FEELING EMPOWERED TO MAKE A DIFFERENCE: 
A STUDY OF PROBLEM-BASED LEARNING AND STUDENTS’ INCREASE OF 
INTEREST IN SCIENCE AND AWARENESS OF ENVIRONMENTAL ISSUES 

A Thesis 

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by 

Farzad Safavi 

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by

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Graduate and Professional Studies in Education
Abstract

FEELING EMPOWERED TO MAKE A DIFFERENCE:
A STUDY OF PROBLEM-BASED LEARNING AND STUDENTS’ INCREASE OF
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Statement of Problem

This study was conducted to establish the effectiveness of utilizing problem-based learning (PBL) strategies in increasing students’ increase understanding, awareness and interest to empower them to take active part in improving environmental conditions in community. The purpose of this study was to measure the growth of middle school science students in overall interest, awareness, and content knowledge regarding environmental issues, while applying problem-based learning methods.

Sources of Data

The data analyzed were student responses to a survey conducted in two GATE middle school physical science classes. The survey was conducted as a pretest and a posttest to both groups. The survey was designed to measure student responses to the
application of PBL strategies and the significant changes between the pre and post surveys. Open-ended questions were included in the posttest to better understand any changes in student perceptions of PBL strategies.

Conclusion

Results of this study demonstrated that the application of PBL strategies did have positive impact in increasing students' understanding of how science relates to their everyday lives as well as empowering them to be an active role in improving environmental conditions locally and globally. In addition, students enjoyed the ownership they felt toward their learning in cooperative and collaborative group discussions. The result of the study also indicated students' growth in knowledge and awareness toward renewable sources of energy and how they can be used to reduce human footprint in global climate change.
DEDICATION AND ACKNOWLEDGEMENTS

I would like to dedicate this to my beautiful and loving wife who has been there with me in every step of the way. Your support, your knowledge, and most of all your patience have been crucial in helping me achieve this goal. I love you Anna-Liisa! I would also like to acknowledge Dr. William who has been a true inspiration for planting the seed of critical pedagogy in me, which hopefully will continue to flourish and grow. Last, but not least, I would like to acknowledge my advisor, Dr. Carinci whom without her never ending support, advise and expertise, this thesis would not have seen the light of day.

Thank you all

Farzad Safavi
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Chapter 1

INTRODUCTION

Urban science education raises several challenges for science educators because of the vast inequalities in terms of resources, social privileges, and capital control, which play out in inner-city settings. McClaren claims that the relationship between capitalism, education, and science has created a system that favors elites, which makes science inaccessible and isolated from those left in impoverishment (interview in Barton, 2001). For example, minority groups are vastly underrepresented in the number of degrees awarded in the physical sciences, computer science, and engineering (National Science Foundation, 2007). In addition, Brown found that minority students struggle with the language used in science classrooms and often do not identify with science discourse (Brown, 2006).

According to McClaren, the marriage between capitalism and science education has created a type of curriculum that has profited the corporate science, and has failed to raise questions and awareness of what counts as knowledge (interview in Barton, 2001). Science teachers are often faced with short-time lines and constrained by state standards hindering flexibility and creativity. Additionally, educators are often challenged by own limitations and fears of stepping out of boundaries of decontextualized curricula which solely relies on lectured based learning and rote memorization, hence the disconnect between scientific content and students’ everyday lives continues to persist.
Urban science students must also suffer the consequences of lack of general resources, as well as absence of quality teaching in urban areas that has led to a gap, which, seemingly, has been created through socio-economical divides (Chapman, Laird, & KawalRamani, 2011). In a comparative study of five different elementary schools located in various neighborhoods of New Jersey, Anyon (1997) concluded that fifth graders of different economic backgrounds are already being prepared to occupy particular rungs on the social ladder. While some schools are on the vocational track, others are geared toward producing doctors, lawyer, and business people. Anyon’s findings indicate that students in working-class schools are simply asked to follow the correct steps and procedure. Teachers at middle-class schools, whose families’ income levels do not exceed $25,000 a year, only look for the correctness of the responses. The expectations and demand from students seemed to increase as the income levels rose in the areas under study (Anyon, 1997). In affluent professional schools where parents’ incomes are below $80,000, students are asked to express and apply concepts. In executive elite school, with six digit income families, children use analytical thinking and logic, and through problem solving they produced intellectual products (Anyon, 1997). Based on Anyon’s findings, it is plausible that the quality of education in America varies depending on the income level of residents of the school neighborhoods.

Despite the fact that urban students compose the highest percentage in high school drop outs, science is still being taught under the same rigid procedural steps dictated by the teacher, where no relativity and meaning is inserted into the curriculum
Based on the Los Angeles Unified School District Report (LAUSD, 2013), 35% African Americans and 27% Latinos dropped out of high school during 2011-2012 academic school year. Compared to their White and Asian counterparts, with 9% and 14% drop out rates, children in urban settings suffer the consequences of an education system that has failed to engage them into the processes of becoming self-actualized problem solvers. Burdens brought by poverty and economical inequities make it difficult for urban students fulfill their own potentials, even if the interest and desire are fully intact.

In the current climate of standards-based teaching, driven by high-stakes testing and accountability, K-12 science across the United States is increasingly presented as a generic collection of facts, concepts, and inquiry processes, organized into strings of discrete benchmarks. These lists of benchmarks are rarely connected and almost never prioritized by importance to their discipline, conceptual difficulty of understanding, or relevance to students' lives. The onset of No Child Left Behind (2002) legislation, which placed heavier emphasis on standards-based testing, not only did little to reduce the achievement gaps across demographic subgroups, but also has largely been responsible for driving the instruction-assessment paradigm (Lee, Deaktor, Enders, & Lambert, 2008). Assessment has now become a driving force behind classroom instruction. These new testing frameworks have dramatically changed instructional practices but have done little to change in the learning outcomes of non-mainstream students (Lee & Luykx, 2006).
Moreover, science has become a mystifying, and inhumane subject for urban students that accessibility to its inner world has become fantastical for them. Lemke (1990) comments on the way science is portrayed in the curriculum:

In teaching the content of the science curriculum, and the values that often go with it, science education, sometimes unwittingly, also perpetuates a certain harmful *mystique of science*. That mystique tends to make science seem dogmatic, authoritarian, impersonal, and even inhuman to many students. It also portrays science as being much more difficult than it is, and scientists as being geniuses that students cannot disconnect from their everyday experiences. It portrays science as a set of objective identify with. It alienates students from science. (p. xi)

This picture of science, mysterious and opaque, estranges students because it is truths and absolute realities to be approached – abstracted, disembodied and decontextualized. In short, it presents science as dogma – a body of uncontroversial, unquestioned and unequivocal knowledge (Claxton, 1991). In this picture, students are positioned outside the theories; they are like spectators, looking in, while theory is presented as a map drawn by experts to depict ‘what is there’ (Middleton, 1995).

Students learn best when they are motivated; when, what they are learning has something to do with them or the immediate environment surrounding them; and when, they are trusted that with some guidance they can work together to reach solutions to problems that are authentic. For such climate to persist, teachers need to step out of own comfort zones and begin exploring ways in which students can
become genuinely engaged in what they are learning. Students’ voices have long been absent within curricula. “To hear each other (the sound of different voices), to listen to one another, is an exercise in recognition. It also ensures that no student remains invisible in the classroom” (hooks, 1994, p. 41). Curricula should be specific and tailored to the population and its needs; hence it should be flexible and open in nature. Curriculum can be a site of contestation, but it is rarely controlled by one group without the control or influence of the other (hooks, 1994). Instead it has developed into a site where textbook publishers, venture capitalists, and politicians attempt to leave their mark in ensuring the maintenance of the status quo. In the midst of the power struggle, the voice and interest of the urban student gets lost.

The need and urgency to address these issues, dictates action toward an equitable transformation; one that would include activating students’ engagement along with inclusion of their stories and experiences in order to make learning authentic. Teachers and educators must aim to make content knowledge applicable to students’ community, culture, and future. Classrooms of the education system can no longer afford to be, as Paulo Freire puts it, banks where the teacher is the depositor and the students are the empty receptacles that are to receive the information that has been deposited into them (Freire, 1970). The ability for a student to learn and reflect on information, then acting upon that knowledge to form a possible solution is far more powerful than simply the memorization of facts.
Statement of the Problem

Science education in urban schools suffers from overall irrelevance and isolation. Science is being taught by presenting a series of irrelevant and disconnected facts and students are often asked to act as mere receptacles only responsible for regurgitating information. Environmental, dietary, and social issues, such as global warming, food deserts, and poverty, which directly affect urban students, is mostly omitted in science classrooms. In order to make science content significant for an urban adolescent, the curriculum must revolve around topics that are relevant to the school culture, hence created and tailored to the needs of the population (Murrell, 2002). It is the intention of the researcher to show that teaching science through solving authentic scientific problems would raise awareness, interest, to empower the students to actively be a part of solutions to community or global problems.

Purpose of the Study

Problem-based-learning (PBL), is a teaching method where an authentic problem is used as a starting point for a set of objectives (Wong & Day, 2008). The problem might be teacher or student generated. It is usually connected to the personal experiences of students, and includes independent and critical thinking opportunities (Mossuto, 2009). Unlike traditional instruction in which students are lectured on a topic before they have the opportunity to apply what they learned, in PBL, students learn the concepts and principles related to the topic through the process of solving the problem (Hmelo-Silver 2004). This approach mirrors how problems are solved in the real world and requires a shift from teacher-centered to student-centered pedagogy, as
learning focuses on understanding and the application of knowledge. As a result, implementation of problem-based learning requires a change from traditional methods of instruction in which the teacher acts as the “expert,” to a role of facilitator or metacognitive coach (Kumar & Natarajan, 2007).

The purpose of this study is to measure the growth of middle school science students in overall interest, awareness, and content knowledge regarding environmental issues, while applying problem-based learning methods. Many youngsters today live in technologically rich environments that involve immediate connectivity and collaboration with others. Problem-based learning provides learners with experiential learning using a variety of technological tools. In this approach, students learn by doing through collaboration with others (Ferreira & Trudel, 2012). As a result, emerging technologies can be easily integrated in problem-based learning. Researchers examining the impact of PBL on student outcomes have found that when well implemented, problem-based learning can lead to greater conceptual understanding and problem-solving skills (Harris, Marcus, McLaren, & Fey, 2001; Wong & Day, 2008). Others found that problem-based learning promoted the development of analytical and reasoning skills as students learned how to learn in order to develop solutions to real-world problems (Duch, Groth, & Allen, 2001; Mossuto, 2009). Furthermore, because students work together in the solution of a problem, one of the most important outcomes of problem-based learning is the development of interpersonal skills.
In this study, 58 eighth grade, middle school, GATE science students were given a realistic challenge in which the city of Sacramento, hypothetically, has ran out of fossil fuels as source of energy, hence the use of cars as modes of transportation has come to an end. Additionally, the landfills are full and students were to research and collaborate in innovating new ways of reusing and recycling trash. As the final product, students presented their findings via Power Point presentations.

**Research Question**

How does the application and implementation of problem-based learning help to increase interest and awareness in middle school science students regarding socio-environmental factors affecting people at community and global levels?

**Methodology**

Collection of data in this study involved a mixed method of quantitative and qualitative approaches. Analyzing data through mixed methods provides better understanding of the nature of the problem. According to Creswell (2008), when one type of data is not enough, the other may compensate and fill in the gaps. Mixed method research is somewhat pragmatic and practical by nature. It provides multiple viewpoints; it combines subjective with objective, and biased with unbiased. The application of mixed methods permits the qualitative results to assist in explaining and interpreting the findings of a quantitative study (Creswell, 2014).

Quantitative methods emphasize objective measurements and the statistical, mathematical, or numerical analysis of data collected through polls, questionnaires, and surveys, or by manipulating pre-existing statistical data using computational
techniques (Babbie, 2010). Quantitative research focuses on gathering numerical data and generalizing it across groups of people, or to explain a particular phenomenon. This method was appropriate for the current study because quantitative data has the ability to demonstrate cause-effect relationships where positive or negative changes may be captured through pre and post experimental data collection (Mertler & Charles, 2011). Quantitative data in this study was analyzed using a repeated measures t-test, a paired samples t-test, and a two-tailed correlations test to measure differences among the variables. The open-ended questions were examined and coded looking at recurrent themes.

In contrast to the quantitative analysis, a thematic analysis utilizing open-ended survey questions were included in order to assemble the comprehensive interpretation from the study participants. Inquiry of this type facilitates assessment of explicit issues in depth and detail. Qualitative methodologies allow for compilation of in-depth information regarding what people think and how they feel (Trotter-Hamilton, 2010). Through thematic analysis of open-ended questions in the pre and post survey, the researcher can "construct categories or themes that capture some recurring patterns... of the data" (Merriam, 1998, p. 179). By creating categories to guide the analysis of the data, the researcher will be able to systematically target the study's purpose through the answers the participants give in the open-ended survey questions (Merriam, 1998). Quinn (2002) believes that through qualitative inquiry, participants reveal their deepness of emotion, how they organize the world and what is happening around them, in addition to how experiences are perceived through their eyes. In this
study, the open-ended questionnaire gives theoretical perspective to analyze results at different levels as well as allowing the researcher to make thematic approaches regarding the participants’ responses for each question.

Data in this research study was collected and analyzed through mixed methods of quantitative and qualitative means. The research study took place in two GATE eighth grade middle-school, physical science classrooms in South Sacramento. Parent informed consent forms, also translated in Spanish and Hmong, were distributed to all students in the two classes (Appendix A). Two students opted out of participating in the study; hence, they were not obligated to complete the pre/post survey, even though they were required to participate in class activities. In addition, all participants completed an informed assent form before the commencement of the study (Appendix B). A total of 58 pre/post surveys were matched and analyzed at the end of the five-week study. The quantitative data was collected through a Likert-scaled survey, modeled after Bryden (2008), before the beginning and the end of the study (Appendix C). The Sacramento Green Project Unit, designed to implement the PBL strategies of this study (Appendix D) commenced the five-week project. These questions were formatted to scale students’ general interest in science and scientific careers, as well as, questions concerning students’ overall awareness towards environmental issues affecting them on daily basis. The qualitative data was collected through a post study questionnaire composed of open-ended questions regarding students’ reactions and reflections of the PBL strategies implemented in the study (Appendix F).
The pre/post survey was conducted to measure the cause and effect of applying approach. The survey utilized a standard 5-point Likert-scale measuring any change in students’ increase in: interest in science, their awareness of environmental issues and ways to solve them, and increase in students’ willingness to be make a difference. The data also included open-ended questions that provided qualitative data that was analyzed using a thematic approach. The open-ended questions were supplemented to the posttest to gain insight toward changes in attitude towards how problem based learning strategies affected their learning.

**Limitations**

Anticipated limitations to this study may involve the familiarity with the instructor by the time of the study may have some altered views and results due to likability toward the instructor. This familiarity could also lead to the possible outcome termed “cooperative-subject effect,” where participants’ main concern is to please the researcher and to be a “good subject”. Kirk (2010) claims that in this case, subjects may be predisposed to providing data that would support the hypothesis. In addition, teaching science, utilizing problem-based learning strategies requires time, familiarity with neighborhood culture, and courage to explore new boundaries. Because of the flexible nature of PBL style of teaching, it may not be suited for all teachers. In addition, the researcher is unaware of students’ prior knowledge related to content materials, which could lead to unknown outcomes. Another limitation that must be taken into account is the Hawthorne Effect, which is the tendency of some people to work harder and perform better when they are participants in an experiment.
(Combs & Smith 2013). Individuals may change their behavior due to the attention they are receiving from researchers rather than because of any manipulation of independent variables (Mulhall, 2002). In case of this study, the GATE students’ familiarity with the researcher and the will to please him may have unaccounted results, which may be defined as another limitation to this study.

**Theoretical Framework**

**Problem-Based Learning (PBL)**

Problem-based learning involves strategies, in which students are presented with a real world challenge, whereby using those strategies, students work in teams to develop a model or a plan to solve the communal problem (Wong & Day, 2008). This teaching philosophy allows students to become independent critical thinkers, as well as practical problem solvers. Studies show that problem based learning is more effective than conventional approaches in developing greater student motivation, breadth of interest, learning satisfaction, developing self-confidence, knowledge acquisition, use of a variety of learning resources and self-directed work (Finch, 1999).

Fourez (1997) points out that science is ‘made by humans for humans’, and therefore, science education should be conceived as a historical construction conditioned by projects that are meaningful and relevant to people’s specific needs and contexts. For example, teaching and learning about the greenhouse effect, which scientists agree is the main cause for the global warming of the planet, includes teaching and learning about the political and ethical debates that surround these topics.
Learning the science related to global warming would include learning about the United Nations' Intergovernmental Panel on Climate Change (IPCC) report, which confirms that global warming is a reality that is jeopardizing our planet's future. It would, therefore, also include learning about laws and regulations approved by different countries to control human produced greenhouse gas emissions that cause global warming. Such an approach allows students to construct a clear understanding of the scientific knowledge as well as the social, economic, political and cultural issues at stake (Fouréz, 1997). As future citizens, it empowers them to make informed decisions, to embrace social justice agendas, and to take political action.

Posing an authentic question acts as the stimulant to drive students to reach reliable solutions. The greenhouse example mentioned, could be presented as a challenge for the students to implement PBL strategies, already introduced and practiced in simpler forms and scenarios. The challenge is real in a sense that it stems from local levels where students can make connections, but at the same time, it is a global problem. Students use resources and each other, to solve a problem such as designing and developing renewable and alternated sources of energy for their community. The contents of the question would cover a wide range of scientific concepts and standards. By using the information in multiple contexts while exchanging knowledge through dialogue, students gain multiple opportunities to interact with each other through a common goal for greater good.
Critical Pedagogy

Brazilian, Paulo Freire, made critical pedagogy somewhat famous in 1970 when his work entitled *Pedagogy of the Oppressed* (1970) was translated from Portuguese to English. Since that time, critical pedagogy has become a full-fledged topic of study in many colleges and universities around the world. Freire (1970) proposed that common people could, with organization, solve problems and thus educate themselves in the process. Freire (1970) endorses students’ ability to think critically about their educational situation; this way of thinking allows them to recognize connections between their individual problems, experiences and the social contexts in which they are embedded. Freire (1970) goes on to reshape the idea of praxis within the educational setting by defining it as; “engaging in a cycle of theory, application, evaluation, reflection, and then back to theory” (p. 50). Additionally, in her book, *Teaching to Transgress*, bell hooks (1994) shares the frequent usage of “Confession narratives” in conjunctions with academic subject matter, to establish concrete connectivity and relatedness to topic of discussion (p. 151). Because these narratives are authentic, they could be used as teaching tools that addresses students’ need for relevance and personal connection, as well as the need for making meaning of the true nature of science.

In 1964, Paulo Freire, when politically exiled from Brazil, used the time to analyze the socio-political situation in his home country and proposed some unique ideas about critical pedagogy. In his work *Pedagogy of the Oppressed* (1970), he describes how the oppression of one people by another more powerful group can be
challenged. Freire (1970) suggests a method of liberation for such people in any situation through education and action. Through these ideas, Paulo Freire became a major influence in the development of how to promote change between a ruling class and an oppressed class the world over. Although his ideas and thoughts may not be easily transferred to the realm of education, but they are key elements that Freire (1970) argues to changing an oppressive situation. Freire (1970) states that “the pursuit of full humanity, however, cannot be carried out in isolation or individualism, but only in fellowship and solidarity; therefore, it cannot unfold in the antagonist relation between oppressors and oppressed” (p. 73). In this quote Freire expresses the fact the people must work together to solve problems. Currently the dominant class sets up and controls the educational system, which seems far from ideas of democratic classrooms where teachers relinquish power and students become critical organizers and participatory thinkers.

Freire (1970) also speaks of dehumanization and the oppressors who cause it. Educators are dehumanizing the students because they are promoting a system of oppression. Teachers strive for an idealistic classroom, one where race and class are less important and every student is capable of achieving tremendous goals. Freire (1970) states that the “…freedom to create and to construct, to wonder and to venture requires that the individual be active and responsible, not a slave to a well-fed cog in a machine…” (p. 55). This implies that if teachers, especially in low-income schools, continue to adhere to the traditional way of Eurocentric education, creativity and true engagement will be lost, and the system will continue to reproduce cogs. Teaches and
the education system, inadvertently, contribute to the oppressive nature of the
dominant society by dehumanizing students into a submissive position. Although
schools today may not be the harsh and oppressive conditions that Freire (1970)
speaks of, they are acting on a more subversive level, just under the consciousness of
public understanding.

In short, critical pedagogy creates new forms of knowledge through its
emphasis on breaking down disciplines and creating interdisciplinary knowledge. It
works to raise questions about the relationships between the margins and centers of
power in schools and is concerned about how to provide a way of reading history as
part of a larger project of reclaiming power and identity, particularly as these are
shaped around the categories of race, gender, class, and ethnicity.

Definitions

**Critical Pedagogy:** Critical pedagogy is an ideology that is committed to the
development and enactment of culture of schooling that supports the
empowerment of culturally marginalized and economically disenfranchised
students (Darder, Baltodano, & Torres, 2009).

**GATE, Gifted And Talented Education:** State legislated programs that provide
differentiated opportunities for learning commensurate with students' particular
abilities and talents (California Department of Education, 2014).

**Inquiry Based Learning:** In inquiry Based Learning is a process of systematically
answering questions based on evidence (Eggen & Kauchak, 1996).
Narrative: Reconstruction of events, either fictional or non-fictional, usually delivered verbally (Bryden, 2008).

New Generation of Science Standards (NGSS): Development states led science standards (K-12) that are rich in content and practice and arranged in a coherent manner across disciplines and grades to provide all students an internationally benchmarked science education (NGSS, 2013).

Problem Based Learning (PBL): Problem Based Learning is a student-centered instructional strategy in which students collaboratively solve problems and reflect on their experiences (Wong & Day, 2008).

Organization of Thesis

The organization of this thesis is as follows. Chapter 1 outlines the overall organization of the thesis. Chapter 2 consists of a review of relevant and related literature on the topics of problem based learning, critical pedagogy, and constructivism in education. Chapter 3 focuses on the methodology of the study explaining the mixed method procedures utilized during the study. Chapter 4 presents the analysis and findings of this study including the qualitative and quantitative data. Chapter 5 focuses on the conclusions drawn from the study and denotes areas of further study relevant to the thesis topic.

Researcher Background

Farzad Safavi was born in Iran and migrated to United States at the age of 15. Having earned his B.S. degree in biological sciences from UC Riverside in 1993, Mr. Safavi has been a science teacher in the middle school settings for the past 10 years.
Upon graduating from university, Mr. Safavi went through a period of time where future did not seem clear, and options seemed limited. The idea of being an educator did not germinate in his mind until he served a one-year contract as a full-time member of Americorps. Assigned in a local middle school, in charge of a Title 1 program, responsible to improve overall performance of students in the program, opened up the path in which he continues to travel on today. Mr. Safavi realizes that teaching is a dynamic profession in which no one student is alike, just as no one day is like the other. He regards education as a portal to view and to prepare students for the realities of the world, before they step into it. He believes that the education system, and in specific, science education, has failed to inform, to enrich, and to politically engage the urban students in being active participants in own education. Teaching a series of standards handed down from the state mandates that seem to have no relevance to students’ lives does not stimulate Mr. Safavi as a teacher. Teaching the traditional lecture-based teaching does not engage his students, no matter how interesting and engaging he makes it to be. He wants his students to make meaning behind what they learn, in that they must be able to apply what they learn in other situations. He desires his students to be problem solvers, critical thinkers, and he wishes to make science an accessible tool to serve human kind.
Science is the continual search to uncover general laws of nature through observation and experimentation. The purpose of science, as we know it, is to produce functional models that are real, tangible, and applicable for everyday people. Via the implementation of its methodical steps, which we know as the scientific method, students learn that science has answers to all their curious questions regarding the world around them. Ramesh and Patel (2013) define science as the systematic study of knowledge that is tentative, dynamic, and empirically verifiable. Although the past few decades have seen a sharp evolution in science teaching through lecture and demonstration-based classrooms, supplemented with hands-on work, science classes still remain a place where facts and information are mechanically transferred from teachers to students. As Freire (1970) puts it, classrooms in the education system today are like banks where the teacher is the depositor, and the students are the empty receptacles that are to receive the information that has been deposited into them. Scientific inquiry in urban classrooms today takes shape in the form of following step-by-step prescribed procedures, previously performed by other students and mastered by teacher. Relevance and meaning behind what students do are replaced with random data collection and pointless vocabulary accumulation. As a result, science has become a subject secluded from realities and injustices of the society that play roles in the continuance of the vicious cycle of social reproduction.
Llewellyn (2005) argues that most of the science conducted in schools is of the traditional cookbook variety, where students passively follow a procedure that resembles a ready-made recipe. As a consequence, the traditional surface approach to learning science has paid little attention to the application of scientific concepts (Selcuk, 2010). Holbrook (2005) notes that the traditional approach to teaching science is more often evident in particular branches of science, such as chemistry laboratory investigations, despite the fact that research indicates that science is unpopular and irrelevant in the eyes of students. The traditional teaching of science also does not promote higher order cognitive skills (Hackling, 2005; Ronis, 2008). The inability of science education in urban public schools to nourish and develop critical thinking has led to gaps between students’ and teachers’ expectations of science (Kain, 2003; Sahin & Yorek, 2009; Yager & Weld, 2000). Students become passive followers of teachers’ instructions and worksheets on structured practical exercises, and have found it difficult to be autonomous decision makers (Hackling, 2005). It appears that the pedagogy of science is not changing, because teachers are afraid of the classroom management involved and the facilitation of critical discussion (Goodnough, 2003).

**Problem Based Learning**

Problem-based learning (PBL) is a constructivist pedagogical approach to learning in which students work together to find solutions to a complex problem. PBL is certainly not a new idea in the world of education, but its definitions and uses are complex and varied. John Dewey was one of the first to use a form of problem based
learning in his laboratory school in Chicago (Savery & Duffy, 1995). One of Dewey’s major philosophical beliefs was experiential education. His theory of experience-based learning continues to be read and discussed not only within education, but also in other fields such as psychology and philosophy. In Dewey’s *Democracy and Education* he states:

> The nature of experience can be understood only by noting that it includes an active and a passive element peculiarly combined. On the active hand, experience is trying -- a meaning which is made explicit in the connected term experiment. On the passive, it is undergoing. When we experience something we act upon it, we do something with it; then we suffer or undergo the consequences. We do something to the thing and then it does something to us in return: such is the peculiar combination. The connection of these two phases of experience measures the fruitfulness or value of the experience.

(Dewey, 1916, p. 74)

What Dewey implies here is that knowledge is earned through concrete experiences and events. The affect and value of those experiences depend on the extent of relationships and continuities to which it has led up to. The phrases “I hear and I forget. I see and I remember. I do and I understand” is credited to Confucius, which in its simplicity resonates that even around 400 BC the power of doing and not just hearing was recognized. Therefore, the context in which information is learned resembles the context in which it will later be applied (Bridges, 1992). This is more technically termed encoding specificity which is achieved in problem based learning.
strategies by having students acquire knowledge in a functional context, that is, in a context containing problems that closely resemble the problems they will encounter later in life (Bridges, 1992).

The application of problem-based learning originated in medical schools in the late 1960s from the realization that traditional methods of instruction that relied on lecture and memorization had limited effect on medical students' later performance during residency (Barrows, 1996). Presently, PBL is a widely used method of instruction in medical schools as well as in K-16 educational settings and when given the choice, students prefer PBL to other more traditional methods of instruction (Arambula-Greenfield, 1996; Heppert, Ellis, Robinson, Wolfer, & Mason, 2001). As the name suggests, in problem-based learning, a "problem" is used as the starting point to teach a set of objectives. The problem, which can be teacher- or student-generated, is usually connected to the personal experiences of students, and includes independent and critical thinking opportunities (Michel, Bischoff, & Jakobs, 2002; Mossuto, 2009). Unlike traditional instruction, in which students are lectured on a topic before they have the opportunity to apply what they learned, in PBL students learn the concepts and principles related to the topic through the process of solving the problem (Hmelo-Silver 2004; Norman & Schmidt, 2000). This approach mirrors how problems are solved in the real world and requires a shift from teacher-centered to student-centered pedagogy, as learning focuses on understanding and application of knowledge. As a result, implementation of problem-based learning requires a change from traditional methods of instruction in which the teacher acts as the "expert," to a
role of facilitator (Gallagher, Sher, Stepien, & Workman, 1995; Kumar & Natarajan, 2007). As a facilitator, the teacher guides the students through (a) what questions to ask during problem definition; (b) how to locate information related to the problem; (c) how to analyze and synthesize the information; and (d) how to sort potential solutions to the problem (Delisle, 1997).

Adolescents today live in technologically-rich environments that require immediate connectivity and collaboration with others. Problem-based learning provides learners with the possibility of learning using a variety of technological tools in improving their immediate surroundings. This approach requires students to collaborate, and to solve the common problem (Kumar & Natarajan, 2007; Skiba & Barton, 2006). As a result, emerging technologies can be easily integrated in problem-based learning.

**Strategies of Problem Based Learning**

Problem and inquiry-based learning strategies are two types of student-centered learning methods that have been studied and applied in various educational settings. Eggen and Kauchak (1996) argue that although both employ different methods however, the intended outcomes are the same. In inquiry-based learning is a process of systematically answering questions based on evidence. The use of hypotheses and data gathering are used to assess and form a conclusion about a problem. This method is very similar to what many would call the scientific method. The steps of the inquiry method include: (a) identify the question; (b) generate a hypothesis; (c) gather data; (d) assess the hypothesis; and (e) generalize or conclude.
These steps are very close to the accepted inquiry model known as the scientific method (Eggen & Kauchak, 1996).

In practice, inquiry based methods still resemble traditional lectured-based learning. Schwartz, Lederman, and Thompson (2001) followed one teacher's experience with teaching science as inquiry, in terms of developing the students' understanding of the nature of science. After instruction by inquiry, students generally maintained their naive views with respect to the nature of science, and the researchers concluded that the state of science education and science education reform is the same today as it was 100 years ago. They contend that although science teachers succeed in relaying the content matter to students, they fail to provide students with the critical organizing themes of nature of science and scientific inquiry. Students are expected to know and understand the nature of science by simply doing science, even though doing science through inquiry presents and promotes a rather naive view of science (Schwartz et al., 2001).

In problem-based learning, students assume primary responsibility for the problem and the teacher facilitates students' investigation of the problem in taking control of their own learning (Eggen & Kauchak, 1996). The goal for PBL students is to gain a deep understanding of a specific topic. This model differs, in the fact, from Inquiry Based Learning, in that there may not be a hypothesis or the analysis of data. The PBL model employs four steps and then a question, they are: (a) assess knowledge relative to the problem; (b) identify additional information needed; (c) develop and implement plans to gather new information; and (d) use new knowledge
in problem solving. Once the students have worked through the four steps, they ask whether or not the problem was solved, if not then the student's return to step two. Otherwise the problem was solved (Eggen & Kauchak, 1996). Problem based learning is not a new phenomenon and it has been implemented with success around the world. Wong & Day (2008) employed PBL methods in a high school in Hong Kong, comparing it to lecture-based learning. The result of the study indicated improved scores in all three categories of knowledge, comprehension, and application. Improvement was observed also in long-term retention of subject matters, when problem based learning strategies were applied.

**Specific Aims and Goals of Problem Based Learning**

What students are to gain from PBL strategies is what scientists do on daily basis. Facing a real world challenge and an authentic task, collaborating, co-learning, co-planning and co-designing, implementing and refining a final product, are all steps that both scientists and PBL strategies follow to accomplish their goals. Applying PBL strategies requires educators to step out of their traditional comfort zones, and through collaboration with other educators create new ways to motivate, engage, and to make meaning of the nature of science for their students (Gürses, Aşıkyildiz, Doğar, & Sözbilir, 2007).

In everyday life, problems are approached by first understanding their nature and then by weighing out different options, the one strategy that would lead to optimum results is attempted. Medical students are trained to collaborate and resolve in face of a problem with solutions that contributes to benefit of all humanity.
Barrows and Tamblyn (1980) suggest the reason why this method of teaching the future doctors is used is because "the learning that results is the product from the process of working toward the understanding or resolution of a problem" (p. 18). In other words, the problem is encountered first in the learning process and serves as a focus or stimulus. Once the problem is isolated, then the application of problem solving or reasoning skills can be applied. The students also need to search for information and knowledge needed to understand the problem and how it might be resolved (Barrows & Tamblyn, 1980). Bridges (1992) asserts that the rationale for using this approach for training of doctors can be applied to other areas of education as well. He specifically cites the training of administrators, but this can be used in any subject where students will need to assess a problem and come up with an applicable solution.

In a study of chemistry students by Gürses et al. (2007), 40% of the students surveyed after a PBL approach to a lesson commented, "PBL encouraged us to investigate, and therefore, use library and Internet resources which made us to take the course more seriously and work intensively" (p. 9). This concept fits with what Bridges (1992) states where he writes that:

Information is better understood, processed, and recalled if students have an opportunity to elaborate on that information. Elaborations provide redundancy in the memory structure, which in turn reduces forgetting and abets retrieval. Elaboration occurs in problem based learning in various ways, namely, discussing the subject matter with other students, teaching peers what they first
leaned themselves, exchanging views about how the information applies to the problem they are seeking to solve, and preparing essays about what they have learned while seeking to solve the problem. (p. 9)

In order for the knowledge to fully sink in and to be understood, it first needs to be processed. Recollection is only a minor part of the process; it also requires scaffolding, talking, listening, drawing, brainstorming, and eventually applying the knowledge into something constructive to improve the human conditions. True learning takes place when proposed ideas are put into action, then tested, and then retesting to continually improve the previous designs. In other words, knowledge is constructed and then reconstructed.

In a comparative study between problem-based learning and inquiry based learning in Hong Kong middle school science classes, Wong and Day (2008) concluded that students taught using PBL strategies indicated higher scores in long term retention, overall knowledge, and the application of the subject matter than their counterparts who learned the same topic under the traditional lecture methods. A study in middle school science, integrating PBL strategies into a traditional lecture course, concluded that a flexible approach to learning modes allows students and staff to find the learning style that suits them best (Johnson, Herd, Anderwartha, Jones, & Malcolm, 2002).

As with all learning theories, there are advantages and limitations when creating or implementing problem-based learning curriculum. Since this grand experiment in medical education began, strong opinions have been expressed and
questions have been raised about the wisdom and effectiveness of problem-based learning. For one, students appear to enjoy the PBL format more and become more actively involved in their own learning (Antepohl & Herzig, 1999). Reports of the benefits of this type of instructional methodology on student performance on national licensing examinations vary greatly from showing that no harm was done by moving to a PBL curriculum to reports of improved performance for students involved in a PBL curriculum (Verhoeven et al., 1998). PBL-based curriculum is no more labor-intensive than a traditional one. It is simply a matter of utilizing the same amount of human resources, but in a different way (Mennin & Martínez-Burrola, 1986).

Problem-based learning students may not perform as well on multiple-choice tests as students taught by lecture-based instruction; however, follow-up studies completed by Norman and Schmidt (1992) reveal better long-term knowledge retention for PBL students. In PBL strategies, the problem itself is used as a motivating stimulus, which has been used as the hook to focus students' interest (Norman & Schmidt, 2000). Problem-based learning provides more meaning, applicability, and relevancy to classroom materials. When problems are engaging, difficult, and useful, higher levels of comprehension and skill development occur than in traditional instruction (Albanese & Mitchell, 1993). Real-world contexts and consequences not only allow learning to become more profound and durable, but increases the transferability of skills and knowledge from the classroom to work (Gallagher, Stepień, & Rosenthal, 1992).
Problem based learning is a process that when properly employed, intimately involves the students in their own learning. It provides opportunities for students to confront, analyze and solve problems. Additionally it forces students to access and use prior knowledge on a regular basis. All of these characteristics are needed and are regularly used in the scientific community and can be successfully used in the science classroom.

**Critical Pedagogy**

Learning science, especially in urban areas, can be practical if old notions of lecture teaching and rote memorization are set aside and are replaced with building applicable knowledge by exchanging ideas, constructing theories, and producing products that would benefit the community. Students of critical science must become aware of how politics of the dominant group in the society use and misuse the tools in science to maintain the status quo. Critical pedagogy for the sciences, which starts with student interests and hopes to expand them, aims to promote life-long exploration of the natural world. “Critical pedagogy recognizes that science is not neutral and wants to use science to further humanization” (Dalke & Franklin, 2003, p. 3).

Whereas traditional, hands-on and inquiry-based methods aim to foster individual success in such practices, a critical pedagogy of science attends to the social dimensions in which students operate, asks how they might be altered, and considers how such alterations can be sustained (Dalke & Franklin, 2003). Critical pedagogy works to enhance and promote awareness and bring connections to issues that affect their circumstances.
Critical pedagogy attempts to connect what McLaren calls technical knowledge to practical knowledge, with the former defined as the empirical and analytical methods and the latter as the type of knowledge that is acquired through describing the actions of daily world and analyzing social issues (Darder et al., 2009). McLaren (as cited in Darder et al., 2009) refers to this connecting bridge as "emancipatory knowledge", the type of knowledge that can be used to understand social relationships, the imbalances in power and the politics that work to maintain the control of the dominant group (Darder et al., 2009). Critical educators are concerned about raising students with critical eye to examine social justice in their world.

Critical pedagogy is a teaching approach, which attempts to help students question and challenge the domination and the beliefs and practices that support the proposed domination. In other words, it is a theory and practice of helping students achieve critical consciousness. Critical pedagogy is concerned with the development of "conscienticizao", the term coined by the most celebrated critical thinker, Paulo Freire, in his book, Pedagogy of Oppressed, usually translated as "critical consciousness." According to his writings, "praxis is the path to liberation, the path in which students and teachers both act and reflect upon their world in order to transform it" (Freire, 1970, p. 60). In Freire’s point of view, authentic knowledge is not attained through depositing of information, but through praxis; practice of constructing and reconstructing knowledge where levels of consciousness are raised in all aspects of human life. Last but not least, Freire capitulates that knowledge is achieved through dialectical relationships where "The teacher is no longer merely the-one-who-teaches,
but one who is himself taught in dialogue with students, who in turn while being taught also teach” (Freire, 1970, p. 61). Students take value in own realm when their prepackaged knowledge is tapped into and recognized. In Freire’s problem posing education, students are challenged and indulged to respond to the challenge, because the problems relate to themselves and the world they live in.

Critical pedagogy is also somewhat unique in its use of dialectical thinking. Dialectical thinking is a critical review of society that searches out contradictions (Freire, 1970). The dialectical nature of critical theory enables the educator to see the school not simply as an area of indoctrination or socialization or a site of instruction, but also as a cultural terrain that promotes student empowerment and self-transformation (McLaren, 1989). McLaren goes on to state: “For the critical educator, there are many sides to a problem...” (1989, p. 168). Critical pedagogy thus allows for students to view problems from multiple analytical as well as socio-economic angles. With this in mind, when children are engaged in activity of interest to them that presents difficulties, they look for a method of coping with the difficulties and thus acquire new skills (Tanner, 1997). When challenges are coped with in a trial and error fashion, additional opportunities are provided for the child to use their newly acquired skills and complete the learning circuit. In this circuit, what is learned must be present to the child as a desirable end or objective and therefore as a motive to exert effort (Tanner, 1997).

Unfortunately, that system has changed very little since Freire’s time, and it still favors the dominant class in this country. Freire (1970) asserts that fear is one
reason that the educational system has not changed. Indeed fear as a powerful factor in race and class interactions from the classroom to the administration building. Freire (1970) describes how both the oppressor and the oppressed are afraid of change. It is interesting to note that he speaks of men’s fear of freedom, as if freedom will be horrible or unjust in some way. Freire (1970) states: “Men rarely admit their fear of freedom openly, however, tending rather to camouflage it- sometimes unconsciously- by presenting themselves as defenders of freedom” (p. 21). The mere fact that most educators are white is in some way the perpetuation of the role of the oppressor, since they represent the dominant group, in terms of power and resources. Unconsciously, teachers with all the best intentions, contribute in maintaining the status quo by not relinquishing the fear of losing control.

In the end, Critical pedagogy is needed to break free of the Eurocentric teaching styles that dominate classrooms today. For teachers to be able to do this an awareness of race and class inside and outside the classroom is needed. Critical pedagogy also encourages teachers to assess and critique the information they are expected to teach for bias and hegemonic undertones. All science educators need to look critically at their curriculum and decide whether or not they are perpetuating a system of controlled, predetermined facts, or promoting true scientific inquiry open to all peoples.

While the application of problem-based learning relies on students' collaboration and independent thinking, critical pedagogy attempts to help the students to think critically about the overall scope of the information on an individual as well as
a global level (Shor, 1992). Students often do not see the connection between the science classroom and the outside world; hence the application of PBL strategies while using critical pedagogy as a tool for socio-economic awareness and engagement would provide them with such opportunities. In the end a classroom that is carefully led loses its ability to think for itself. Problem Based Learning strategies would act as the bridge scientific thinking, problem solving, and application of knowledge to promoting social justice and community development.

**Constructivism and Critical Pedagogy in Harmony with Problem Based Learning**

The development of the problem based learning as a meaningful way to engage elements of the curriculum was influenced by both constructivist as well as critical pedagogy theorists. Constructivist, Piaget (1964) asserts that children build their own understandings through experience, Vygotsky (1978) notions that collaborations enhance understanding, and Dewey claims (1897) that projects help children acquire knowledge. Piaget poses two goals of education that contrast with the goal of passing standardized tests. According to Piaget (1973),

The principal goal of education is to create men who are capable of doing new things, not simply of repeating what other generations have done—men who are creative, inventive, and discoverers. The second goal of education is to form minds which can be critical, can verify, and not accept everything they are offered...So we need pupils who are active, who learn early to find out by themselves, partly by their own spontaneous activity and partly through
material we set up for them; who learn early to tell what is verifiable and what is simply the first idea to come to them. (p. 36)

Progression of time represents evolution of all things, including education. What worked for past generations does not necessarily work for today's generation, especially with the increased diversity of population all around the globe. Today's youth can obtain information just by touching the screen of a smart phone, hence he/she must be guided to critique and question the source and validity of the information and whom it aims to benefit. Piaget's assumptions (1964) regarding education as a forum for critique, selectivity, and resistance, is directly in congruence with teaching and learning situated in knowledge production rather than knowledge consumption and regurgitation. An underlying conjecture regarding the implementation of the problem-based learning is the involvement of students in meaningful collaborative authentic problem solving projects facilitated by their teachers. Teachers in turn employ real world problems to stimulate their interests and understanding across all curricular disciplines. Constructivist notions of learning harmonize with the aspects of critical theory and critical pedagogy that shape the implementation of the problem based learning.

**Problem Based Learning and New Generation of Science Standards (NGSS)**

The emergence of the New Generation of Science Standards (NGSS) has shown promise of progress in the future of secondary science education. Its standards, broken down by grade levels, attempt to bring practicality, applicability, as well as creativity into science classrooms (NGSS, 2013). By integrating actions verbs such as
planning, defining, generating, designing, testing, the NGSS invites educators to challenge students in solving practical problems. A closer look reveals the similarities between PBL methodologies and the objectives in NGSS. They both require students to think critically to reach solutions in which they could be tested and applied to real world situations. Complicated concepts and NGSS such as evolution can be taught and explained to middle school students through problem-based learning and technology (Wang, Hsu, & Posada, 2014). By offering a real problem, as stimulant, teachers engaged students to define and break down the problem by sharing what they knew and what they needed to know. Teachers were facilitators of students' search for answers.

It is not yet clear, how the alignment of NGSS with the Common Core, will take place. Districts in northern California are collaborating with higher education institutions to introduce science teachers to possible methods of implementing NGSS into their classrooms (SASP, 2015). These methods, as demanded in the New Generation of Science Standards, utilize problem-based learning strategies. The standards are written in such language that it stresses the engagement of students in application of scientific content and their awareness towards social issues such as population growth and global warming (NGSS, 2013). Higher education institutions are ideal places for developing models for educators and other professionals involved. They must work with school districts to stage forums where science teachers can collaborate and share ideas, in adopting strategies to make science a more practical and exciting topic for our future scientists, today.
Both Murrell (2002) and Freire (1970) speak of praxis. Praxis is at the heart of both pedagogy's and both call upon the learner to take charge of their learning and challenge the traditional social order in which they find themselves. Problem Based Learning can access the principals of both theories to create a more effective framework for inquiry based science instruction. Dewey stated in his pedagogic creed (1897): "I believe that education, therefore, is a process of living and not a preparation for future living." Bridges states (1992) that information is better understood, processed, and recalled if students have an opportunity to elaborate on that information. Elaborations provide redundancy in the memory structure, which in turn reduces forgetting. Additionally, Tanner (1997) asserts that the (PBL) activities supply occasions for creating difficulties and motives for dealing with them, and there is no sudden transition as children acquire new skills. Clearly PBL strategies work in the classroom from doctors to kindergartners; therefore when the proven strengths of PBL are combined with the social constructs of critical pedagogy, strong multimodal learning and positive student engagement can occur in the classroom.

**Gender Inclusion in Science Classrooms**

It is a challenge for females not only to see themselves in the curriculum, but also to find relevance and make any personal connection. Science in particular is often stripped down to operations, skills and abstractions, robbed of anything personal or personally relevant. When students are unable to connect to the curriculum content or unable to make any personal connection or value then they are not as likely to value or pursue that curriculum (Noddings, 2005). Without the relevance or personal
connection, females struggle to maintain or develop interest in science. As such, females are not as likely to pursue advanced courses in science or to feel empowered to make a difference in the community conditions.

For females to continue their interest in scientific fields, they must feel that they can succeed in these courses. To insure that females are successful, educators need to employ teaching styles that meet females' learning style needs. Females and males learn differently from each other (Belenky, Clinchy, Goldberger, & Tarule, 1997). When females are taught in formats that are not best suited to females' learning style, then they lack the opportunity to develop interest or relevance in a subject. Research suggests that females learn best when there is opportunity for them to become engaged with the topic, when they do not feel like a stranger in the classroom, when they have opportunity to interact and when cooperative work is valued over individual competitive work (AAUW, 1999). Teachers need to build in relevance in order to better connect girls to the subject matter (Belenky et al., 1997). Instructors need to examine text and materials for gender bias and either compensate or address any biases (Carinci, 2007).

Research suggests that for students to succeed and to continue in advancement in scientific fields, they needed to experience science from more of a relevant perspective (AAUW, 1999). One key to raising student interest in science is to provide a more connected learning experience (Singh, 2002). It is logical to conclude that if lack of interest is one of the main reasons females do not continue to enroll in science courses, then generating interest would encourage continuation of other
advanced science course enrollment (Lapan & Shaughnessy, 1996). For educators to present a curriculum that is relevant and provide the opportunity for females to connect to the content, further research on improving science interest level for females is indicated.

**Summary**

Science is not always black and white and discoveries are often made when they are not expected. In today’s current climate of high stakes testing, the opportunity for students to be able to engage in this type of learning is very limited. Indeed the whole notion of high stakes testing harkens back to Victorian times when only facts were considered important (Kliebard, 1998). Additionally many would argue that the current system of education promotes a limited worldview that does not access those strengths of individual cultures or thought processes (Giroux, 2003). As simply stated by John Dewey (1897), “I believe that under existing conditions far too much of the stimulus and control proceeds from the teacher…” (p. 2).

The preceding literature indicates that problem based learning, as a constructivism approach with potential to make secondary science applicable and advancing to scientific fields accessible. Using the real world problem as the stimulus to motivate, problem based learning requires students to apply prior knowledge to brainstorm and plan for a practical and applicable solution to the problem. The implementation of these strategies entails a shift from teacher-centered to a student-centered teaching, where teacher takes the role of the facilitator. When combined with critical pedagogy theory, PBL strategies would grant freedom to students to question
and challenge the beliefs and practices that support and benefit not all, but only the dominant group. In other words, critical pedagogy helps students achieve critical consciousness, and when paired with PBL strategies, the dialectical nature of both teaching styles would allow students to search for contradictions in the society. The essence of the two theories is to enable the educator to see the school not simply as an area of training or socialization or even instruction, but also as a cultural terrain that promotes student empowerment and self-transformation.
Chapter 3

METHODOLOGY

Introduction

The findings in this study are presented through a mixed method of quantitative and qualitative study. The data is composed of a pre/post 5-point Likert scale survey, and a post study open-ended questionnaire given to two eighth grade GATE physical science students, in a South Sacramento middle school. Fifty-eight students participated in the unit study which required students to apply problem based learning (PBL) strategies to find solutions to a real-world problem. Data from the Likert-scale survey and the post study open-ended questionnaire were analyzed statistically to find differences between pre and post survey responses. Open-ended questions were analyzed by emerging themes, which supported the data from the Likert-scaled survey. The researcher, also the teacher, is on his ninth year of teaching at this middle school. He was drawn to problem based learning strategies through exposure to critical pedagogy theorists, and his desire to make science education tangible, accessible and real for his students.

Study Design and Data Collection

To gather data regarding the effectiveness of PBL in students' interest and awareness, and empowerment regarding socio-environmental issues, the research study question utilized a mixed method of quantitative and qualitative data collection. A mixed-method approach helps increase the trustworthiness of the findings through methodological triangulation by using data collected in one way to cross-check the
accuracy of data collected in other ways (Morse, 2003). Mixed methods also allow for a more detailed and comprehensive understanding of the phenomena being studied. Analyzing data through mixed methods provides better understanding of the nature of the problem. According to Creswell (2008), when one type of data is not enough, the other may compensate and fill in the gaps. Mixed research is somewhat pragmatic and practical by nature. It provides multiple viewpoints; it combines subjective with objective, and biased with unbiased. The application of mixed methods permits the qualitative results to assist in explaining and interpreting the findings of a quantitative study (Creswell, 2014).

The quantitative data was gathered through a pre and post 5-point Likert-type survey (Appendix C), containing 19 statements attempting to scale the participants’ responses regarding general knowledge, feeling, and awareness regarding science, their surrounding environment and environmental issues. These questions were designed with the rationale that responses would result into sufficient data to observe and analyze the before and after effect of the implementation of PBL strategies. Hence the questions invoked participants to respond to the research question. Subsequently, the questions were matched by student ID’s, and were analyzed via \( t \) test paired samples.

Quantitative research is the most effective research method when using surveys to answer research questions. The validity and reliability of quantitative data “leads to meaningful interpretation of data that is objective in nature” (Creswell, 2008 p. 124). The quantitative results from the survey provided a means of explaining
numerically the attitudes and opinions of the students whom participated in the study (Creswell, 2008). The use of quantitative data ensured that concrete results were present at the conclusion of the data analysis.

The post study open-ended questionnaire (Appendix F) constructed the qualitative data. The five open-ended questions were created in hopes gain a deeper understanding of the Likert-scaled survey questions. The questions aimed to examine how the participants felt regarding the PBL strategies and the unit in specific. The questions were categorized and analyzed based on thematic data analysis, that developed in students’ responses (Creswell, 2014; Trotter-Hamilton, 2010). By creating categories to guide the analysis of the data, the researcher will be able to systematically target the study’s purpose through the answers the participants give in the open-ended survey questions (Merriam, 1998). Qualitative data aims to make understanding of the meaning participants make, where finding are often comprehensive, holistic and descriptive (Merriam, 1998). The addition of qualitative data collection allowed a narrative outlet for students to describe their experiences during the problem based learning unit. Providing the open-ended questions allowed students to express their own voices regarding the project and to add insight to responses in the quantitative data. (Merriam, 1998).

**Research Question**

How does the application and implementation of problem based learning help to increase interest and awareness in middle school science students regarding socio-environmental factors affecting people at community and global levels?
Research Instruments

An informed parent consent form was created and given to participants to take home allowed the participants’ parents the opportunity to opt out of the study (Appendix A). The students, too, were given a personal opportunity to opt out of the study by completing the student assent form (Appendix B). Two students opted out of the study by bringing back the parent consent form signed for not permitting to participate.

The pre/post Likert-scaled survey questions were modeled after Bryden (2008), who completed a study of effect of narratives in middle school math class. Survey questions were designed to students’ overall knowledge of environmental issues affecting human kind. They also aimed to scale students’ interest in science class and science careers. Furthermore, the questions intended to measure the feeling of empowerment they would attain after the study in becoming active participants and instruments of change in the future. The open-ended questionnaire, attempted to tap into the participants’ reasoning toward the effectiveness of the PBL strategies. It was also gauged to evaluate their willingness to participate in improving conditions in their own community, and to scale what they knew and did not know, before and after the unit study.

Setting

This study took place in two eighth-grade, GATE, physical science courses in a South Sacramento middle school. Demographics of the school is composed of 21% African Americans, 49% Latinos, 24% Asians, 4% Whites. Indians, Pacific Islanders,
and duel ethnicities make up the other 4% of the population. The school offers 100% free lunch to all students and has been receiving extra funding from the district under the "Program Improvement" umbrella for the past four years. As it stands, students in grades fifth, eight, and tenth, are still required to take the California Standardized Test for science. The unit of study intended for this research was "The Sacramento Green Project" (Appendix D). Students were given the unit on May 1, 2015 and the unit ended June 5, 2015. The final lesson included viewing students' power point presentations. The five-week study was conducted periods one and five, both GATE classes, for the 52 minutes of each school day.

Participants

Fifty-eight students in two GATE middle school physical science classes made up the participants in this study. The GATE classes were selected as subjects in this study due to students' need to be enriched as well as convenience for the researcher. Participants' demographic and gender distribution is shown in Tables 1 and 2 below.

Table 1

Demographics of the Population under Study

<table>
<thead>
<tr>
<th>Demographic Groups</th>
<th>GATE 1 Number/Percentage</th>
<th>GATE 2 Number/Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latinos</td>
<td>15/47%</td>
<td>19/60%</td>
</tr>
<tr>
<td>Asian</td>
<td>6/18%</td>
<td>3/0.1%</td>
</tr>
<tr>
<td>African American</td>
<td>6/18%</td>
<td>5/0.5%</td>
</tr>
<tr>
<td>White</td>
<td>1/0.03%</td>
<td>2/0.06%</td>
</tr>
<tr>
<td>Pacific Islanders/Indian/Dual ethnicity</td>
<td>4/0.12%</td>
<td>3/0.1%</td>
</tr>
</tbody>
</table>
Table 2

Distribution of Population by Gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>GATE 1</th>
<th>GATE 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number/Percentage</td>
<td>Number/Percentage</td>
</tr>
<tr>
<td>Females</td>
<td>16/51%</td>
<td>17/63%</td>
</tr>
<tr>
<td>Males</td>
<td>15/48%</td>
<td>10/37%</td>
</tr>
</tbody>
</table>

Procedures

Problem based strategies include students interactions that may require previous exposure and practice. Community building, conversational skills, and understanding specific roles are examples of some skills students should have previously exercised. The real world problem that was presented to the participants involved developing a renewable source of energy for South Sacramento Area. Through teacher facilitation students researched different types of renewable energy and as stakeholders, chose and developed a plan to introduce the renewable source of energy for the community they live in. Part of the challenge involved innovating new ways to dispose of trash instead of using landfill. Each team presented their findings to the class via any chosen media. Implementation of problem-based learning in this study followed the seven-step approach suggested by Delisle (1997): (a) setting the climate, (b) connecting with the problem, (c) setting up the structure, (d) visiting the problem, (e) revisiting the problem, (f) producing a product or performance, and (g) evaluating the performance.

Parent permissions were obtained through the informed parent consent forms (Appendix A), which were also translated to Spanish and Hmong. Student
permissions to participate in the study were attained via the student assent form after a brief verbal description of the purpose of the study. Immediately, before the commencement of the study, the pre survey was administered (Appendix C), serving as the first set of quantitative data. “The Sacramento Green Project” information sheet (Appendix D), introduced the project to the participants. The weekly schedule below shows a general flow of the progress of the students throughout the unit project. It is important to recognize that the absence of definite structure in the flow of schedule. This fluidity mainly is result of the PBL strategies being student-centered where teacher takes the role of the facilitator.

**Week 1**

1. Groups assign roles
2. Create team names
3. Digest and analyze problems
4. Brain storm idea
5. Set Goals
6. Begin Research

**Week 2**

1. Carry own roles
2. Complete self/teammate evaluation sheets
3. Share findings with group members
4. Revisit goals/Set new ones
5. Research and plan

6. Share finding with other groups

**Week 3**

1. Evaluate progress

2. Carry own roles

3. Complete self/teammate evaluation sheets

4. Share findings with group members

5. Revisit goals/Set new ones

6. Research and plan

7. Share finding with other groups

8. Begin creating presentations

**Week 4**

1. Evaluate progress

2. Carry own roles

3. Complete self/teammate evaluation sheets

4. Share findings with group members

5. Revisit goals/Set new ones

6. Research and plan

7. Share finding with other groups

8. Create Power Points
Week 5

1. Begin presentations

2. Peer/Self Review

3. Reflections and discussion on the process

At the end of each day, groups met and completed a daily reflection sheet where they recorded their accomplishments, their setbacks, and plans of action for the next day. During the first three weeks of study, when research comprised bulk of students work, members from different groups met, once a week to exchange ideas and findings. Each member was then responsible to report their peers’ shared information to their own group. The end of presentations were followed by peer/self evaluation and an in depth discussion of what was learned. To complete quantitative data the post survey (Appendix C), was administered to all participants. In additions, the open-ended questionnaire was supplemented with the post survey, to constitute the quality data (Appendix E).

The pre and post survey questions were matched, by participants’ last four digits of student ID’s. Data was entered and analyzed through a paired samples t-test, and a two-tailed correlations test to measure differences among the variables. The open-ended questions were examined and coded looking at recurrent themes.

Summary

The survey was conducted using pre and post questionnaires measuring variables that were examined for this study. Following collection of surveys the data was analyzed using both a quantitative and a qualitative approach. Incorporating data
from a standard 5-point Likert-scale on both a pretest and on a posttest with qualitative
data from open-ended questions on the posttest, the researcher was able to collect
sufficient data. The researcher's intent was to determine any effects of problem based
learning strategies in students' increase in interest, awareness, regarding
environmental issues and their willingness to be active participants in making a
difference.
Chapter 4

FINDINGS

The study examined 58 GATE middle school physical science students. The units of study entitled, “The Sacramento Green Project”, was delivered within five weeks; with the pre/post Likert-scaled surveys administered before and after the unit. The purpose of the study was to examine the effect of problem based learning strategies in increasing interest and understanding regarding science, awareness, and overall empowerment of the students regarding environmental issues influencing human kind. The post unit Likert-scaled survey was also paired with open-ended questionnaire for qualitative analysis.

The Likert-scale component of the survey was analyzed using a repeated measures t-test, a paired samples t-test, and a two-tailed correlations test. The quantitative questions were employed to detect increases in three categories:

1. students’ interest and understanding of the relatedness of science to their daily lives;
2. awareness of students regarding environmental issues that are facing humanity, locally and globally;
3. students’ empowerment toward being able to make a difference in the environmental conditions and own community.

The open ended questions were designed to determine how problem based strategies influenced students learning, allowing students to reflect on the process of PBL strategies.
Quantitative Results

The Likert-scale survey was analyzed using a paired samples t-test to determine significant differences between the pre and post questions. The pre-test items were paired with the post-test items to identify changes in targeted study questions. The pre/post survey contained 20 items. Specifically, seven questions out of the twenty were designed to measure students' perception students interest and understanding toward relevance of science to everyday life, their awareness toward environmental issues, and their feeling of empowerment to be a part of the solutions to those problems. The paired samples t-test identified all seven items to be statistically significant between the pre survey and the post survey questions. Table 3 shows the frequency of the responses in pre/post surveys for the seven specified items.

Table 3

Frequency of Responses to the Survey Questions

<table>
<thead>
<tr>
<th>Statements: strongly agree &amp; agree</th>
<th>Frequency Pretest</th>
<th>Percent Pretest</th>
<th>Frequency Posttest</th>
<th>Post test percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>I look forward to science class</td>
<td>42</td>
<td>72.4</td>
<td>46</td>
<td>79.3</td>
</tr>
<tr>
<td>I am well aware of sources of renewable energy</td>
<td>17</td>
<td>29.3</td>
<td>45</td>
<td>77.6</td>
</tr>
<tr>
<td>I know the sources of energy in city of Sacramento</td>
<td>12</td>
<td>20.6</td>
<td>39</td>
<td>67.3</td>
</tr>
<tr>
<td>Science relates to my life</td>
<td>29</td>
<td>50.0</td>
<td>36</td>
<td>62.1</td>
</tr>
<tr>
<td>I am aware of environmental problems that are affecting me</td>
<td>29</td>
<td>50.0</td>
<td>36</td>
<td>62.1</td>
</tr>
<tr>
<td>I believe can make positive impact on environment</td>
<td>33</td>
<td>57.0</td>
<td>43</td>
<td>74.1</td>
</tr>
<tr>
<td>Science can contribute in improving community conditions</td>
<td>36</td>
<td>62.1</td>
<td>47</td>
<td>81.0</td>
</tr>
</tbody>
</table>
To measure the results, a paired samples t-test was utilized producing t-values that were used to calculate the significance. The significance determines whether or not a statistically significant change occurred in the data from the pretest to the posttest. For this value to be classified as statistically significant it must measure less than 0.05. Seven of the items from the survey produced significance values that were less than 0.05. The significance value varied among the seven responses. Values less than 0.0001 indicate greater significance in the change between the two surveys.

**Interest in Science and Understanding of Its Relatedness to Everyday Life**

Responses agreeing to the statements “I look forward to science class” and “Science relates to my life” increased from pre-survey to post-survey were significant enough to produce values less than 0.05 (Table 4). In this case the, the null hypothesis is rejected and based on the results the implementation of PBL strategies did have a significant impact on students’ interest toward science and how it relates to their everyday life.

Table 4

*Students’ Interest Toward Science and How it Relates to Life*

<table>
<thead>
<tr>
<th>Statements (Agree)</th>
<th>Mean Time 1</th>
<th>Mean Time 2</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>I look forward to science class</td>
<td>3.9</td>
<td>4.2</td>
<td>0.002</td>
</tr>
<tr>
<td>Science relates to my life</td>
<td>3.4</td>
<td>3.7</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>
Awareness Regarding Environmental Issues

Responses to statements “I am aware of environmental problems that are affecting me,” “I am aware of sources of renewable energy,” and “I know the sources of energy in Sacramento,” produced t values less than 0.0001, which indicate strong significance between pre test and posttest (Table 5). An increase of 0.6 in the mean between pre/post responses signifies that using PBL strategies students were able to have improved awareness regarding environmental issues affecting them. With 0.9 increase in mean between the pretest and the posttest is an indication that while utilizing PBL strategies, students’ gained a much better understanding what are the sources renewable energy and how they are used. The percent increase in frequency between the two tests was 48.3 (Table 3). The statement “I know the sources of energy in the city of Sacramento” had increase in mean of 1.1 and 55.3% increase in frequency. The t value less than 0.0001 indicate a strong significance of change between the pre and post surveys.

Table 5

<table>
<thead>
<tr>
<th>Statements (Agree)</th>
<th>Mean Time 1</th>
<th>Mean Time 2</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am aware of environmental problems that are affecting me</td>
<td>3.4</td>
<td>4.0</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>I am well aware of sources of renewable energy</td>
<td>3.0</td>
<td>4.1</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>I know the sources of energy in city of Sacramento</td>
<td>2.7</td>
<td>3.8</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>
Feeling Empowered to Make a difference

The lower than 0.05 significant values for both statements, “I believe I can make a difference in improving the environmental conditions” and “Science can improve community conditions” indicate substantial difference between the pre/post survey results (Table 6). Utilizing problem based learning strategies students felt empowered to use science as a tool for improving the environmental conditions surrounding them. The mean difference between pre and post surveys was 0.4 and 0.5, respectively.

Table 6
Feeling Empowered

<table>
<thead>
<tr>
<th>Statements (Agree)</th>
<th>Mean Time 1</th>
<th>Mean Time 2</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>I believe I can make a difference in improving the</td>
<td>3.6</td>
<td>4.0</td>
<td>0.002</td>
</tr>
<tr>
<td>environmental conditions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science can improve community conditions</td>
<td>3.7</td>
<td>4.2</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

Gender Analysis

A paired t test analysis of both males and females indicated significant changes between the pre and post survey result in four statements (Table 7). The statement, “I am aware of renewable sources of energy,” “I look forward to science class,” “I know the sources of energy in the city of Sacramento,” and “Science can contribute in improving community conditions,” yielded significant t-values less than 0.05 which is indicative of positive changes in students’ perception in regards to those statement.
For the statement “I look forward to science,” only males showed significance difference between pre and post surveys with significant t-value of 0.03 where females showed no change. Females however, felt more empowered to be able to make an impact on the environmental conditions, when responded to “I believe I can make a positive impact on environment” with t-value of 0.009. Male’s t-value for this statement was equal to 0.1 showing insignificant change between the pre/post surveys.

Table 7

Gender Analysis

<table>
<thead>
<tr>
<th>Statements (Agree)</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Time 1</td>
<td>Mean Time 2</td>
</tr>
<tr>
<td>I look forward to science class</td>
<td>3.9</td>
<td>4.3</td>
</tr>
<tr>
<td>I am aware of sources of renewable sources of energy</td>
<td>2.7</td>
<td>3.9</td>
</tr>
<tr>
<td>I know the sources of energy in city of Sacramento</td>
<td>2.6</td>
<td>3.6</td>
</tr>
<tr>
<td>I am aware of environmental problems that are affecting me</td>
<td>3.1</td>
<td>3.9</td>
</tr>
<tr>
<td>I believe I can make positive impact on environment</td>
<td>3.6</td>
<td>3.7</td>
</tr>
<tr>
<td>Science can contribute in improving community conditions</td>
<td>3.6</td>
<td>4.1</td>
</tr>
</tbody>
</table>

The seven designated Likert-scaled survey questions in the study, all resulted in positive changes between the pre and post sessions. Regarding the interest of students in science and their understanding of its nature, the two statements, “I look forward to science class” and “Science relates to my life” were inserted into the
survey. Although both statements produced significant changes, they were not as significant with only 0.3 increases in the means for both statements. Males showed significant change in this category whereas the females did not. On the other hand, the statements, ”I am aware of sources of renewable energy,” “I know the sources of energy in the city of Sacramento”, and “I am aware of the problems that are affecting me” resulted in mean increases between 0.5 to 1.1. These questions were designed to measure increase in students’ awareness in the environmental issues facing human kind at local and global levels. The statement, “I believe I can make a positive impact on environment” and “Science can improve community conditions” were inserted to gauge students’ empowerment to be a part of improving community conditions by applying what they have learned. The results for both questions were significant with mean increases of 0.4 and 0.5, respectively. Paired sample t tests for female’s responses in these two questions yielded significant changes between the pre and post surveys, whereas the males did not.

**Qualitative Results**

Using thematic data analysis, four themes emerged after examining the open-ended items: (a) interest and understanding of relatedness of science to students’ daily lives, (b) increased awareness of environmental problems and gain in cognizance of solutions to those issues, (c) increased willingness to actively participate in improving community conditions, and (d) what the students liked and disliked about PBL strategies.
What Students Liked about PBL

One of the open-ended questions in the questionnaire asked: “What did you enjoy most about the way you learned in this (PBL) unit?” Forty-one percent of responses were those who enjoyed collaboration with classmates and working in groups. Included in this group are also students who appreciated minimum teacher input and lack of lecture style lessons. A female Latina stating: “I enjoyed how we were very independent as individual and just had each other and our research to depend on” and “I enjoyed the freedom of learning” are examples that were included in the data. Fifty-three percent of the respondents claimed they relished researching for solutions to realistic problem. Six percent of the respondents took most out of making the power point design and presenting their finding (Table 8).

Table 8

Likes about PBL Strategies

<table>
<thead>
<tr>
<th>Question #1: What did you enjoy about the way you learned in this unit?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Themes</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>Collaboration &amp; Independence</td>
</tr>
<tr>
<td>Researching for Solutions to a Real Problem</td>
</tr>
<tr>
<td>Power Point Design &amp; Presentation</td>
</tr>
</tbody>
</table>

What Students did not Like about PBL

Five themes emerged from students’ responses when presented with the question, “What did you enjoy least about this unit?” About half of the students, 54%,
were hesitant and maybe shy about conducting presentations in front of an audience. Twenty-five percent of participants chose having to do research as their least enjoyable aspect of the unit whereas 13% enjoyed everything. Three individuals, preferred working alone, and two denoted that the project entailed too much writing and lacked hands-on activities. Also included is what an individual signified as: “Not having enough time to make more in depth research and slides.” Sue, an Asian student stated: “I am not too keen on doing stuff as a group unless I’m the leader” is places her amongst those who did not prefer group work. On the other hand, a female African American student stating: “Honestly, I didn’t dislike anything. I’m glad we as young kids can look at the world we live in, a little deeper. This was a great idea” could be an indication that many enjoyed all aspects of PBL strategies (Table 9).

Table 9

<table>
<thead>
<tr>
<th>Dislikes about PBL Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Question #2:</strong> What did you like least about this (PBL) unit</td>
</tr>
<tr>
<td><strong>Themes</strong></td>
</tr>
<tr>
<td>Presentation</td>
</tr>
<tr>
<td>Research</td>
</tr>
<tr>
<td>Enjoyed Everything</td>
</tr>
<tr>
<td>Group Work</td>
</tr>
<tr>
<td>No Hands-on</td>
</tr>
</tbody>
</table>

Interest in Science and how it Relates to life

The response to question #3, “Would you say your interest in science has increased or decreased during the last unit?” indicated that almost all students realized more interest in science and how it can be used to help community and environmental
conditions. Emerging themes included gaining awareness toward how science can be applied, being challenged and interested, and learning new information. Of the 6% who did not see their interest grow, comments ranged from the unit being boring, not having enough hands on activities, in having to do too much work.

Support for affirmative responses varied. Some claimed that the increase in interest in science is due to understanding of how science and technology can offer different ways to help solve problems that relate to their own community. Included within this category are those who express having gained more knowledge and awareness regarding how science can be applied to own immediate surroundings. Eddie, an African American participant indicated: “Increased because I got to learn how science really impacts our lives.” Others asserted that the topic was so interesting that they felt challenged and intrigued, as a male Latino student stated: “I actually got interested in the unit and ended up spending free time researching about it.” Two percent of participants stated the project was fun and one individual credited the teacher for the gain in interest. Six percent of participants indicated that their interest regarding science did not increase (Table 10).
Table 10

*Interest in Science and Understanding of its Relatedness to Everyday Life*

<table>
<thead>
<tr>
<th>Themes</th>
<th>Percent</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gained awareness toward how science can be applied</td>
<td>34</td>
<td>21</td>
</tr>
<tr>
<td>Challenged &amp; Interested</td>
<td>27</td>
<td>16</td>
</tr>
<tr>
<td>Learning New Information</td>
<td>28</td>
<td>17</td>
</tr>
<tr>
<td>Teacher</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>No Increase</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

**Awareness Regarding Environmental Issues**

All but one of the respondents to the question, "would you say your knowledge of environmental issues that are affecting us, locally and globally, has increased or decreased?" indicated increase in knowledge and awareness regarding problems facing humanity environment as a result of human activities. Forty-seven percent of participants deemed their growth in knowledge to be due to having gained the awareness of sources of renewable energy and how they can help their community conditions. Seventeen percent of the participants claimed having learned different ways of disposing waste and recycling and another 17% asserted they realized greenhouse gases released into the atmosphere as a result of burning fossil fuels to be the cause of global warming. John, an African American participant admits, “Now that I know how hurtful fossil fuels, not recycling, and treating planet Earth like our trash can, I’m more determined to help my community and beyond.” Twelve percent
stated they learned things they never knew existed while a few made connections to current events or messages to fictional books they read. Statements such as, “Made connection to a partly fictional book I read about post global warming Earth. I now know much more and understand book’s purpose and message” and “I didn’t know microalgae can be used to make a lot of biofuels”, both attest validly, to the emergence of the two themes.

One individual claimed no increase in knowledge. Table 11 summarized the themes developed from responses to question #4.

Table 11

<table>
<thead>
<tr>
<th>Increase of Knowledge Regarding Environmental Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question # 4: Would you say your knowledge of environmental issues that are affecting us, locally and globally, has increased or decreased?</td>
</tr>
<tr>
<td>Themes</td>
</tr>
<tr>
<td>Sources of Renewable Energy and Their Application</td>
</tr>
<tr>
<td>Waste Management</td>
</tr>
<tr>
<td>Fossil Fuels as Cause of Global Warming</td>
</tr>
<tr>
<td>Learning New Things They Never Knew it Existed</td>
</tr>
<tr>
<td>Made Connection</td>
</tr>
</tbody>
</table>

Feeling Empowered to Make a Difference

Aside from the three negative responses to the question, “Would you say that there are things you could do now, and in the future, to help solve problems that are facing our environment?” 55 of the participants believed they are empowered to take
steps to help the environment and the community they live in. Of the three who responded with a negative answer, one was a Latina female who exclaimed: "I actually don't think I can do anything because I'm just a young lady", and two were males. The range of affirmative responses varied. The majority of students felt they could make small changes by making the right choices and taking the correct actions. Statements such as "If we don’t do anything now everything is going to stay the same," "I now know how I can change the world around me and make it better" and "By making changes to our everyday lives" are indications that students feel empowered to take small steps by modifying behaviors now. Those actions include recycling, composting, minimizing use of fossil fuels, saving power and water, reusing plastics. Many specified implementing renewable sources of energy in the future, and others stated that they could begin by talking and educating others (Table 12).

Table 12

<table>
<thead>
<tr>
<th>Feeling Empowered to Make a Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question #5: Would you say that there are things you could do now, and in the future, to help solve problem that are facing our environment?</td>
</tr>
<tr>
<td>Themes</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>Start Now by Doing Now</td>
</tr>
<tr>
<td>Use of Technology in the Future</td>
</tr>
<tr>
<td>Talking and Educating Others</td>
</tr>
<tr>
<td>Not Empowered</td>
</tr>
</tbody>
</table>
Summary

The findings of this study demonstrated exposure to problem based learning strategies had a significant effect on students. Responses on quantitative portion of the survey displayed significant changes between the pre and the post sessions. The differences demonstrated that exposure to PBL strategies affected students’ perception towards: the nature of science and how it relates to everyday life; how human activities has led to increase in greenhouse gases in the atmosphere and methods to reduce that effect; and whether the students felt empowered to take steps to make a difference in improving community conditions.

While the data of the entire population indicated significant changes in those categories, when analyzed separately, girls did not show significant changes in regarding their growth in interest in scientific studies, but the girls scores did improve when in feeling empowered to make a difference. Yet, boys did not show significant changes in their willingness to partake an active role in making their community a better place. Each of the five questions from the open-ended questions was analyzed based on emerging themes, and subsequently, each occurrence was tallies and percentages were calculated. Responses from the five open-ended questions supported the quantitative data, which were indicative of student’s advancement in their interest, awareness and empowerment in regards to science and environmental issues.
Chapter 5
DISCUSSION, CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

Introduction

The purpose of the study was to examine the effect of problem based learning strategies in increasing interest and understanding regarding science, awareness and overall empowerment of the students regarding environmental issues influencing human kind. The problem based learning (PBL) strategies were implemented to improve students’ independent and critical thinking and problem solving skills, while working together to solve a real world problem (Michel, Bischoff, & Jakobs, 2002; Mossuto, 2009). Although PBL strategies have been utilized in higher education since 1960s, they are rarely employed at secondary level, especially at middle schools (Barrows, 1996). Science education at the secondary level has followed a traditional path with lecture based learning and prescribed recipe book for laboratory exercises (Selcuk, 2010). As a consequence very little attention has been paid to the application of science in students’ daily lives.

The study’s findings do support the assertion that the students in this study enjoyed and benefited from problem-based learning. As previously found by other researchers, the students in this study emerged as active learners (Torp & Sage, 2002) and were more motivated to learn during the various stages of the PBL process. Dods (1996) asserted that students who initially engage in a “problem-based frame of mind” connect pieces of information meaningfully, which “enables access and recall” (p. 227), while Delisle (1997) pointed out that PBL promotes independent, self-directed
learning because, “it requires students to make choices about how and what they will learn” (p. 11). Indeed, the sense of ownership and control of their learning that the students in this study felt was one of the most noteworthy outcomes of this study. Students particularly enjoyed the autonomy that PBL afforded them, particularly when designing their own projects. These results support other researchers’ claims that allowing students to investigate and analyze their results gives them ownership over the science needed to establish a resolution for the problem (Thomas & Chan, 2002).

Discussion

Quantitative

Interest in science and understanding of its relatedness to everyday life.

The two statements designed to gauge students’ increase in interest in science and how it relates to their everyday lives, yielded significant changes in the post survey session. The statement “I look forward to science class” showed a significant change when sample paired test was analyzed for the entire population. When the paired test was performed by gender, only males indicated a positive change in their responses, whereas the females’ responses did not result in a significant value. This difference in the significant value between the two groups, leads to the conclusion that the positive change in the entire population was mainly due to the fact that boys became more interested in the nature of science. In response to the statement “Science relates to my life” the significant change was noticed in the entire population, as well as in both males and females, separately.
The PBL strategies in this study, themselves, served as stimuli to attract students' attention and provide continuous motivation. The authentic nature of the problems allowed students remain interested, since the solution and their application had direct or indirect influence on the state of their immediate environment. As Bridges (1992) indicates, the context in which information is learned serves as stimulus to raise interest, because the information resembles the context in which it is applied. Statements such as "I did not know how much science can help improve community conditions," and "looking for solutions of a real problem is fun" are indicative that students not only gained interest in nature of science but also have a firm understanding of how science relates to everyday life.

**Awareness regarding environmental issues.** The result of the study points toward increased awareness regarding how human activities have led to increased environmental problems. The positive significant changes in all three statement designed to measure students' increased awareness were higher than other two questions in the study. The increases in the means for this category were the highest compared to other groups. These upturns are imply that the exposure to PBL strategies had the greatest impact in conveying awareness and wakefulness toward environmental issues, renewable sources of energy, and current sources of energy in city of Sacramento. Most noteworthy of the finding of the data showed the highest increase between the pre/post surveys in the two statements: "I am well aware of sources of renewable energy," and "I am well aware of sources of energy in Sacramento," with 0.9 and 1.1 mean increases.
The findings demonstrated that students gained more cognizant regarding issues such as global warming that are facing our planet, while being exposed to PBL strategies. Many expressed having learned about the existence of technologies that never knew it existed. Others realized some of their own ideas are already being applied in various green technologies. Science transpires into search for answers to solve a problem that relates not only to them, but also to all human kind. What applies to their local settings, also applies to all children like them around the world. Having discovered that most of Sacramento's energy is supplied through natural gas, a form of fossil fuel, encouraged students to be more determined to find alternative sources for their homes. As mentioned, here the problem was used as a stimulus, and once the problem was isolated, then the application of problem solving and critical reasoning was applied (Barrows & Tamblyn, 1980). In addition, the co-planning, co-designing, and refining the final product, which are attributes of PBL strategies provided a student-centered atmosphere where participants were allowed to collaborate and learn from each other (Gürses et al., 2007).

Feeling empowered to make a difference. The study also aimed to examine the affect of PBL strategies in willingness of students to be active participants in improving their surrounding community. The quantitative data of all participants revealed positive significant changes between pre and post surveys. The sample paired test for males, however, disclosed that boys are more reluctant to see themselves as instruments of change as their significant value yielded a value higher than 0.05. Question #5 in the open-ended questionnaire yielded all but three positive
responses, representative of the students' empowered feeling and willingness to take steps towards improving environmental conditions. Of the three individual who gave negative responses of whether they felt empowered enough to be a part of change, one female student indicated “No, because I’m just a young lady” and the other two negative answers belonged to boys who claimed either that their “actions would not matter” or they agreed that there are many viable ideas but in reality they are “not ready to make it happen.” The rest of the students listed various ways they could contribute to cultivating and improving their immediate surroundings. Most striking and most powerful were those who were inspired enough to educate others by starting conversations to talk and reason about what should and should not be done to reverse the effects of global warming.

When concepts in science lose their isolation from being abstract concepts and become tools of application for improving conditions, learners can feel empowered to at least want to make a difference. Antonia Darder et al. (2009) exclaim that in utilizing critical pedagogy, examining societal factors such as race, gender, and class can bring more awareness, hence, more empowerment in youth, especially, within the culturally marginalized and economically disenfranchised groups (Darder et al., 2009)

Gender Analysis

The students were asked to consider the current laws in affect regarding distribution of energy and its cost, and to deliberate new laws and policies that are equitable and cost effective for all citizens. In that respect, the students were employing critical pedagogy into their curriculum, where the social dimensions in
which students operate, asks how they might be altered, and considers how such alterations can be sustained (Dalke & Franklin, 2003). Female students in this study felt more empowered to make a difference in community than did the boys. As indicated in chapter 2, female students find success when they find value and connectedness in what they are learning (Belencky et al., 1997). The result of this study coincides with other research findings, since not only they were interested in learning, but also, they were invested to take steps to change the status quo. Females thrive when they are involved in cooperative work rather than individual, competitive work (AAUW, 1999). Problem based learning strategies provided this opportunity for females, where solutions were proposed through non-competitive, collaborative work, and hence, they felt more empowered to be involved in a change for the better.

Critical pedagogy works to enhance and promote awareness and bring connections to issues that affect their circumstances. Students were allowed to bridge the technical knowledge to practical ones, where the latter attempts to describe the actions of daily world to analyzing social issues (Dalke & Franklin, 2003). Another aim of this study was to help students question and challenge the domination and the beliefs and practices that support the proposed domination. It is the researcher’s conclusion, that more time was needed to carve in deeper regarding the biases and social injustices that continue to dehumanize scientific inquiry and fields.

Qualitative Discussion

The introduction of “The Sacramento Green Project” brought about a buzz, a different sensation, and an excitement to the class that was never felt all throughout
the year. With teacher as the facilitator, groups met on daily basis to brainstorm their ideas and to collaborate with each other in order to share what was accomplished and to determine the next plan of action (Appendix D). Once a week, for the duration of the unit, members from different groups who carried the same role met to talk and share their findings. These collaborative groups turned out to be the most fruitful and productive meetings since each member had discovered new information from their peers to bring back to their own team. As a female African American student stated: "The most enjoyable parts were when we sat down and talked about whatever we were learning." Forty-one percent of participants declared they liked the problem based learning strategies because it involved very little teacher intervention and most of all they enjoyed working independently and collaboratively, with peers to find solutions to the common problem. This result coincides with other research findings that reiterates elaboration via discussing the subject matter with other students, teaching peers what they first leaned themselves, exchanging views about how the information applies to the problem they are seeking to solve, and preparing essays about what they have learned while seeking to solve the problem; are all key ingredients of problem based learning strategies (Bridges, 1992).

**What Students Liked and Did Not Like about PBL**

The qualitative result of this study conveyed that 53% of participants enjoyed researching for solutions to a realistic problem. The point has to be made again, that if the problem or the challenge presented to the students is authentic and can be related to everyday life, then motivation, enthusiasm, and engagement become an automatic
side-effect in the process. Forty-one percent of participant liked being independent from the teacher and enjoyed collaborating with peers. The remaining 6% enjoyed designing the power point presentations. The findings support research in PBL strategists and constructivists. John Dewey (1916) implied in his writing that knowledge is earned through concrete experiences the nature of those experiences can be fully grasped by a combination of active learning (Dewey, 1916). The finding in this study further support the fact that students like PBL strategies because it grants them the freedom to take control of own education. Teacher gave up control and in return students became engaged active learners. As one female African American student stated “My favorite part was when we all got together to share information about what we learned”

When presented with the question what did they NOT enjoy about the implementation of problem based learning, no one students answered, lack of teacher involvement; which in turn is an indication that students prefer to work independently with other peers and to only use teacher for guidance and assistance. Other emerged themes that participant did not like included presentation at 54%, research at 21%, group work at 8%, and lacking hands-on activities at 7%. Thirteen percent of students indicated they enjoyed all aspects of the unit. Research has shown the students enjoy using PBL strategies and the result of this study indicates, and become more active in own learning (Antepohl and Herzig, 1999). As with other studies (Kumar & Natarajan, 2007), PBL also facilitated the development of student interpersonal skills. Group collaboration could help promote creative problem solving and higher order
thinking skills as well as develop an appreciation of individual differences and teamwork.

**Interest in Science and Understanding of its Relatedness to Everyday Life**

As the responses in the open-ended question: “Would you say your interest in science has increased or decreased during the last unit? Please explain” indicated, the vast majority of students noted an increase of interest regarding science and its usefulness for the betterment of the community. Many attributed their increased interest to the fact that the unit created a sense of excitement and purpose to the class. Once the project guidelines were set, the students seemed engaged and involved in carrying their roles to achieve their goals. This engagement became especially apparent when students, during their research, realized that some of their own ideas they had brainstormed during team meetings, were already being implemented and applied in environmental sciences. For example, as a solution to overflowing landfills, a few groups in this study proposed burning the garbage to produce heat and electricity, an idea that is viably being used in Europe with considerable reduction in waste production and carbon footprint. In fact, 27% of the respondent who expressed increase of interest in scientific studies claimed they were challenged and genuinely engaged in the topic of the unit, to such extent that some did research on their own; attesting to the fact that engagement arises when problem is genuine and relevant. In turn, when students become engaged they gain deeper understanding. In PBL strategies, the problem itself acts as the stimulus to motivate students, which has been a hook to grasp students’ interests (Norman & Schmidt, 2000). Real world,
challenging, and useful problems could lead to higher levels of comprehension and a more durable and profound learning, which in turn can increase the possibility of transferring theory into work (Albanese & Mitchell, 1993)

**Awareness Regarding Environmental Issues**

The positive responses to the open-ended question: “Would you say your knowledge of environmental issues that are affecting us has increased or decreased? Please explain”, reaffirmed the significance in the quantitative data in which all participants asserted an increase in their knowledge and awareness regarding environmental issues at play. Realizing human activities to be the main cause of global warming seemed to have had an awakening impact on many of participants. As one female Latina emotionally stated: “We need to stop hurting our environment and start fixing the problems” attest to students’ understanding as well as their frustration of the fact that humans activities are the cause of dilemma the environment is faced with today. Students were moved and sometimes amazed in their findings of the abundance of new innovations in producing green energy. A statement such as: “I can’t believe that microalgae can be used to produce so much energy”, quoted by a male Latino verifies that the student has clearly gained an authentic knowledge that was constructed and hopefully, will be reconstructed in the future. Participants’ responses to the above question also included investigating innovations that lead to more efficient ways of disposing and recycling trash while a few involved making connections to fictional books and current events. For example the recent oil spills and their consequences to wild life were mentioned by three individuals’ responses to
this question. The overall reactions of students were indicative of an escalation in their mindfulness in regards to those concerns. In this study the teacher facilitated the process by guiding students through the various steps of PBL: connecting students with the problem, setting up the structure, visiting the problem, revisiting the problem, producing a product or performance, and evaluating the performance (Delisle, 1997).

**Feeling Empowered to Make a Difference**

The question: “Would you say that there are things you could do now, and in the future, to help solve problems that are facing our environment? Please explain”, yielded all but three positive responses. Those who denoted negative responses were most likely overwhelmed by the mount of innovations they discovered during their research and felt powerless to implement such high technology to today’s society. As one Asian female admitted: “I actually don’t think I can do anything. I’m just a young lady.” Most others came to realization that making a difference begins with one person at a time. Many students were able to distinguish between what they could do individually now, and what they could do with the technology in the future in order to make their community a better place. Statements such as: “Reduce water usage”, and “When I get older I am going to be an environmental scientist” corroborate the participants felt empowered that they can be instruments of change in improving community conditions. When real-world problems are inserted into classroom context, learning takes the shape of applicable knowledge that is transferrable and relevant (Gallagher, Stepien, & Rosenthal, 1992).
Gender Inclusion in Classroom

Even though gender and race were not under the scope of this study, results point toward interesting outcomes that maybe worth a short discussion. As mentioned in the quantitative results in chapter 4, female participants felt more empowered to take active roles in improving community conditions. Research indicates that females are more successful when females are taught in format that are best suited for females (Belenky et al., 1997). During the study, all groups were working together, independent of the teacher, deciding on their own the direction of their research and solutions to their problems. In essence, participants, were given autonomy and control for their own education. In addition, research suggests that females learn best when they are given opportunities to engage with the topic (AAUW, 1999). Engaging with the topic in this study was to tackle authentic, real-world problems that affect students' quality of life. Result of this study shows that females were tuned in and were empowered by the nature of the problem, which through PBL strategies, seemed tangible to solve. The significant value for the positive change in females feeling empowered to make a difference supports what research indicates that if female students are motivated and challenged regarding real issues, they may exhibit more sensitivity and resolve.

Notable Finding

The researcher did not intend to study PBL and its relationship with race, however, noteworthy to consider is how African American students perceived science after the application of PBL strategies into the study. African American students
expressed their interest in science had increase because they realized how science can contribute to the improvement of their community. Statements such as “Makes me want to learn more about how we can help our community”, “Because I get to learn how science really impacts our lives”, and “it helped me to know how I can change the world around me.” point to those participant’s increased understanding of the nature of science and how it can serve people. According to Murrell (2002), African American students enjoy their reliance on self-identity, culture, and community, and if these aspects are present in a classroom, African American students are bound to succeed.

Conclusions

Science is about asking questions and solving problems. This process though is not one that is easily learned or put into practice. The idea of problem based learning allows for students to learn the needed techniques to critique and solve problems faced in science. Additionally, it allows students to work in a non-threatening environment that also promotes free thought. Being able to critically address a problem is a great benefit to any student. The application of PBL by the student and the teacher is different depending on the role (Wang et al., 2014) Teachers are facilitators by presenting problems, working to foster a culture of scientific thought as well as recognizing and remove hegemonic barriers (Darder et al., 2009). Students on the other hand work to find the solutions to a task as an individual while working within a community to critically examining a problem.

With critical pedagogy as the tool, that seeks out to critique and analyze current issues facing individuals a strong problem based learning program can be built.
Teachers should embrace the cultural strengths of students, teach them to question the curriculum (and science), and foster the development of a culture of inquiry. The synthesis of these two separate ideas by the author (PBL and Critical Pedagogy) creates a media where learners can feel free to take active part in own education as well as, in building a just and green community.

**Limitations**

The findings of this study are limited by the small number of participants from one very specific area in Sacramento. The small sample size prohibits the generalization of the results to a larger and more diverse population. Familiarity with, and wanting to please the teacher may have also had skewed the result in anticipatory fashion. The short duration of implementation of the problem-based learning strategies could not measure the full effectiveness of environmental issues and how they relate to social injustices and biases that makes science obsolete and inaccessible to many. In addition, problem-based learning strategies require educators to step out of traditional style of teaching where control of the classroom is rendered and students take center stage and teacher takes on the role of a facilitator. Furthermore to obtain more substantial result in measuring PBL's effectiveness in short-term and long-term recall, comprehension, and application, a comparative study between PBL and traditional strategies should follow.

**Recommendations**

A longitudinal study that follows the students through their high school and college courses is needed to better measure any effects of problem-based learning on
students’ long term career interest. Future studies should designate ample time for
students to observe and analyze the biases and injustices that are at play that are
affecting how science is perceived and pursuit. It is the researcher’s suggestion that
pursuing studies would entail the integration of narratives where students, with
structured guidance of teacher, are allowed to collaborate and choose what aspect of
science they would prefer to apply to their daily lives, and through that window tap
into the critical consciousness of students. Another consideration that should be made
for future investigations would be to include a comparative study between PBL
strategies and a lecture based teaching, as the control group, to analyze levels of
comprehension, as well as application of the concept.

Final Reflection

This study provided an exciting opportunity along with hopeful results.
Discovering the positive effects of using problem based learning strategies has
provided additional incentive to take on further research in application and relatedness
of science and how students respond to these strategies. As seen in the literature
review problem based learning has the potential to affect many aspects of a students’
experience in learning and application of science. These aspects ranged from
connection to personal experience, awareness of environmental problem and possible
solutions to those problems, and feeling empowered to make a difference. Problem
based learning is yet to be fully explored and implemented in secondary education.
Many ingenious and original ideas surfaced from students’ collaboration, which were
presented in the power point format, but not all could be included in this paper.
Hopefully, problem based learning strategies will eventually, become more of common practice within secondary science classes, but before that happens, teachers need to be trained and educated regarding best practices to implement PBL strategies.
APPENDIX A

Informed Consent Letter
Dear Parents and Student,

My name is Farzad Safavi and I am your child’s physical science teacher. I am currently completing a thesis study for my Master’s Degree at California State University Sacramento. This study will be examining student attitudes regarding their interest in science and their awareness about environmental issues facing us on the local and global levels. This study will be guided through mini lessons regarding environment and healthy living where students will collaborate to solve common and applicable problems. Through students’ own narratives, during class meetings, I aim to raise awareness regarding social/environmental issues and to empower them in seeing themselves capable of making a change. I will also be conducting a survey in your/your child’s physical science class before and after the mini-lessons as a measure for comparison. The mini lessons and the surveys do not present any risk to students. In addition, this study will compare the effectiveness of two methods of philosophies in teaching: Problem-Based Learning, and Inquiry-Based Learning, where the latter is almost equivalent to traditional methods of teaching. A pre and post examination in the subject matter will be administered for this purpose in all classes under study. All information gathered will remain strictly confidential in order to ensure your child’s privacy.

If you choose not to have your child participate please mark the box located at the bottom of the letter, sign and have your child return to their Physical Science instructor. Thank you for your time. Your participation will benefit all involved since there is an absence of students’ voices in academia, especially in the secondary level, as I firmly believe that science education needs to be connected to ways of ordinary life. If you have any questions please contact me at: (farzad-safavi@scusd.edu 916-433-5000).

Sincerely,

Farzad Safavi

☐ I grant permission to my child ________________________________ to participate in this study

☐ I would prefer that my child ________________________________ not participate.

Parent Signature ________________________________

(If it is only necessary to return this letter if you do not want your child to participate.)

NOTE: If this permission slip is not returned within a week, it is assumed that a permission is granted by the parents for the students to participate in this study.
Consentimiento Informado carta

Queridos padres y estudiantes, Fecha:

Mi nombre es Farzad Safavi y yo soy tu hijo del profesor de ciencias físicas. Actualmente estoy realizando una tesis estudio de mi grado de Maestría en la Universidad del Estado de California Sacramento. Este estudio se examinan las actitudes de los estudiantes respecto de su interés en la ciencia y la conciencia acerca de los problemas ambientales que enfrentamos en los planos local y mundial. Este estudio serán guiados a través de las mini lecciones sobre el medio ambiente y la vida sana en la que los estudiantes colaborarán para resolver problemas comunes y aplicables. Gracias a los estudiantes las propias narrativas, durante las reuniones de la clase, mi objetivo es crear conciencia sobre temas sociales y ambientales y que las capaciten para ver que son capaces de hacer un cambio.YO también llevara a cabo una encuesta en tu/su hijo clase de ciencia física antes y después de la mini-lecciones como una medida de comparación. El mini lecciones y las encuestas no presente ningún riesgo para los estudiantes. Además, este estudio comparar la eficacia de dos métodos de las filosofías de la enseñanza: didácticos basados y Inquiry-Based Learning, donde este último es casi equivalente a los métodos tradicionales de enseñanza. Un pre y post examen en la materia serán administrados para este fin en todas las clases de estudio. Toda la información obtenida será estrictamente anónima con el fin de garantizar la privacidad de su hijo.

Si elige no hacer que su niño participar por favor, marque la casilla situada en la parte inferior de la carta, firmar y que su hijo regrese a su Ciencia Fisica instructor. Gracias por su tiempo. Su participación se beneficiarán todos los participantes dado que hay una falta de voces de los estudiantes de la academia, especialmente en el nivel secundario, que creo firmemente que la educación científica debe ser conectado a la manera de la vida ordinaria. Si tiene alguna pregunta, póngase en contacto conmigo en: (farzad-safavi@scusd.edu 916-433 -5000).

Sinceramente, Farzad Safavi

☐ Concedo permiso a mi niño ___________________________ participar en este estudio.

☐ Yo preferiría que mi hijo ___________________________ no participar.

Firma Principal ___________________________
Cov tsab ntawv tso cai

Nyob zoo txog niam txiv thiab cov me nyuam kawm ntawv, hnub tim:

Kuv npe hu ua Farzad Safavi thiab kuv yog koj tus me nyuam tus xib fwb physical science. Kuv tabtom tam sim no sau ntawv ib thesis tshawb rau kuv tswv 's Degree nyob California State University Sacramento. Txoj kev tshawb no yuav tsum coj cov miv miv txog cov paj laum rau science thiab lawv khaiv los txog tej teeb meem txog txojkev peb nyob rau naa tuu lub los thiab ntiaj teb no. Txoj kev tshawb no yuav tuu ua los ntawm mini tshooj lus hais txog cov ib puag ncig thiab kev noj qab haub huv nyob qhov twg menyuam kawm ntawv yuav ua haujlwm ua ke mus daws tau cov teeb meem tshwm sim thiab muaj feem xyuam. Los ntawm cov zajlus kawm ntawm tus kheej, thau lub caij kawm ntawv sib tham, kuv tsom mus tsia khiaiv txog kev/tej teeb meem thiab kom lawv nyob mus ntsib lawv tus kheej muaj peev uas ua tau ib qhov kev hloov. Kuv yuav kuj tau tsim ib daim ntawv ntsuam xyuas nyob rau hauv hoob kawm physical science koj/koj tus me nyuam ua ntj thiab tom qab cov mini-tshooj ua ib qho kev ntsuas rau kev sib piv. Cov tshooj lus mini thiab tus kuaj tsis pov meem rau cov me nyuam kawm ntawv. Tsis tas li, txoj kev tshawb no yuav sib piv txoj kev philosophies rau kev qhia ntawv ob txoj hauv lwm zoor: qhov teeb meem raws li kev kawm thiab kev nug raws li kev kawm, tus tom kawg nyob qhov twg yuav nsw yuav Hmoob txoj kev qhia ntawv. Ib tug uantej thiab ncej kev xeem nyob rau hauv tus txheej txheem nwg yuav xeem rau cov ntsib tus no nyob rau hauv hoob nyob rau hauv txoj kev tshawb no. Tag nrho cov ntaub ntawv sau yuav nyob confidential nruj me ntsis thiaj li yuav tswj tau koj tus kheej.

Yog tias koj xaiv rau koj tus menyuam mus koom tsis thov kos lub thawv nyob rau nram qab ntawm tsab ntawv, kos npe thiab coj koj tus me nyuam rov qab mus rau lawv cov txij Physical Science. Ua tsaug rau koj lub sij hawm. Koj kev koom tes yuav tau tag nrho cov koom tes vim yog ib nyuas sab cov suab nyob academia, tshwj xeem tshaj yog nyob rau hauv cov qib them nraeb, tsis li kuv nrees ntseeg hais tias cov kev kawm science yuav tsum txuas nrog rau txoj kev ua neej zoo tib yam. Yog hais tias koj muaj lus nug thov hu rau kuv ntawm: (farzad-safavi@scusd.edu 916-433-5000).

Ua tsaug,

Farzad Safavi

☐ Kuv tabtom granting tso cai rau kuv tus me nyuam ________________ to cov koom tes rau txoj kev tshawb no.

☐ Kuv yuav xav tias kuv tus me nyuam ________________ tsis koom tes.

Leej niam/txiv kos npe _________________________________________________________________________________________
APPENDIX B

Student Assent Form
Dear students,

As you may know already, I am in the process of obtaining my masters degree from Sacramento State University, Department of Education. My research study focuses on how I, as your teacher, and maybe other educators in the future, can teach a different type of science that would be more related to your daily life. So you, in essence, are the subjects of my study. Before the unit of study begins, you will fill out a general survey where you will be ranking the strength of your responses on the scale of 1-5. You will use your students ID numbers to protect your privacy. Your name will not be used, in any shape or form. You will take the survey once more, at the end of unit, which will take approximately a month to complete. Although you are required to learn the materials presented to you, choosing, or not choosing to participate in my study will not affect your grade in this class.

Yours Truly

Mr. Safavi

☐ By checking the box, I, agree to participate in this research study.

☐ By checking this box, I, choose NOT to participate in this research study.
APPENDIX C

Pre/Post Survey
Pre/Post Survey

Period ________  Last 4 digits of Student ID ________

Circle One

African American  Asian  Native American  Male  Female

Caucasian (white)  Latino  Decline to state  other:

Please use the following scale to indicate whether or not you agree, or disagree with the following statements. Circle the appropriate number.

<table>
<thead>
<tr>
<th>(strongly disagree)</th>
<th>(disagree)</th>
<th>(Neutral)</th>
<th>(agree)</th>
<th>(strongly agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

I look forward to science class

| 1       | 2       | 3   | 4    | 5    |

I am well aware of sources of renewable energy

| 1       | 2       | 3   | 4    | 5    |

I find science challenging

| 1       | 2       | 3   | 4    | 5    |

I focus and pay attention in science class

| 1       | 2       | 3   | 4    | 5    |

I know where the energy in Sacramento comes from

| 1       | 2       | 3   | 4    | 5    |

Science relates to my life

| 1       | 2       | 3   | 4    | 5    |
I am interested in making my community a better place
1 2 3 4 5

I learn more in solving problems that interest me
1 2 3 4 5

I learn more when I try to solve problems in a group setting
1 2 3 4 5

I learn science best by doing science
1 2 3 4 5

I am aware of problems that are influencing my environment
1 2 3 4 5

I do not believe environmental issues such as climate change have an affect on me
1 2 3 4 5

I believe that I can make a positive impact on my environment
1 2 3 4 5

Science can contribute to improving my community conditions
1 2 3 4 5

I prefer lecture classes
1 2 3 4 5

I think science is fun
1 2 3 4 5
I am likely to do my assignments when I am more interested in the lesson

| 1 | 2 | 3 | 4 | 5 |

Science has nothing to do with my life

| 1 | 2 | 3 | 4 | 5 |

I do my best when I can relate to something in the lesson

| 1 | 2 | 3 | 4 | 5 |

I don’t see myself as a science major

| 1 | 2 | 3 | 4 | 5 |

**Please check all that apply.**

I have considered majoring in:

- Mathematics
- Science
- Engineering
- Computer Science

OTHER: ________________________________

I have considered pursuing a career in:

- Mathematics
- Computer Science
- Science
- Engineering

Mother’s Highest Level of Education: (check one)

- [ ] some High School
- [ ] High School Diploma
- [ ] some college
- [ ] college degree
- [ ] some graduate school
- [ ] Master’s degree
- [ ] Ph. D
- [ ] don’t know
Father's Highest Level of Education: (check one)

- some High School
- High School Diploma
- some college
- college degree
- some graduate school
- Master's degree
- Ph. D
- don't know
APPENDIX F

Post-Study Questionnaire
Post-Study Questionnaire

Please answer the following questions to the best of your ability. (This portion of the survey will be administered in post assessment).

1. What did you enjoy most about the way you learned in this unit?

2. What did you enjoy least about this unit?

3. Would you say that your interest in science has increased or decreased during the last unit? Please explain.

4. Would you say your knowledge of environmental issues that are affecting us, locally and globally, has increased or decreased? Please explain by giving examples.

Would you say that there are things you could do now, and in the future, to help solve problems that are facing our environment? Please explain
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