Smith 2004). In many places, spring and summer are the ideal and possibly only time to conduct outdoor research due to weather restrictions. Again, there are solutions to conducting field study during the fall and winter months, while weather conditions are not ideal. These solutions will also be addressed in a chapter four. The disadvantages and concerns of educators conducting field study are valid and need to be addressed.

Desired Elements to Field Science

For some educators field study may be minimal compared to other educators. However, there are opportunities for all science teachers to teach field study lessons and overcome the disadvantages. The advantages truly outweigh the disadvantages (Abraham
2002). One must consider that most of the disadvantages can be overcome with a little creativity and administration backing. With the advantages established, we turn to the necessary components to a productive and successful field study event or program. These elements can vary in degree and amount, but the more you have the better the chance of a successful event.

**Use of Inquiry**

A crucial element to learning and teaching science is the use of inquiry. The current method of lecture and direct instruction interfere with the true nature of science and how it needs to be taught. It has been suggested that students learn best and retain more information when they discover the concept themselves and piece the process together (Bybee 2002). The inquiry process is the prime example of the method for teaching science. It allows students to question and discover scientific processes under the guide of a science educator. It connects the content standards to the process. Field science by nature encourages questioning and data gathering and analysis, thus involving the method of inquiry instruction.
Connection to Content Standards

Another critical component is connection to the science content standards. The more standards a study covers, the more connections students will make between the various scientific processes. It will also encourage administrators to support the educator’s field study. In addition, the same amount or more standards will be covered by testing time than the traditional method of teaching.

If one is to compare state standards to the national standards, they will discover that the national standards are far more comprehensive and most of the state standards can be found with in the national science education standards, but in a different context. If a teacher chooses to teach from the national standards (NRC 1995) they will cover most of their state standards, such as the California Science Content Standards (CDE 1998) as well.

Use of Experts

Another component to consider is having a real scientist or researcher involved in the study (Abbott 2006). When a scientist is working beside a student a number of advantages are created. First, it gives the student the feeling of importance. It helps them to relate the experience to everyday life. Secondly, it exposes the
general public to the scientific community, placing a human face to the vast and somewhat intimidating scientific realm. This was a goal of the BSCS in the 1950’s and 60’s as they tried to create a new face to the science community (Rudolf 2002). This intention of the BSCS was to have the general public be aware of science and appreciate it, thus gaining their support in the political and public eye.

Partnerships

Another proven beneficial component needed in field study is the creating of a possible partnership with local businesses and companies. For years, the private sector has moved away from public education. It was easier to write a check every now and then to a school, then truly invest time in the educational process. However, recently companies have seen the benefit of getting involved. They realize by working in the educational field they can train their future pool of employees. In addition, it brings the science to the public and makes them a part of it. Helge H. Wehmeier, president and CEO of the Bayer Corporation is quoted as saying, “Science is the common denominator across our employees, our customers, our suppliers, the communities in which we live and work” (Curtis 2005). Bayer has a number of programs instituted throughout the
United States, educating students and teachers alike. Other companies, such as Ford Motors (FMC 2005) and Johnson and Johnson (AED 2005) have similar programs that fund field trips, equipment in the classroom and other such field oriented components.

Conclusion

Science is continually subjected to the influence and opinion of the public. Education has always been in the political arena and spectrum as well. Therefore, science education is always under great scrutiny. It may be from the religious right and their fight against evolution or the extreme left upset with animal testing and other such ethical issues. Often times, the public takes for granted what science has thus far done for them. They expect immediate results that will further benefit society, such as the cure to cancer or HIV. When those results are not immediate or to level of expectation, then society wants answers and money pulled from research (Kuhn 1962). Most of these feelings come from the lack of knowledge that the public has in science. In addition, with the entertainment industry producing fictional movies and shows based on science, the public gain lofty expectations of science (Skamp 2005).
Science is vital in the continuing success of the United States of America as a super power in the world. The science that has pushed the United States to the status it now enjoys began in the classroom decades ago. As the instruction deteriorates in the classroom, due to apathy and disregard, we place our nation’s future in jeopardy.

The world is quickly changing. Nations such as India, China and Brazil are on the rise. They are investing enormous amounts of money into research and development (COSEPUP 2006). As other countries develop, foreign investment in the United States’ research and development will dwindle and move towards the developing countries. In addition, this will lower the prospect of jobs for the future in the United States and the “privileged position” that the United States has enjoyed for many decades will erode.

We need field science to be incorporated into the classroom to better serve the science community. The many advantages of field studies, that we have discussed, preparation for the future, increase motivation and interest in students for science, teaching of the nature of science, and connecting science to the everyday person
far out weigh the disadvantages or obstacles of utilizing field studies.
CHAPTER THREE

METHODOLOGY

Development of Project Idea

As an educator and student of science, this researcher has always been intrigued and fascinated in field science, from participating in it as a student to helping other students with it as an educator. This author has noticed that through his science education, the amount of field science has been limited. As an educator and a student of science education he began to realize the various methods of teaching science and which were more effective. Field science fell into that category of effectiveness, and therefore, began to move away from direct instruction and work towards inquiry with the focus on field science in his classes. The students seemed to appreciate the experience, as did the educator. However, it was surprising to see the amount of obstacles faced when attempting to conduct field studies with the high school students. It was these experiences that led this author to pursue a master’s in science education and to choose a topic of field science for an area of research.
Collection of Data

The source of the data in this project came from two major sources. The first major source was from the literature review. Through an intense and lengthy study, vast amounts of information concerning field studies and related such topics were discovered. Not only did it enlighten understanding of the author in this topic it also supported personal beliefs about field study. These personal beliefs have developed over time due to the experiences in science education and participation in field studies, both as a student and an educator. This in turn was the second source of data in this project, personal experience. It has been through experiences in the field that have given the positive perception of field study to this author. These experiences are worth including because is gives an additional viewpoint and depth to the project.

Organization of Field Science Data

Between these two sources, the literature review and author’s personal experiences, key points about field studies have been designed. This author has determined what components are necessary for a field study and how a teacher can implement these components into their current
curriculum. In addition, this researcher has discovered and created a number of lesson plans or field studies that can be adapted to the current science curriculum. The studies have been divided up into four categories. They are industrial/research, informal learning centers, expert related, and teacher/student directed. See Table 2.

Table 2. Categories of Field Study Lessons

<table>
<thead>
<tr>
<th>Categories</th>
<th>Characteristics</th>
</tr>
</thead>
</table>
| Industrial/Research           | • Partnership with the business sector.  
                                | • Partnership with university or college.                                                                                                                                 |
| Informal Learning Centers     | • Attendance at the following: Zoos and aquariums, museums and planetariums, botanical gardens, parks, and nature centers.                        |
| Expert Related                | • Use of individuals closely related to the field of study: Scientists, researchers, medical staff, engineers, veterinarians, etc.                |
| Teacher/Student Directed     | • Studies performed by students under the direction of the educator. All components of the study are created and performed under the direction of the educator.  
                                | • Studies carried out at home or on students own time with minimal involvement from the educator.                                                                 |

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Each category has different aspects that make it unique. However, they also share some common characteristics. They all address the National Science Education Content Standards (NRC 1995) and California State Science Content Standards (CDE 1998). In addition to the science standards, each of these categories also connects across the curriculum to such disciplines as math and English. They all address the nature of science with its data collection and explanations. They all use inquiry to an extent. Some may use the more formal 5E method previously discussed while others simply encourage exploration and explanation of a scientific process. Each of these categories provides the student with hands-on experiences encouraging the student to participate and hopefully increase motivation. The differences are in the way they are carried out and what outside factors influence the project. The differences include what businesses, established facilities, and experts are involved. These categories help the educator to decide which lessons and studies are more adaptable to his or her classes.
The Organization of the Implementation of Field Science Data

The second focus of this project is the ability of an educator to implement these field studies into their class. The process to implement is not a traditional step-by-step program or instruction manual, rather it involves the obstacles an educator may encounter while attempting to set up a field science program or study. In some cases, the obstacles will be easy to overcome or nearly non-existent, where as other sites the educator may face a steep climb or battle to institute the program.

It is this second part of the project that this author draws most the conclusions from personal experiences. The literature review aided in the discovery of the components of a successful field study program and gave insight and depth to the different types. However, there was not as much information on the obstacles to placing or instituting field study into the curriculum. Where the literature lacked in depth, personal experience can make up.

This researcher has taught sciences for four years, including such courses as: earth science, life science, biology, botany, marine science and oceanography and zoology. Among these courses, several included sheltered
classes whose primary focus was on the English learners. In most of these classes field science was attempted to some degree. Many obstacles and barriers were faced, with both success and failure. The failures were recognized and learned from to create successes later in the year. In addition, failures and successes from colleagues of this author who have attempted to utilize field studies as well have been observed. It is from this knowledge and experiences that a guide of suggestions for educators to attempt in order to implement field science into their classes has been created. Most science educators have the knowledge and ability to carry out a field study, the difficulties lie in more practical matter such as funding, litigation, lack of support and availability of field study locations. Therefore a table has been created that describes the categories listed above with possible solutions. See Table 3. All suggestions in the table have been carried out by science educators and the effects have been positive. They have allowed the educator to accomplish their goals of field science implementation.
Introducing a Field Study into Their Courses

Table 3. Possible Obstacles an Educator may Encounter when Introducing a Field Study into Their Courses

<table>
<thead>
<tr>
<th>Obstacle</th>
<th>Solution</th>
</tr>
</thead>
</table>
| Funding            | • Gain support of the administrator  
|                    | • Solicit local businesses, for a tax deductible donations  
|                    | • Fundraisers  
|                    | • Grant writing  
|                    | • Booster Club  
|                    | • On campus science club  
|                    | • Parents  
|                    | • Local community boards and clubs.                                      |
| Litigation         | • Teacher’s Union  
|                    | • Selective in participants  
|                    | • Proper paperwork/forms                                                 |
| Lack of Support    | • Invite parents and administrators to participate  
|                    | • Connect standards to study  
|                    | • Cross curriculum connections                                           |
| Availability       | • Local community colleges or universities  
|                    | • Local businesses related to the field of science  
|                    | • Websites (Appendix)  
|                    | • Creativity on part of instructor                                       |

It should be understood that although this table is in depth and specific it is by no means complete. There is an amount of creativity that each individual educator brings with them when attempting to overcome such obstacles as designated in the table. However, this table
should be helpful and thought provoking for the user. It is this author’s desire that the user of the table will gain some insight as to how they need to accomplish the implementation of field science, yet with their own twist.

Conclusion

In conclusion, this researcher has gathered my data from two main sources; an in depth literature review of the subject and personal experiences from this author and colleagues. This data has been categorized into two groups; the first is based on the type of field science conducted, and the second is based on the obstacles that may interfere with incorporating field science into the current curriculum. Each of these categories has been further divided into sub-categories as detailed in tables 2 and 3. The data in Table 2 is simply categories of various types of field science, which requires little assessment if any. Categorically, it is well thought out and organized. The data, which is provided in Chapter 4, will speak for itself as the various artifacts correspond with one another and show similarities. Secondly, the data in Table 3 has been assessed, by several educators thus giving the data a review by experts, resulting in success with field science implementation. With this data being
assessed and deemed successful and its organization, I can now create the product in which to better aide a science educator in their desire to incorporate field science into their courses.
CHAPTER FOUR

RESULTS

Categories in Field Study Lessons

Industrial/Research

The category industrial/research has two main participants other than the students. Those participants are the business sector and a university or college. A field study in this category can include both of the above-mentioned participants or only one of them. These field study lessons do not follow the traditional 5E’s inquiry lesson plan, but they do involve various components of it. They have students “explore” ideas, “explain” various concepts and “extend or apply” what they have learned (Bybee 2002). In addition they do contain such aspects desirable of a field study such as hands on, working with experts, data collection and interpretation and real life experience.

As a result of an in depth literature review and study, numerous higher educational institutions that currently offer partnerships with local high schools have been discovered. Most high schools have a few colleges that they feed into and most colleges or university have partnership programs with the local high schools. Some of
the programs are far more in depth, while others simply provide equipment and suggested lessons for the classroom. In order to access this tool, an educator only needs to contact the colleges or universities near their high school.

One example of a partnership is the University of Southern California (USC); school of medicine working with a Los Angeles, California based High School, Francisco Bravo Medical Magnet High School, to increase scientific literacy in biomedical disciplines to better increase the chance of inner city students entering the medical field. Another example is the partnership between the University of Riverside (UCR) and Arlington High School in Riverside, California. In this program, students enter the field study as freshman and participate in agricultural genomics studies, side by side with researchers, until they graduate from high school.

The other participant in this category of Industrial/Research is the business sector. Again, just as there were numerous colleges participating in high school field studies, there are many businesses taking advantage of this opportunity. The pharmaceutical company Johnson & Johnson has a program titled, the Bridge to Employment Initiative (BTE) (AED 2005). This program continues to
expand. In 2004, BTE added 3 more sites to the existing 6 sites. These sites range from San Diego, California to Wilmington, Delaware. In these programs, students are given the opportunity to carry out research in the labs of Johnson & Johnson. Guest speakers visit the classrooms, teachers are trained and after-school mentoring is offered. Students are given the chance to shadow various employees of Johnson & Johnson, to gain first hand knowledge of the role of science and its many facets.

Other companies such as Ford Motor Company (FMC 2005) and the Bayer Corporation (Bayer 2005) have similar programs. Many of these large corporations have the resources to aide a teacher in instituting field study programs. The Ford Motor Company for example, has a program, The Ford Partnership for Advanced Studies. In this program Ford will contact local businesses and educational facilities within the educator’s location, to better help a teacher set up a field study experience.

Due to the sheer number of business and university partnerships available to the educator, two useful websites that cover a broad range of available partnerships throughout the United States have been given. These websites will point an educator in the right
direction to receive more information and contacts about a particular program.

The first of these websites, http://www.ncrrsepa.org is the Science Education Partnership Award (SEPA). This organization has been created to encourage professionals in the biomedical arena to form partnerships with local educators in attempts to introduce field science techniques to students. This website allows educators to search for opportunities of field study partnership with various businesses and universities. It can be grouped by subject matter or geographical location within the United States. It discusses funding, lesson plans, suggestions for field studies and other informal learning settings.

Another foundation that helps adapt field studies into the science curriculum is the National Association of Health and Science Education Partnerships (NAHSEP), which can be accessed at http://www.nahsep.org. This group focuses on health aspects of science education, which makes up at least 40% of the California Science Content Standards. This organization will help find funding to support field studies. They will locate laboratories in a high school’s local area, and provide curricular and partnership ideas.
Both of these websites have a vast amount of information to utilize field studies through a partnership with a business or university. Most of these programs are already established and are fairly rigid in regards to the topic being covered and the aspects of their research. Therefore, it is up to the educator to find the program that fits their needs in the classroom. Although the programs are established, there may be some room for individual adaptation and need. Most of the footwork is finding and establishing the study in the school. However, once instituted, renewing each year is fairly easy, allowing the educator to build up enrollment in the study and make possible adaptations to the classroom end of the study.

Informal Learning Centers

The second category of field study is that of the informal learning centers. This category is unique in the fact that it has been designed mostly for the general public. These facilities include such places as museums, zoos, aquariums, botanical gardens, nature centers and parks. These facilities vary in location. Some schools have far more access than others. Most of these centers have an educational department for educators to contact. The amount of information available to the educator will
vary from institution to institution. The degree of pedagogy will also vary. Some facilities have a small brochure, which contains very simple facts about the topic at hand; while others will have a full program addressing all levels of Bloom's taxonomy (van Loggerenberg-hattingh 2003).

Regardless of the material provided, it is expected that the educator would adapt it to their need in the classroom. In order to be an effective lesson, the educator should try to include the following aspects to the study: data collection, inquiry, metacognition, hands on, and real life experience. Some of these components are inherent when visiting such places as museums, zoos and aquariums.

Expert Related and Teacher/Student Directed

The next two sections, expert related and teacher/student directed, are far less rigid and give the educator more freedom to focus the lesson on the need of the class. Based on the literature review and personal experience, two example lesson plans have been created for each section (See Table 4). All lessons created for these two sections, follow a similar 6 part format, which include: California (CDE 1998) and National Science Education Standards (NRC 1995) addressed, objectives, the
lesson itself, assessment, possible materials and teacher notes. Each lesson addresses several standards, as well as covering several science disciplines. In addition, all lessons follow the 5-E’s inquiry approach, (Bybee 2002) cover numerous standards and allow students to collect large quantities of data.
<table>
<thead>
<tr>
<th>Lesson Title</th>
<th>General Description</th>
<th>Science topics covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Quality Field Study</td>
<td>Students will measure a number of various aspects of water (CO2, phosphate, bacteria count, etc.) to determine the quality of water samples from various sources.</td>
<td>Chemistry, Biology, Environmental Science, Ecology, Marine Science, Investigation &amp; Experimentation, Science Technology</td>
</tr>
<tr>
<td>Dissection Field Study</td>
<td>Students conduct non-evasive experiments on living organisms and perform dissections on preserved specimens.</td>
<td>Zoology, Anatomy, Physiology, Marine Science, Biology, Investigation</td>
</tr>
<tr>
<td>Transect Field Study</td>
<td>Students conduct 4 transect studies in a disturbed ecosystem and determine the effects of human actions on the environment.</td>
<td>Biology, Botany, Field Science, Environmental Science, Ecology, Investigation</td>
</tr>
<tr>
<td>Night Sky Field Study</td>
<td>Students keep a field journal and observe celestial bodies and determine their movement and force on one another.</td>
<td>Astronomy, Physics, Earth Science, Investigation</td>
</tr>
</tbody>
</table>

*For full lesson plan see Appendices A, B, C and D.

**Expert Related**

This category at times could be confused with the first category industrial/research, considering both utilize experts. In businesses and universities, students are working along side a scientist or expert. In this
category experts are still involved and working with the
students. However, in the industrial/research category,
the experience is occurring at the university or place of
business. In addition, the program is usually established.
In this category, the educator creates the field study and
contacts an expert to help participate in the data
collection and interpretation of it at the location of the
study and/or in the classroom. An expert can include such
professions as doctors, nurses, other medical staff,
enGINEERS, veterinarians, park rangers, and other such
professions. This category has a wide range of
possibilities, for both physical and life sciences, as is
demonstrated in the following two lessons.

The first of these lessons, Water Quality Field
Study, addresses the various aspects of water and is
designed primarily for a chemistry class (See appendix A).
However, I have included several possible adaptations that
could provide relevance to such classes as biology,
zoology environmental science and marine science. The
lesson plan that I have created is both general and
specific. It is specific in that there are a number of
characteristics listed that an educator can choose to test
for, yet general enough to allow the educator to adapt it
to their needs in the classroom. This lesson can be
conducted by an educator without the aide of an expert, however, utilization of an expert will allow for a more in depth study for the students and provide real world experience.

A positive aspect of this lesson is the involvement of a local water company. Most water companies have an educational department that services the schools within that water district. Many of the suggested materials in this lesson plan can be provided by the water company. In addition, if an educator prefers to focus on a specific element of water quality, the water company is extremely knowledgeable and accommodating. By use of the local water company, ties are established within the community between the local school district and business sector.

The second lesson, Dissection Field Study, requires a local veterinarian as the expert (See Appendix B). This lesson is more appropriate for life sciences, particularly zoology or anatomy and physiology. However, it too as the previous lesson can be adapted to other courses. This lesson also provides a tie with the community, yet on a different level. The water company, a large organization, at times may lack the personal touch that a small business owner or local professional may be able to bring into the classroom.
Again, this opportunity gives the students a real world experience. As students conduct non-evasive experiments on living organisms and dissections on preserved specimens, they will be able to gain first hand knowledge and experience from the veterinarian. It is probable that a local veterinarian may have a student attending the local high school, in which the educator chooses to conduct this field study. If this is the case, not only does the educator incorporate the community, but involves parent participation as well.

**Teacher/Student Directed**

This last category is the least restrictive of the different types of field studies and most flexible. It allows a wide range of topics to be covered. It is up to the teacher's discretion as to how to conduct the study and what time frame to use. This study may involve close direction of the instructor or may be carried out at home by the student with a limited role by the instructor. The two lessons designed for this section represent a life and a physical science. In addition, the first lesson, Transect Field Study (Appendix C), is more teacher directed, where as the second lesson, Night Sky Field Study (Appendix D), is more student directed, with a limited teacher role.
Since the time frame is not such an issue in this section, the lesson created, titled Transect Field Study (Appendix C), is to be conducted throughout the entire school year. It is a cumulative study that covers a number of topics and can be referred to throughout the year. This study is adaptable to any ecosystem and occurs at several different seasons, allowing students to compare and contrast long-term data. Not only is this study hands-on; it is a true method used in ecology by professionals, thus giving the students a real experience in the science field.

This field study is more instructor oriented, in that the educator is consistently moving about the groups as they conduct their study. Students are free to explore or pursue their selected area, yet are instructed to conduct the study in a certain manner. In this way, students are taught a true scientific method of data collection yet still explore and make discoveries on their own.

The second field study that I have created is the Night Sky Field Study (See Appendix D). As the other lesson already discussed, this lesson also addresses the California (CDE 1998) and National Science Education Standards (NRC 1995). However, its emphasis is more on the nature of science, including data collection based on
observation. Interestingly, both the California (CDE 1998) and National Science Education Standards (NRC 1995) are fairly weak in the discipline of astronomy. Most of the astronomy standards focus on the evolution and origin of the universe and in particular our solar system. This lesson addresses the rotation of the earth, its orbit around the sun and the relationship of the moon to each of those motions. This lesson would be suitable for a basic physical science class or Introductory Earth science course. It is ideal for an advanced science class such as astronomy. The concepts covered in this lesson are essential in lunar/Earth motions, which are discussed heavily in astronomy classes.

Unlike the previous lesson, Transect Field Study (Appendix C), this study is mostly student directed. It is up to the student to carry out the study on their own time in the evenings at their place of residence. The instructor’s role is limited, but the role that he or she plays is essential to the success of the study. Instructors will discuss in the classroom more basic requirements such as how to keep a field journal and suggestions on observation techniques of the sky. The rest of the study is left to the student’s imagination. They will determine various aspects of the study such as,
objects to observe, what diagrams are necessary and what type of information is relevant and need to be included in their field journal. As with the other studies, this field study allows the student to participate in real data gathering and have a true hand on science experience.

Solutions to Field Study Obstacles

Funding

There are a number of obstacles that educators face when instituting field studies into their classes. A major obstacle is funding or the lack there of. There are a number solutions to overcome this obstacle. Obviously some field studies are far more expensive than others. It would be far more expensive for a class to participate in a field study at an informal educational facility such as the zoo than a home field study that requires a journal of observations. Some of the more in depth and extensive field studies, though they be expensive, are often times paid for by the business or university partnership, thus removing the financial burden from the instructor.

Other field studies such as those found in the teacher/student directed category are fairly inexpensive. For example, the materials needed in the Transect Field Study (Appendix C), are no more than some rope or
clothesline and meter sticks. If an instructor plans a field study that may cost more than a budget allows there are several money raising methods an educator can utilize. They can participate in various fundraisers such as car washes, candy and food sales, recycling drives, and other such activities, local tax deductible donations from the community, on campus science club, create a booster club to help raise and handle finances and parent involvement.

Parent involvement would be key in increasing funding. When parents are involved and see their children excited about school and learning, they in turn become excited and develop a more positive attitude towards the educational system. This positive attitude may increase the likelihood of personal donations to the study, volunteer help in various fundraisers and leadership roles in a booster club. It is often suggested that a booster club is far more successful than a campus club, because less restrictions are imposed on a booster club. For example, most schools prefer that clubs earning money do it at separate times throughout the school year, limiting the time to fundraise. In addition, the ASB committee must approve fundraising for a club, approve of the spending of that money and the money raised is placed in a general fund that is accessible to all clubs on campus, not the
individual clubs who raised that money. Clubs must meet on
a regular basis to keep the club status and maintain a
certain number of enrolled members. Booster clubs may
fundraise as often as they choose, all money goes into a
secure fund that can accrue interest for the particular
club of interest, has tax exempt status, more resources
for fundraising and meeting times are at the discretion of
the booster club.

Being prepared is critical in receiving increased
funding. Often times, a school district will release money
to various sites unexpectedly. In addition, there are
stipulations with that funding in the form of a time
limit. For example, districts have been known to fund a
school with tens of thousands of dollars and told to spend
it within a month’s time or less. When these opportunities
arise, the instructor who is prepared with a budget for a
field study can immediately submit it, with a better of
chance of securing some of that funding. Another reason to
be prepared is that fundraising may require a fair amount
of planning. If an instructor can begin fundraising in the
fall to prepare for a large-scale study in the spring,
they have more time to trouble shoot situations as they
arise and thus accomplish their goal of a field study.
There are a number of ways to raise money; requirement is
limited only to the creativity of the instructor and their determination to conduct the field study. If an instructor is not sure of the type of fundraisers available, they should speak with an administrator or their Associate Student Body advisor.

The last suggestion in overcoming a funding issue is to write proposals for various grants. Grant money is free and an excellent method to obtain expensive equipment needed in field studies such as telescopes, electrophoresis apparatuses and various probes. Most grants are specific in nature and are looking for specific wording in the proposal. If an instructor is not familiar with writing grants, there are many weekend courses offered by local colleges in grant writing. Many school districts will count such classes as continuing education units towards maintaining their teaching credentials. The National Science Foundation (NSF) has a website that lists a number of available grants or available funding. The website is http://www.nsf.gov/ehr/MSP/. Another website educators should access for available grants is the NSTA’s website, http://www.nsta.org/awardscomp/ &program_type=grants. An example from this website is the Toyota TAPESTRY Grant program. This program awards 50 grants up to $10,000 a year and 20 “mini-grants” up to
$2,500 to K-12 educators. The site provides suggestions and necessary components for the grant proposal. With a little research and internet browsing and educator can find a number of available funding grants to apply for. As a teacher becomes more comfortable with grant writing, they will begin to see success. This success will not only bring equipment into the classroom, but help the instructor to gain the support of administrators, which in turn can always help in funding issues when the need arises.

**Litigation**

Another issue that arises when conducting field studies is the threat of litigation. We are currently living in a litigation heavy society. School districts face multiple lawsuits on an annual basis. Many educators fear personal liability and punitive action by the district when or if a field study goes astray. There are two important factors that can help curb the threat of litigation.

The first is paperwork and documentation. The more documentation an individual has the better their chances are in a suit against the district or themselves. It is crucial that educators have all proper district papers filled out pertaining to a field study and that all
guidelines and regulations are strictly adhered to. Such paperwork may include, parent permission slips and administrator/district approval. Educators should keep a log of all conversations pertaining to the field study with various individuals such as parents, administrators, district level employees and students. The log should contain dates, times, individuals involved and topic discussed. This documentation and record keeping along with official district forms alone will minimize the chance of litigation.

The second important factor to preemptively curb litigation is to be highly selective of participants in the field study. Not all students are mature enough to participate in field studies, and unfortunately some may need to be removed from the study. It is recommended that students be given a task previous to the field study. This task should carry with it the opportunity to participate in a field study. For example, many teachers require a homework assignment that pre-assesses the student about the topic to be covered in the field study to be handed in before the field study is carried out. Those that choose not to do the assignment are not given the opportunity to participate in the field study. Other educators choose to base field study participation on behavior and discipline
of the student within their classroom. For example, a student who consistently disrupts the class and has major behavior issues in a classroom would be excluded from the study. By combining both of these methods, pre-assessment assignment and behavior assessment, as a tool to select participants in a field study, gives an educator a better chance of removing students who could possibly pose a threat or danger to the study and other students involved, thus removing the potential of mishaps worthy of litigation. Students who do not participate in a field study still have the right to a fair and valuable education. Therefore, they are given another assignment in place of the study. This assignment may be a written or oral report that involves literature reviews and research. It can still contain inquiry and metacognition.

If the situation arises that litigation is possible educators should be covered by the school district’s policies and legal teams. In addition to the district’s backing, most teacher unions will provide legal counsel, advice and financial support in litigation matters concerning the practice of the teacher. If a teacher takes the necessary precautions, most field studies will go well and be an excellent tool in helping to advance the pursuit of science education. If litigation arises, the teacher
should find comfort in the fact that they have support in legal matters.

Lack of Support

Oftentimes, science lacks the support of the administration in an environment where math and language arts are the emphasis. The administrator is not against science; their priorities simply lie with other areas. There are a number of ways that an educator can gain the support that they need to carry out a field study. Parents can be the greatest advocate for the educator. If a teacher communicates clearly and often with parents, they begin to build a relationship of trust with them. If an inexpensive field study can be carried out at the beginning of the year, parents should be invited to attend and participate with their student. This will give the parent a first hand scientific experience and show them the type of education the teacher wants to provide to their student. Most parents will not be able to attend, but as long as the offer is there, the teacher begins to make the communication bridges necessary for parent support. In addition to parent attendance, administrators should also be invited, so they may see the work that the educator is carrying out and the quality of the content being delivered. By including both administrators and
parents, they become empowered and become an active part of the learning system.

Another way to gain support of the administrators is to incorporate many science content standards in the study. Under the current federal administration and its educational policies, standards and high stakes testing are crucial. By connecting multiple standards to a lesson or field study, an educator helps the administrator to buy into the idea of field study. In addition to tying in science content standards, an educator should attempt to incorporate cross-curricular connections as well. An educator will gain more support form the administration if they can show that a field study will address math and English standards, and further the skills of the student in those areas. As support increases from both parents and administrators, the likelihood of increase funding will follow.

Availability

The last obstacle is availability of field study locations. Many rural schools lack the availability of established informal learning centers such as zoos, museums, and aquariums. However, they do have more access to open ecosystems. In contrast, urban schools have a
variety of informal learning centers, colleges and business contacts, yet lack the open fields or ecosystems.

Regardless of the location there are always opportunities for field study. The lessons that have been provided, in general, can be conducted in most high schools. All schools have local water districts, availability to the nighttime sky and veterinarians in the area. Many urban schools lack wide-open ecosystems to conduct various field studies. However, the transect study created for this project (Appendix C), can be modified to students conducting one transect study rather than 4. Most urban high schools have at least a small field for sports on campus which could be used to conduct a transect study. They may even be near a vacant lot near by that can be used to conduct the study. All schools have contact with their local business sector and there are a wide range of possibilities for finding experts in any given town. Most high schools have a local community college nearby that can aide in conducting field studies. There are a variety of solutions, regardless of the location of the high school.

Often, educators feel that due to inclement weather, field studies can only be carried out in the late spring. There are numerous studies that can be carried out during
times of snow or rain. Studies can range from experimentation on the various properties of water such as freezing, salting the roads during the winter, water quality testing of the rain, organisms' behaviors to various weather changes, and other such related topics. In addition, field study does not necessarily require the outdoors. Two of the lessons provided in the expert category were conducted in the classroom. When students participate in university laboratory fieldwork, oftentimes the entire setting is indoors. There are always field studies available to the educator as long as the creativity and effort is present.
CHAPTER FIVE
CONCLUSION AND DISCUSSION

Summary

Science has been slowly neglected over the years as other disciplines have taken precedent over it such as math and language arts. Science classes have lost the nature of science and turned to a more directed instruction of lecture, bookwork, high stakes testing and the occasional "cook book" lab. A necessary component of science education is field studies. Through an in depth literature review and personal experiences of colleagues and this author, this researcher has been able to determine what should be included in a field study as well as solutions to overcoming obstacles in incorporating field studies into current curricula.

Field studies have significant impact on the teaching of science in an inquiry method that truly represents the nature of science. It increases student motivation and prepares student for the future with a career in science. There are several factors that a field study should include to maximize its use. It should include inquiry, data gathering and interpretation, hands-on experience and be based in science content standards. The type of field
study can vary in its description and can fall under any of the following categories, Industrial/Research, Informal Learning Centers, Expert Related and Teacher/Student Directed.

There will be a number of obstacles that educators will face when conducting and incorporating field studies into their current advanced science courses or science electives. Those obstacles may vary in degree but include funding, litigation, available resources and lack of support for the program. These can all be overcome by the creativity and effort of the educator. Once a study has been established, the follow up each year is less complicated and allows the educator to further adjust and develop the study.

Conclusion

There are a number of opportunities for educators to incorporate field studies into the classroom. However, the searching and developing of these opportunities is extremely time consuming and tedious. Due to the added responsibilities to educators under NCLB and the current environment of the education system, the time factor is a major limitation for many educators to pursue the incorporation of field science into their current courses.
It was for this reason that this project was needed. This project categorized and organized the information on field studies and provided support to an educator desiring to incorporate field science into their classes. It has been designed as a guide to inform and help educators begin to incorporate field science into their advanced science classes. However, the lesson plans and suggestions created for this project can be followed precisely as written. They can also be adapted to the need of the educator and their class. If the project is not utilized in this method, it can at the minimum provide examples of field studies to help educators formulate their own ideas into practice. This project is the initial stepping stone for educators who desire to incorporate a field study program in their class.

Recommendations

The information in this project is at best a summary of the availability of field sciences open to the science educator. It has discussed the importance of field study, its benefits and obstacles. It has explored a significant amount of research on the purpose of field study and its benefits; as well as the difficulties in conducting field sciences at the high school level.
However, one aspect that is lacking in both this project as well as in general research on field studies is the impact that field science has on test scores. Currently, all education at the K-12 level is focused on high stakes testing. Before this high stakes testing was put in place, state approved exams were still being given at the end of the year to assess the students on the content of their courses. More research needs to be done to see how field study can have an effect on high stakes testing. This would also include the ability to remember and retain scientific concepts. Other possible research would be the effects of field studies on other disciplines other than science. Current literature suggests that it could improve learning in all disciplines, yet there is no empirical evidence showing the effects on current high stakes testing. Given the environment in education at this time, research showing the effects of field studies on standardized testing would be significant.
APPENDIX A

WATER QUALITY FIELD STUDY
**Water Quality Field Study**

1. **Standards:**

*California Science Education Standards:*

**Investigation & Experimentation**

1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:

   a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.

   b. Identify and communicate sources of unavoidable experimental error.

   c. Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.

   d. Formulate explanations by using logic and evidence.

   k. Recognize the cumulative nature of scientific evidence.

   l. Analyze situations and solve problems that require combining and applying concepts from more than one area of science.
Chemistry

Chemical Bonds

2. Biological, chemical, and physical properties of matter result from the ability of atoms to form bonds from electrostatic forces between electrons and protons and between atoms and molecules. As a basis for understanding this concept:

a. Students know atoms combine to form molecules by sharing electrons to form covalent or metallic bonds or by exchanging electrons to form ionic bonds.

b. Students know chemical bonds between atoms in molecules such as H₂, CH₄, NH₃, H₂, CCH₂, N₂, Cl₂, and many large biological molecules are covalent.

d. Students know the atoms and molecules in liquids move in a random pattern relative to one another because the intermolecular forces are too weak to hold the atoms or molecules in a solid form.

g. Students know how electronegativity and ionization energy relate to bond formation.

Acids and Bases

5. Acids, bases, and salts are three classes of compounds that form ions in water solutions. As a basis for understanding this concept:

a. Students know the observable properties of acids, bases, and salt solutions.

b. Students know acids are hydrogen-ion-donating and bases are hydrogen-ion-accepting substances.

d. Students know how to use the pH scale to characterize acid and base solutions.

f. Students know how to calculate pH from the hydrogen-ion concentration.
Solutions

6. Solutions are homogeneous mixtures of two or more substances. As a basis for understanding this concept:
   a. Students know the definitions of solute and solvent.
   b. Students know how to describe the dissolving process at the molecular level by using the concept of random molecular motion.
   c. Students know temperature, pressure, and surface area affect the dissolving process.

Biology/Life Sciences

Cell Biology

1. The fundamental life processes of plants and animals depend on a variety of chemical reactions that occur in specialized areas of the organism's cells. As a basis for understanding this concept:
   a. Students know cells are enclosed within semi-permeable membranes that regulate their interaction with their surroundings.
   b. Students know enzymes are proteins that catalyze biochemical reactions without altering the reaction equilibrium and the activities of enzymes depend on the temperature, ionic conditions, and the pH of the surroundings.
   c. Students know usable energy is captured from sunlight by chloroplasts and is stored through the synthesis of sugar from carbon dioxide.

Ecology

6. Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept:
   a. Students know biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.
d. *Students know* how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.

e. *Students know* a vital part of an ecosystem is the stability of its producers and decomposers.

**National Science Education Standards:**

**Science as Inquiry**

**CONTENT STANDARD A:** As a result of activities in grades 9-12, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

**Physical Science**

**CONTENT STANDARD B:** As a result of their activities in grades 9-12, all students should develop an understanding of

**STRUCTURE AND PROPERTIES OF MATTER:**

- Atoms interact with one another by transferring or sharing electrons that are furthest from the nucleus. These outer electrons govern the chemical properties of the element.

- An element is composed of a single type of atom. When elements are listed in order according to the number of protons (called the atomic number), repeating patterns of physical and chemical properties identify families of elements with similar properties. This "Periodic Table" is a consequence of the repeating pattern of outermost electrons and their permitted energies.

- Bonds between atoms are created when electrons are paired up by being transferred or shared. A substance composed of a single kind of atom is called an element. The atoms may be bonded together into molecules or crystalline solids. A compound is formed when two or more kinds of atoms bind together chemically.

- The physical properties of compounds reflect the nature of the interactions among its
molecules. These interactions are determined by the structure of the molecule, including the constituent atoms and the distances and angles between them.

Life Science

CONTENT STANDARD C: As a result of their activities in grades 9-12, all students should develop understanding of

THE CELL

- Cells have particular structures that underlie their functions. Every cell is surrounded by a membrane that separates it from the outside world. Inside the cell is a concentrated mixture of thousands of different molecules which form a variety of specialized structures that carry out such cell functions as energy production, transport of molecules, waste disposal, synthesis of new molecules, and the storage of genetic material.

- Cell functions are regulated. Regulation occurs both through changes in the activity of the functions performed by proteins and through the selective expression of individual genes. This regulation allows cells to respond to their environment and to control and coordinate cell growth and division.

- Plant cells contain chloroplasts, the site of photosynthesis. Plants and many microorganisms use solar energy to combine molecules of carbon dioxide and water into complex, energy rich organic compounds and release oxygen to the environment. This process of photosynthesis provides a vital connection between the sun and the energy needs of living systems.

THE INTERDEPENDENCE OF ORGANISMS

- The atoms and molecules on the earth cycle among the living and nonliving components of the biosphere.

- Energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers.
• Organisms both cooperate and compete in ecosystems. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years.

• Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms.

• Human beings live within the world’s ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology, and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems will be irreversibly affected.

Science and Technology

CONTENT STANDARD E: As a result of activities in grades 9-12, all students should develop

- Abilities of technological design
- Understandings about science and technology

Science in Personal and Social Perspectives

CONTENT STANDARD F: As a result of activities in grades 9-12, all students should develop understanding of

- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

History and Nature of Science

CONTENT STANDARD G: As a result of activities in grades 9-12, all students should develop understanding of

- Nature of scientific knowledge
2. Objectives:

Students will know...

- The true nature of science which include data collection, interpretation, inquiry, use of technology, and its limitations.
- Characteristics of chemical bonds as it pertains to liquid, ions, and electronegativity.
- Characteristics and calculations of the pH scale.
- Characteristics of a solution.
- The role of a semi permeable membrane in osmoregulation and ion regulation
- The role of various ions in cell activity
- The use of photosynthesis by aquatic flora
- The role of producers in an ecosystem
- The role of abiotic factors in an aquatic ecosystem
- The impact of humans on aquatic ecosystems

3. Possible Materials:

Microscopes and dissecting scopes

Water samples:
Students bring a sample from home, bottled waters, fish tanks, local streams, lakes and other bodies of water, puddles, vernal pools, and rain water.

PASCO probeware:
Probes: pH, dissolved oxygen, temperature, ammonium, chloride, calcium, fluoride, fluoride, lead, nitrate, sodium and potassium

Water quality kits or individual assays:
Alkalinity, total hardness, various bacteria, phosphates
4. 5-E Inquiry Lesson:

1. Engage
   • Expert from water company will give brief presentation on water quality
   • And introduce various equipment used in the lab.

2. Explore
   • Students will divide into groups test various water samples for water quality.
   • Collect data.

3. Explain
   • Students will discuss their results with the class in a brief oral presentation.
   • Expert will clarify and help interpret their results.

4. Extend (Application)
   • Students will determine how each of the components of water quality will affect human populations who need to utilize that source of water.

5. Evaluate
   • Students will write a metacognitive reflection on:
     The components of water quality
     The usefulness of an expert in the study
     What new information they have learned.
     What they would like to learn more about
   • Students will create a report based on their data and suggestions for the care and treatment of water in their community.
5. Assessment:

Artifacts to be assessed:
1. Reflection
2. Water quality report

Rubric:

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<td><strong>Reflection</strong></td>
<td>Does not address all parts of the reflection</td>
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6. Teaching notes:

- Educator may choose to add or eliminate objectives to better suit their class.
- Water samples may vary due to availability.
- Data collected may vary due to available technology.
- Many water companies have provide equipment to classrooms.
- Teacher may want to review or introduce how to write a scientific paper.
- Lesson may take several lab periods.
- Groups of students may be assigned specific criteria to analyze (i.e. living organisms, water chemistries) in order to speed up the pace.
• Dependent of availability of funds, instructor may want to take students on field trip to collect samples and make observations; Or visit water treatment plant
APPENDIX B

DISSECTION FIELD STUDY
Dissection Field Study

1. Standards:

California Science Education Standards:

Investigation & Experimentation

2. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:

a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.

b. Identify and communicate sources of unavoidable experimental error.

c. Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.

d. Formulate explanations by using logic and evidence.

j. Recognize the issues of statistical variability and the need for controlled tests.

k. Recognize the cumulative nature of scientific evidence.
Physiology

9. As a result of the coordinated structures and functions of organ systems, the internal environment of the human body remains relatively stable (homeostatic) despite changes in the outside environment. As a basis for understanding this concept:

a. *Students know* how the complementary activity of major body systems provides cells with oxygen and nutrients and removes toxic waste products such as carbon dioxide.

b. *Students know* how the nervous system mediates communication between different parts of the body and the body’s interactions with the environment.

c. *Students know* how feedback loops in the nervous and endocrine systems regulate conditions in the body.

d. *Students know* the functions of the nervous system and the role of neurons in transmitting electrochemical impulses.

e. *Students know* the roles of sensory neurons, interneurons, and motor neurons in sensation, thought, and response.

f. *Students know* the individual functions and sites of secretion of digestive enzymes (amylases, proteases, nucleases, lipases), stomach acid, and bile salts.

g. *Students know* the homeostatic role of the kidneys in the removal of nitrogenous wastes and the role of the liver in blood detoxification and glucose balance.

h. *Students know* the cellular and molecular basis of muscle contraction, including the roles of actin, myosin, Ca\(^{2+}\), and ATP.

i. *Students know* how hormones (including digestive, reproductive, and osmoregulatory) provide internal feedback mechanisms for homeostasis at the cellular level and in whole organisms.
National Science Education Standards:

Science as Inquiry

CONTENT STANDARD A: As a result of activities in grades 9-12, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Life Science

CONTENT STANDARD C: As a result of their activities in grades 9-12, all students should develop understanding of

THE BEHAVIOR OF ORGANISMS

- Multicellular animals have nervous systems that generate behavior. Nervous systems are formed from specialized cells that conduct signals rapidly through the long cell extensions that make up nerves. The nerve cells communicate with each other by secreting specific excitatory and inhibitory molecules. In sense organs, specialized cells detect light, sound, and specific chemicals and enable animals to monitor what is going on in the world around them.

- Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organism’s own species and others, as well as environmental changes; these responses either can be innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli.
Science and Technology

CONTENT STANDARD E: As a result of activities in grades 9-12, all students should develop

- Abilities of technological design
- Understandings about science and technology

History and Nature of Science

CONTENT STANDARD G: As a result of activities in grades 9-12, all students should develop understanding of

- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

2. Objectives:

Students will know . . .

- The true nature of science which include data collection, interpretation, inquiry, use of technology, and its limitations.
- Organisms respond to various stimuli in order to maintain homeostasis
- The basic functions of the main body systems and their role in homeostasis.
- The major organs of the main body systems and their role in homeostasis.

3. 5-E Inquiry Lesson:

1. Engage
   - Local Veterinarian gives brief introduction to the veterinary field

2. Explore
   - Part I: Students will divide up into groups and conduct non-evasive studies of their choice on live organisms. Examples: Feeding behavior, interaction with other organisms, exercise, and response to minimal temperature change.
   - Part II: Students will conduct dissection on preserved specimen that corresponds to the organism from part I of this explore step.
Students are to determine various organs and possible functions.

- Veterinarian and Educator aide students and help trouble shoot during Parts I & II.

3. **Explain**
   - Students will give an oral report on the studies they conducted with the living organisms and discuss what they found in the dissection that may contribute to the data collected in Part I of explore
   - Veterinarian helps clarify and provides more in depth knowledge to students.

4. **Extend (Application)**
   - Students will be given common symptoms of various organisms from the veterinarian. Based on their discoveries during the explore and explain steps they will attempt to come up with a diagnosis.

5. **Evaluate**
   - Students will write a metacognitive reflection on:
     The usefulness of an expert in the study
     What new information they have learned.
     What they would like to learn more about
   - Students will create a report based on their data and suggestions for the care and treatment of their organism.

4. **Assessment:**

Artifacts to be assessed:
1. Reflection
2. Organism care report
**Rubric:**

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5. **Possible Materials:**

- PASCO probeware: Dissolved oxygen, CO₂, and temperature.
- Microscopes and Dissection Scopes
- Materials for wet mounts
- Dissection Kits and Trays
- Various live organisms
- Various preserved specimens
6. Teaching notes:

- Educator will need to check with district policy of live animals in the classroom.
- Educator needs to ensure that no harm is placed on the live organisms.
- Organisms and preserved specimens may vary.
- Study should take several class periods.
- Objectives can vary depending on class need.
- If funding allows, field trips to the veterinarian office to observe treatment, surgery and routine check ups would add to the in-depth understanding.
- Teacher may assign a particular organism to groups ahead of time to allow group to do internet research.
APPENDIX C

TRANSECT FIELD STUDY
Transect Field Study

1. Standards:

California Science Education Standards:

Investigation & Experimentation

3. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:
   a. Select and use appropriate tools to perform tests, collect data, analyze relationships, and display data.
   b. Identify and communicate sources of unavoidable experimental error.
   c. Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
   d. Formulate explanations by using logic and evidence.
   m. Recognize the cumulative nature of scientific evidence.
   n. Analyze situations and solve problems that require combining and applying concepts from more than one area of science

Ecology

7. Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept:
   a. Students know biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.
   b. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.
c. Students know how fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration, and death.

d. Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.

e. Students know a vital part of an ecosystem is the stability of its producers and decomposers.

f. Students know at each link in a food web some energy is stored in newly made structures but much energy is dissipated into the environment as heat. This dissipation may be represented in an energy pyramid.

g. * Students know how to distinguish between the accommodation of an individual organism to its environment and the gradual adaptation of a lineage of organisms through genetic change.

**Evolution**

7. The frequency of an allele in a gene pool of a population depends on many factors and may be stable or unstable over time. As a basis for understanding this concept:

   a. Students know why natural selection acts on the phenotype rather than the genotype of an organism.

8. Evolution is the result of genetic changes that occur in constantly changing environments. As a basis for understanding this concept:

   a. Students know how natural selection determines the differential survival of groups of organisms.

   b. Students know a great diversity of species increases the chance that at least some organisms survive major changes in the environment.
National Science Education Standards:

Science as Inquiry

CONTENT STANDARD A: As a result of activities in grades 9-12, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Life Science

CONTENT STANDARD C: As a result of their activities in grades 9-12, all students should develop understanding of

THE CELL

- Plant cells contain chloroplasts, the site of photosynthesis. Plants and many microorganisms use solar energy to combine molecules of carbon dioxide and water into complex, energy rich organic compounds and release oxygen to the environment. This process of photosynthesis provides a vital connection between the sun and the energy needs of living systems.

BIOLOGICAL EVOLUTION

- Species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring.

THE INTERDEPENDENCE OF ORGANISMS

- The atoms and molecules on the earth cycle among the living and nonliving components of the biosphere.
- Energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers.
• Organisms both cooperate and compete in ecosystems. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years.
• Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms.
• Human beings live within the world’s ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology, and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems will be irreversibly affected.

MATTER, ENERGY, AND ORGANIZATION IN LIVING SYSTEMS

• The energy for life primarily derives from the sun. Plants capture energy by absorbing light and using it to form strong (covalent) chemical bonds between the atoms of carbon-containing (organic) molecules. These molecules can be used to assemble larger molecules with biological activity (including proteins, DNA, sugars, and fats). In addition, the energy stored in bonds between the atoms (chemical energy) can be used as sources of energy for life processes.
• The distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials.
THE BEHAVIOR OF ORGANISMS

- Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes; these responses either can be innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli.

- Like other aspects of an organism's biology, behaviors have evolved through natural selection. Behaviors often have an adaptive logic when viewed in terms of evolutionary principles.

- Behavioral biology has implications for humans, as it provides links to psychology, sociology, and anthropology.

Science in Personal and Social Perspectives

CONTENT STANDARD F: As a result of activities in grades 9-12, all students should develop understanding of

- Personal and community health
- Population growth
- Natural resources
- Environmental quality
- Natural and human-induced hazards

History and Nature of Science

CONTENT STANDARD G: As a result of activities in grades 9-12, all students should develop understanding of

- Science as a human endeavor
- Nature of scientific knowledge
2. Objectives:

Students will know . . .

- The true nature of science which include data collection, interpretation, inquiry, use of technology, and its limitations.
- A variety of organisms can be found with in a given area and are affected by change in that area.
- The importance and role of producers in an ecosystem.
- The methods utilized by producers to be successful within the ecosystem studied.
- The characteristics that have allowed various organisms to be successful within their respected ecosystem and the role that natural selection has played to allow this characteristics to be expressed.
- Energy and matter have limited the amount of species in their field study.
- How to provide evidence to support their thinking in an analytical view.
- How to determine the type and number of organisms in a given area.
- How to predict and determine the impact on a given area by human interactions.
- The responsibility of stewardship in their communities and local environment.
- How to write a professional journal article supporting their ideas.

3. 5-E Inquiry Lesson:

1. Engage

- The students will watch several clips showing the diversity of organisms in various ecosystems around the world.
- Students will write similarities and differences between the various ecosystems.
2. Explore

- The students will conduct 4 transect studies over the course of a year. Students will be familiar with transect studies.
- They will be required to pick an appropriate area that represents the area studied.
- They will also be required to develop their own method of data collection and recording.
- Students will be required to show the number of individuals and populations found in their study.

3. Explain

- After each study, students will create a table of biodiversity.
- They will discuss the difficulties and successes they had with the class as they worked on their study. This will be a class discussion in which the teacher will help to clarify and qualify remarks made by the students.

4. Extend (Application)

- The students will predict what effect a disturbance will have on their area in their 4th study.
- This will be presented in an oral report to the class and a written report to the teacher.

5. Evaluate

- The students will create a report based on the format of a professional journal article.
- They will also write a metacognitive reflection discussing:
  - What they learned from the study
  - How they could apply it to future use
  - The difficulties that they ran into and how they may overcome those if they had the opportunities to repeat the project.
4. **Assessment:**

Artifacts to be assessed:
- Report
- Reflection.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Inadequate</th>
<th>Proficient</th>
<th>Exceptional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional Journal Write Up</td>
<td>Does not follow format. Disorganized Missing key elements Lacks visuals Shows lack of understanding of topic discussed</td>
<td>Follows format. Organized. Includes all key elements May have visuals Promotes a basic understanding of topic discussed</td>
<td>Follows format Highly organized Includes all key elements Includes visuals Promotes deep understanding of topic discussed Discusses further research</td>
</tr>
<tr>
<td>Diversity of Species</td>
<td>Uses a biodiversity table incorrectly with few species or does not even use one</td>
<td>Uses a biodiversity table mostly correct and has some species</td>
<td>Uses a biodiversity table correctly with numerous species</td>
</tr>
<tr>
<td>Prediction of Human Impact on Given Area</td>
<td>Makes no prediction. Makes prediction based on feelings rather than evidence. If evidence is presented in lacks coherency</td>
<td>Makes prediction based on evidence from previous transect studies. Evidence is coherent</td>
<td>Makes prediction based on previous study and related research of other professionals. Evidence is coherent</td>
</tr>
<tr>
<td>Reflection</td>
<td>Does not address all parts of the reflection</td>
<td>Discusses all parts of reflection</td>
<td>Discusses all part of the reflection with in depth perspective</td>
</tr>
</tbody>
</table>
5. Possible Materials:

- Meter Sticks
- Rope
- Graph Paper

6. Teaching notes:

- Educator may choose to add or eliminate objectives to better suit their class.
- Teacher may need to refer to lesson throughout the year to keep students thinking about the project. Suggested reference to the lesson on a weekly basis.
- Prepare for possible hazards, depending on location of study (i.e. twisted ankles, heat exhaustion, animal bites, allergic reactions to flora, etc.)
- Educator must determine area that students can conduct field study in. Example of transect studies carried out at West Valley High School, Hemet, California is provided:
  - Students will conduct 4 transect studies
  - Study 1 – 3 will all occur in the same area.
    - Study 1: Agriculture area at school campus
    - Study 2: Agriculture area after agriculture class has developed the area
    - Study 3: Agriculture area after agriculture class has discontinued use of the area
    - Study 4: Mustang Hill (fairly undisturbed area of chaparral behind campus)
  - Students will compare data of studies 1 – 3. Students will be given a fictitious disturbance to their 4th area.
  - Students will predict the effects of that disturbance based on observation and study of the first 3 studies.
APPENDIX D

NIGHT SKY FIELD STUDY
Night Sky Field Study

1. Standards:

California Science Education Standards:

Investigation & Experimentation

4. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:

b. Identify and communicate sources of unavoidable experimental error.

c. Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.

d. Formulate explanations by using logic and evidence.

g. Recognize the usefulness and limitations of models and theories as scientific representations of reality.

i. Analyze the locations, sequences, or time intervals that are characteristic of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).

k. Recognize the cumulative nature of scientific evidence.

n. Know that when an observation does not agree with an accepted scientific theory, the observation is sometimes mistaken or fraudulent (e.g., the Piltdown Man fossil or unidentified flying objects) and that the theory is sometimes wrong (e.g., the Ptolemaic model of the movement of the Sun, Moon, and planets).
Earth Sciences

Earth's Place in the Universe

1. Astronomy and planetary exploration reveal the solar system's structure, scale, and change over time. As a basis for understanding this concept:

   f. Students know the evidence for the dramatic effects that asteroid impacts have had in shaping the surface of planets and their moons and in mass extinctions of life on Earth.

2. Earth-based and space-based astronomy reveal the structure, scale, and changes in stars, galaxies, and the universe over time. As a basis for understanding this concept:

   b. Students know galaxies are made of billions of stars and comprise most of the visible mass of the universe.

Physics

Motion and Forces

1. Newton's laws predict the motion of most objects. As a basis for understanding this concept:

   g. Students know circular motion requires the application of a constant force directed toward the center of the circle.
National Science Education Standards:

Science as Inquiry

CONTENT STANDARD A: As a result of activities in grades 9-12, all students should develop
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

CONTENT STANDARD D: As a result of their activities in grades 9-12, all students should develop an understanding of

Physical Science

CONTENT STANDARD B: As a result of their activities in grades 9-12, all students should develop an understanding of

MOTIONS AND FORCES

- Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship $F = ma$, which is independent of the nature of the force. Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.
- Gravitation is a universal force that each mass exerts on any other mass. The strength of the gravitational attractive force between two masses is proportional to the masses and inversely proportional to the square of the distance between them.
History and Nature of Science

**CONTENT STANDARD G:** As a result of activities in grades 9-12, all students should develop understanding of

- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

2. Objectives:

**Students will know...**

- The true nature of science which include data collection, interpretation, inquiry, use of technology, and its limitations.
- The effects of the earth’s gravity on the moon
- The difference between the heliocentric and geocentric model.
- The phases of the moon are due to the orbit of the earth around the sun as well as the moon’s orbit around the earth.
- The moon’s surface and characteristics are due to asteroid impacts.
- The characteristics and results of the earth’s rotation on its axis.

3. 5-E Inquiry Lesson:

1. Engage

- Students will watch a short clip discussing the treatment of earlier scientists such as Copernicus, as well as astronomical events throughout the universe.
- Students will devise ideas that early astronomers may have used to observe the sky and make discoveries in early astronomy.
2. Explore
• Students will keep a daily or nightly journal of observations of the sky. Such observations should include: phases of the moon, placement of stars and planets in the sky at various dates and times of the year, and other such pertinent observations.

3. Explain
• Students will give updates on their research at various intervals determined by the teacher throughout the study.
• Students will find similarities, facilitated by the instructor, among their research to develop explanations to their observations.
• Teacher will help explain their observations with official terminology and laws of science.

4. Extend (Application)
• Based on their observations and explanations, students will predict the placement of celestial bodies in the future as well phases of the moon.
• Students will determine the movement and force between various celestial bodies based on the universal laws of gravitational force.

5. Evaluate
• Students will keep a field log of observations
• They will also write a metacognitive reflection discussing:
  ▪ What they learned from the study
  ▪ What experiences they may have had that would correspond to experiences of early astronomers.
  ▪ The difficulties that they ran into and how they may overcome those if they had the opportunities to repeat the project.

4. Assessment:

Artifacts to be assessed:
  o Field Journal
  o Reflection
Rubric:

<table>
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<tr>
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<th>Exceptional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Journal</td>
<td>Lacks formatting such as dates, times, etc.</td>
<td>General formatting includes dates, times, etc.</td>
<td>Formatting is specific with dates, times, etc.</td>
</tr>
<tr>
<td></td>
<td>Lacks visuals.</td>
<td>Has some visuals.</td>
<td>Includes many visuals with detail.</td>
</tr>
<tr>
<td></td>
<td>Shows lack of understanding of topic discussed.</td>
<td>Promotes a basic understanding of topic discussed.</td>
<td>Promotes deep understanding of topic discussed.</td>
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5. Possible Materials:

- Field Journal
- Pens, pencils, rulers and other need tools for drawing and sketching.
- Basic telescope (optional)

6. Teaching notes:

- Teacher may need to explain some basic techniques for sky observation. Such as reference points to measure distances in sky.
- Study should last at least one lunar cycle, but may last full school year.
- Some days may have inclement weather preventing students from participating that evening.
- Teacher should discuss the purpose of a field journal and how to keep it.
REFERENCES


California Department of Education. 1998. California Science Content Standards.
http://www.cde.ca.gov/be/st/ss/scmain.asp

California Education Codes (CEC). 2005. Sections 35330 and 35331. Retrieved from Official California Legislative Information: http://www.leginfo.ca.gov/cgi-bin/waisgate?WAISdocID=68469411580+0+0+0&WAISaction=retrieve


http://newton.nap.edu/catalog/11463.html


