ENVIRONMENTAL EDUCATION LINKING ACADEMIC NEEDS WITH RESOURCE MANAGEMENT GOALS

A Thesis

Presented

To the Faculty of

California State University, Chico

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Interdisciplinary Studies:

Science Teaching

---

by

Fall 2012

ENVIRONMENTAL EDUCATION LINKING ACADEMIC

NEEDS WITH RESOURCE MANAGEMENT GOALS

A Thesis

by

Timmarie Hamill

Fall 2012

APPROVED BY THE DEAN OF GRADUATE STUDIES
AND VICE PROVOST FOR RESEARCH:

Eun K. Park, Ed.D.

APPROVED BY THE GRADUATE ADVISORY COMMITTEE:

Leslie Atkins, Ph.D.
Graduate Coordinator

Randy Senock, Ph.D., Chair

Julie Monet, Ed.D.

PUBLICATION RIGHTS

DEDICATION

To my children, Heather and Suzanne, for your patience,

while "your mom goes to school."

To Joe and Will , whose love and encouragement

helped me complete this thesis.

To my grandmother and parents, to whom I attribute my respect and love of nature. They made an effort to take my brother and me (and our friends) on outdoor adventures most weekends. We'd pack a picnic lunch, pile into the old funky car, and drive to Stinson Beach, Mt. Diablo, Golden Gate Park, or maybe an old cemetery or mission. They let us climb the tall deodar cedars in our yard to the tippy tops to sway in the wind overlooking the town, stay up late playing hide-and seek learning not to be afraid of spiders whose webs stretched across our faces, and slid down the giant hill behind my grandmother's house on cardboard, sliding so fast then bailing off before flying into the creek at the bottom. Our lives revolved around being outdoors. Thanksgiving dinners were set up in the yard, and birthdays were always in a park. Thanks!

ACKNOWLEDGMENTS

I would like to express my sincere gratitude to my graduate chairperson, advisor, and coordinator Dr. Randy Senock and Dr. Julie Monet, and Dr. Leslie Atkins. Thank you for your time, encouragement and continued support. In addition, I'd like to express my thanks to Dr. Nancy Carter and Dr. Neil Schwertman for their guidance and support selecting appropriate statistics for analysis of results.

TABLE OF CONTENTS

CHAPTER PAGE

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

ENVIRONMENTAL EDUCATION LINKING ACADEMIC

NEEDS WITH RESOURCE MANAGEMENT GOALS

by

© Timmarie Hamill 2012

Master of Arts in

Interdisciplinary Studies: Science Teaching

California State University, Chico

Fall 2012

This thesis focused on providing information regarding the efficacy of a storm water curriculum unit to increase student knowledge about the causes of storm water pollution and to inform students about effective stewardship practices. Integrating place-based, hands-on learning strategies based on the social constructivist theory, the thesis promoted collaboration between community groups and schools to provide essential, place-based learning for students, which is currently underutilized in Chico schools. In an effort to bridge this gap, the educational unit evaluated provided a starting point from which to build more effective collaboration between community educators and teachers. Instruction centered on providing opportunities for students to interact within their own community, learning about issues impacting their local creek. Building strong bonds with natural places within one's community is an important prerequisite to students taking an active role in protecting those areas. Pre- and post-surveys quantitatively measured the change in student understanding resulting from the curriculum by comparing student responses before and after instruction. Analysis included both descriptive and inferential statistics to analyze survey question responses and identify any patterns or distinct relationships concerning the strengths and weaknesses of lesson components. Although survey results were not uniform across all questions, the data do not indicate the curriculum had a significant effect on improving student knowledge of storm water runoff pollution and effective stewardship practices. A small population of 46 students was sampled; the validity of the results could have been improved by enlarging the sample size.

CHAPTER I

INTRODUCTION

Background

The Environmental Protection Agency (EPA) has identified non-point source pollution as one of our nation's largest remaining water quality problems. Non-point source pollution is not caused by discharges from big factories or from sewage treatment plants, but is generated by all of us as a result of the choices we make in our everyday lives (EPA, 2003). Urban storm water runoff associated with over fertilizing lawns, letting oil drip from our cars, littering, paving parking lots, and reducing pervious surfaces are human practices causing cumulative impacts to water quality in most urban waterways. Education in schools that encourages students to become more aware of the effects their actions have on water quality, while also developing water-wise habits and making informed choices, are important to ensure clean water is available in the future.

Unfortunately, public education and curriculum have become more concerned with outcomes on state tests, minimizing opportunities for students to interact with their environment and learn to protect it (Louv, 2009). Without this interaction, students are less likely to fully appreciate the need to change behaviors that cause environmental degradation (Heberlein, 1989). Whether individuals dispose of old paint improperly or fail to remove pet waste while out walking dogs along the creek, contamination of our drinking water is the result. Without the chance to interact directly with the environment and experience first-hand such connections, students are less likely to be concerned or make reasoned choices about how their individual actions can make a difference (Crawley & Koballa, 1992).

Although there is substantial evidence that outdoor education has positive impacts on student learning (Lieberman, 1998; Cleaver, 2007) and attitudes towards caring for the natural environment (Manzanal, Barreiro, & Casal Jimenez, 1999), teachers do not typically involve students in these activities for a variety of reasons. Mainly because they do not have the time or resources to plan and organize the logistics involved, let alone develop curriculum, instructional materials, and activities that make connections between classroom content and resource protection efforts. They do, however, show great interest in participating in local resource protection efforts, such as watershed assessments and habitat enhancement projects, when a community group provides transportation and complimentary curriculum to enrich classroom instruction.

Poshnick-Goodwin (2005) suggests that partnerships between schools and community organizations offering informal education can help bridge this gap by providing direct services for teachers to integrate more place-based outdoor learning environments into their teaching. Community groups serve as informal educators, “using nature as a classroom” (p. 6), often linking activities provided with a local resource management project and sometimes even with classroom content. Promoting collaboration between schools and community groups to align appropriate environmental curriculum would enhance opportunities for students to apply what they are learning in their classrooms to real-life environmental projects that benefit their communities.

Statement of the Problem

Effective environmental education is needed to achieve storm water runoff management goals in the Chico area. Community environmental educators could assist schools by providing project-based service learning linked with local storm water education efforts, but effective curriculum is needed to build sustainable partnerships. In addition, the effectiveness of these efforts has not been evaluated.

Purpose of the Study

The primary purpose of this thesis was to develop and evaluate the effectiveness of a storm water curriculum. A secondary purpose is to encourage partnerships between schools, community groups, and natural resource managers in order to link their respective goals to assist schools in providing place-based learning linked to community environmental issues.

Description of the Study

This study provided storm water curriculum and evaluated its effectiveness. The curriculum provided information regarding the ecological functions of watersheds, storm water runoff, and effective stewardship practices in an effort to inform student actions to prevent storm water pollution and raise awareness of environmental degradation.

Existing partnerships between The Stream Team, a local environmental education non-profit organization, the City of Chico Storm Water Management Program, and a local high school were utilized to facilitate implementation of this project. The

Stream Team provided volunteers to lead the field trip learning stations during classroom and field trip instruction. The City of Chico provided use of their storm water survey tool to assess student knowledge. The participating high school inserted the project curriculum into their Integrated Science course.

The conceptual framework for the curriculum was the social constructivism theory, where reality, knowledge, and learning are constructed in the context of human experiences while engaged in social activities (Kukla, 2000). Social constructivism stresses that knowledge is constructed through personal experiences and interactions in the context of culture and community (Powell & Kalina, 2009). Constructivism is student-centered. Teachers provide experiences to learners, experiences that provide new information for deeper understanding, challenging students to think critically about the world in which they live (J. Brooks & M. Brooks, 1993). Instructional strategies focus on posing problems and providing learning environments in which students can correct misconceptions and develop new mental models based on evidence they've gathered (Powell & Kalina, 2009). In this way, they begin to understand more fully the relationship of environmental degradation and the choices they make.

Literature in the areas of service learning, place-based learning, and social constructivism pedagogy informed both teaching strategies and curriculum content. Specifically, the teacher's guide for the Global Learning and Observations to Benefit the Environment Program (GLOBE, 2002) provided examples of curriculum and strategies for environmental education. *Getting in Step* (EPA, 2003) provided information on causes and related issues associated with storm water pollution. The *Clean Water Team*

Compendium (State Water Resources Control Board, 2009) provided environmental monitoring protocols and parameters used by the state to track water quality in streams. The *Storm Water Quality Handbook* (California Department of Transportation, 2003) was also used to understand management strategies and low impact development practices used to reduce storm water runoff. Teaching strategies and storm water content material, based on the information provided in these guides, were incorporated into the project curriculum.

Curriculum was also intended to be similar to the environmental lessons being implemented in local schools by existing community groups. In order to achieve this goal, curriculum development was informed by interviews with local community group leaders and teachers. Information regarding lesson topics, duration of lessons, activity schedules, perceived gaps or known overlaps of services and availability to participate was gathered through one-on-one conversations.

In addition, I attended a meeting facilitated by the Chico Creek Nature Center at which local environmental educators identified the specific natural resource issues being targeted by their individual education efforts. While seeking partners to provide educational opportunities, my goal was to identify efficient and effective strategies to link efforts and reduce duplication. Based on the information gathered at the Chico Creek Nature Center and one-on-one conversations with community educators, I learned that most groups were providing one, two, or three one-hour instructional units, with or without a field trip component. Topics typically included watershed terminology, local geology, invasive and native plant identification, wildlife and aquatic insect habitats, and stewardship practices such as removing invasive plants, planting natives, picking up trash, and surveying water quality.

Although The Stewardship Council (2009) has noted the limited effectiveness of short duration instruction such as local environmental educators are providing. I adopted their model for my project to provide additional information about the effectiveness of such curriculum. The data collected through this project were intended to provide information regarding the efficacy of short-duration curriculum units and to use the data to determine best practices.

Significance of the Study

Increased interest in providing environmental education, unfortunately, runs parallel to the growing degradation of ecosystems (Manzanal et al., 1999). Thus, integrating effective environmental education, including field-based studies, is critical for reducing negative environmental impacts and achieving resource management goals. Research shows that aligning field science explorations with both classroom instruction and existing local resource protection projects results in contextually relevant instruction, translating into greater success in achieving resource management goals (Glynn & Winter, 2004).

Because Chico offers a unique situation where students can take a short walk to a vast array of habitats well suited for outdoor learning, including salmon-bearing creek systems, vernal pools, wetlands, grasslands and oak woodlands, students are ideally situated to participate in outdoor learning experiences. Outdoor experiences leave lasting impressions by providing opportunities for students to interact in nature, encouraging a sense of enjoyment and respect for the natural world (Weinstein, 2008). Through these interactions students evaluate their own behaviors and observe how those behaviors negatively impact the environment. Currently, few such opportunities are available to high school students.

To mitigate negative attitudes and behaviors, Chico has developed a support system of informal community educators, university experts, college interns, an Ecological Reserve, and a progressive City Parks Department, which can partner in a concerted effort to connect youth to their natural environment. However, such collaboration between community and schools is currently underutilized. This project was an effort to bridge that gap by providing and evaluating one educational unit. In this way, community educators and teachers have a starting point from which to build ever more effective collaborative efforts.

Limitations of the Study

Luehmann (2001) stressed the importance of understanding the needs of the cooperating teacher when developing the curriculum. For this project, however, there was no collaboration on curriculum development. Collaboration occurred only in the area of logistics such as classroom management, scheduling, materials, and permission slips.

In hindsight, incorporating additional introductory demonstrations or a group reading activity of the handouts would have provided necessary background information (Marx, 2008) to form mental models about conductivity and would have avoided students' misunderstandings during the lesson.

Due to the limitation of conducting instruction in another teacher's class, implementing all the teaching strategies suggested from the literature review was not feasible. For example, Manzanal, Barreiro, and Casal Jimenez (1998) recommend diaries and interviews as possible tools for assessing attitudes and knowledge about the environment. These were not possible due to the time constraint imposed by three short lesson periods, and, overall, the reflection component of the lesson was rushed. Bauer (2012) discusses how memory is formed and the importance of time to consolidate memory. More time for meaningful reflection by students would encourage them to explore more fully why storm water runoff is an issue and how their informed actions can make a difference. In addition, if this project were continued, students could develop an action plan to address the issues they observed. The long-term goal was to make a lasting connection to the classroom to provide on-going, student-directed, outdoor education.

Noddings (2005) emphasized the importance of making connections between the project curriculum and other educational disciplines resulting in cross-curricular education. This did not take place.

Nuhfer (2003) notes that survey questions need to be open-ended and based on Bloom's taxonomy to elicit critical thinking. He recommends teachers avoid questions that solicit low-level responses. For this project, an existing survey was used to assess knowledge, and the survey questions did not challenge students to analyze or evaluate. Since the survey had instead been designed to test the effectiveness of the City of Chico's Storm Water Outreach Program, it limited what I could test about students' comprehension of the project curriculum.

I also hoped that interest would be generated in creating inter-organization outreach materials, so educational content could be aligned to promote a consistent community message. These types of community efforts require significant contact and communication with community partners, school site administrators and teachers, as well as local and state resource agencies.

A description of my project was provided to other participants at a meeting held by the Chico Creek Nature Center, including a request for their feedback on project curriculum and a request for them to participate as leaders of field trip learning stations. However, participants did not follow up on this request, which reflects the lack of collaboration between community groups. That said, most groups were operating with limited funding and were thus unable to spend extra time to support collaboration to align curriculum. Most groups indicated a verbal willingness to schedule collaborative events, but there was not any follow-through.

CHAPTER II

REVIEW OF LITERATURE

Background

The No Child Left Behind Act (NCLB) has proved challenging to teachers across the country. Some fear that NCLB is narrowing the curriculum, requiring teachers to “teach to the test.” Its unfunded mandates stretch school budgets, eliminating “extras” such as science field trips. This limits students’ opportunities to interact in their communities to become engaged citizens or practice “real-life” project-based science, using nature as a classroom. The 18% drop-out rate for high schools in Butte County (Lucile Packard Foundation, 2009) points to the fact that too many students find school boring and irrelevant.

The theory of social constructivism provides the basis for teaching strategies used in this project. These strategies follow the belief that learning occurs in the context of the environment through our interactions with others. We learn by doing. Constructivist theory borrows from Piaget’s and Vygotsky’s ideas of assimilation and accommodation. For learning to be meaningful and long-term, students need opportunities to apply their understanding to a real life setting, emulating the work of real scientists. In addition, a common framework is needed for community environmental educators to align their efforts. A systematic collection of data to inform future planning would ensure a stronger collective impact. This project is intended to test a unit of storm water curriculum, providing additional data for this purpose.

Review of Related Literature

Problems Associated with No Child Left Behind

Since its proposal in 2001 (Duschi, Schweingeruber, & Shouse, 2007), the No Child Left Behind Act (NCLB) has pressured schools to reform, a narrow view of reform that is evaluated largely through test scores. As a result, teachers have been increasingly pressured to "teach to the test" and limit educational content to what is most likely to be tested. Students become vessels to fill with information that can be recalled at test time, validating the effectiveness of the teachers and the educational system. This view of education runs counter to that of Spretnak (1997), who argues that our way of thinking is grounded by our interactions with nature and society, and that education processes should integrate personal and community engagement. Spretnak believes that we lose much of our humanity if we lose connections with the earth, and that we are not fully human if we are socialized to be oblivious to nature.

Also arguing for a less narrowly focused educational approach, Posnick-Goodwin (2012) promotes teaching environmentalism so that students are well rounded and sensitive to the world around them and know that they can make the world a better place. She also credits environmental education with improving academic achievement, as well as benefitting students who don't perform well in traditional settings. This is confirmed by the American Institutes for Research (2005),which found that students who were provided with opportunities to learn outdoors raised their science test scores by 27%, and the gains were extended to reading and math scores as well.

Noddings (2005) expresses concerns that the pressures to improve test scores put on schools by NCLB have failed to address the purpose of public education in encouraging a democratic society. He asserts that the focus on testing narrows the breadth of the curriculum being taught and limits teaching strategies in ways that promote apathetic, uncaring graduates with little understanding of their role in a democratic society. Because a healthy democracy requires participation, schools need to provide opportunities for students to interact within their community, encouraging consciousness that their actions determine the future for the natural environment. He believes that many facets of our democracy are not addressed when we treat each content area as an individual component and argues that we need to find ways to make connections across content areas and provide opportunities for students to be treated as whole persons with an important role in society. Educating a person goes much deeper than covering content; it should assist in developing and preparing students to be thoughtful citizens who make wise civic choices. Our democratic society demands much more than reading, writing and math skills; it requires graduates who exhibit sound character, have a social conscience, think critically, are willing to make commitments, and are aware of local and global problems.

Acknowledging the challenges for educators in the era of NCLB, McTighe and O'Connor (2004) recognize the battle to teach for meaning as a result of the accountability movement and standards-based teaching. They encourage teachers to teach key ideas and processes in engaging ways and argue that research reveals that students need much more in-depth understanding of concepts than just the memorization of facts about them. Students need to build a conceptual framework that will create meaningful, lasting understanding. Weinstein (2008) agrees and reminds teachers of the need to connect students with why the content being taught is important. For example, if water quality is important, then students must be convinced that their actions will make a difference.

Unfortunately, many teachers struggling with overcrowded classrooms find it increasingly difficult to provide authentic, holistic teaching experiences, in part because, as President George Bush expanded NCLB, the law lacked sufficient funding to carry out its mandates. Posnick-Goodwin (2005) suggested that one solution to the lack of funding may be to encourage schools to build partnerships with foundations and community organizations. With classroom overcrowding and lack of textbooks and supplies, she believes

> it makes sense to use nature as a classroom, which will also encourage the development of a sense of self and place, which is critical to solving environmental problems related to over population. (p. 6)

Cleaver (2007) agrees with Posnick-Goodwin's summary. In response to NCLB, which put environmental education on the backburner, Congress proposed "The No Child Left Inside" Act. Cleaver argues that education is more than tests, and if educators want to raise test scores, they need to get students outdoors, learning. She believes that outdoor learning environments provide a myriad of benefits, including raising test scores by connecting science to students' parks and neighborhoods where they can use science knowledge in real situations such as gathering information about where rain water goes.

Kielsmeir, Scales, Roechlkepartain, and Neal (2004) cites research that shows that students drop out because school is boring and irrelevant to their lives. He promotes education that offers authentic experiences in students' own communities in order to broaden their career awareness and recommends that students take actions on implementing solutions by participating in community projects. However, underfunded school districts find it increasingly difficult to provide rich authentic experiences, especially to students living in poorer communities with the highest drop-out rates.

Theory of Learning/Curriculum Development

Social constructivism is a theory of education that is compatible with Kielsmeir et al.'s (2004) and other researchers' recommendations that students participate in authentic learning activities such as community projects. Kim (2001), in her explanation of social constructivism, posits that reality is constructed through human activity, that individuals create meaning through interactions with the environment and others. Learning is not passive, but an active, social process and meaning and knowledge evolve through negotiation with others, as learners extend their understanding through communication.

J. Brooks and M. Brooks (1993) believe that constructivist classrooms start with an understanding of how students learn and how teachers teach, not with legislated outcomes. The theory is based on the proposition that we learn by constructing new understandings and relationships, and that educators must invite students to do so by asking questions and challenging them to think critically about the world in which they live. The constructivist approach to instruction is student-centered and assists learners to internalize and transform new information; the goal is deep understanding of the content. J. Brooks and M. Brooks highlight the five principles that drive constructivist based instruction: (a) teachers seek and value their students' points of view, (b) classroom activities challenge student suppositions, (c) teachers pose problems of emerging relevance, (d) teachers build lessons around primary concepts and big ideas, and (e) teachers assess student learning in the context of daily teaching. Constructivist instruction is based on the idea that conceptual understanding matters more than test scores.

Powell and Kalina (2009) divide constructivism into two types: cognitive constructivism (Piaget) and social constructivism (Vygotsky). Piaget (2006) stated that learners construct a "schema" through a process of assimilation and accommodation. Assimilation occurs when one brings new information to his or her schema and accommodation occurs when one changes his or her schema to accommodate the new information. Learning is a process of allowing new information to fit into what already exists in one's memory, thus working at a student's own pace is key. Vygotsky (1962) added to Piaget's work, explaining that social interaction was integral to learning. Central to his theory is what he termed the zone of proximal development (ZPD) in which learning occurs. ZDP is described as a discrepancy between a child's actual and potential mental age. Both cognitive and social constructivists value the inquiry method introduced by Socrates and guided forms of teaching.

Bauer (2012) compares forming memory to making gelatin. "The experience is the liquid gelatin: you pour it into a mold. The mold is the hippocampus, and it has to go through a process of refrigeration known as consolidation" (p. D5). Bauer says that two qualities predict whether a child is likely to hold on to a particular memory. If an emotion is mentioned when describing a memory, it is much more likely to stick, and if the memory is described coherently, with a sequence and cause understood, it is more likely to be retained. Discussing memories and asking who-what-when questions can help.

Also concerned with Piaget's concept of "schema," Christ (1995) believes that presenting information in a meaningful context increases the likelihood that students will retain the information long-term. Christ describes the "Real World Curriculum" that was designed to assist students to learn the standards while making it meaningful to real life situations they will encounter. Open-ended activities are recommended so that students can apply their understanding in a real-world setting. Marx (2008) also provides insight on the importance of including interactive learning opportunities. He recommends having students make predictions after witnessing a demonstration or experiment then gather information to support their predictions, a teaching strategy informed by Piaget's process of assimilation and accommodation.

Project-based Learning

Similarly, Luehmann (2001) discusses project-based learning which involves students in authentic investigations of meaningful problems, "incorporating and assimilating new information in light of what they already know," thus emulating the work of real scientists. Since qualities of initiative, creativity, diversity, and cooperation are desired by employers, Luehmann believes these should be the focus of current science reform. In contrast to requiring facts to be memorized from textbooks or lectures, science educators should engage students in activities that occur across extended time frames, are student-centered, interdisciplinary, relevant, and engage them in scientific inquiry.

A good example of this type of education is discussed by Rigney (1997), who describes the economic and environmental benefits to society of providing public education regarding the effects of pollutants on our waterways. He shows how a community-wide volunteer water-quality, monitoring program has led to increased awareness of the problems associated with water pollution, and highlights the benefits of working with volunteers and community members, including students.

Manzanal et al. (1999) summarized research regarding the contributions fieldwork makes toward improving student understanding of concepts and principles of ecology. The experimental design included pre- and post-knowledge tests, an ecology unit for freshwater ecosystems, and an evaluation of an independent variable (field trips) on improving students' attitudes towards protecting the environment. It also included tools for assessing attitude (class diaries and interviews) and an approach for categorizing student responses to pre- and post-questions, aligning with desired curriculum outcomes.

Brown (2000) debates the perception that environmental education attempts to influence decision-making processes and attitudes about the environment. Because the type of project students are involved in could dictate their attitude toward a specific environmental issue, he suggests there is a need for accurate assessments regarding the effects environmental education curriculum has on students' attitudes, values, and beliefs. He summarizes the findings of several researchers and concludes there are no consistent findings that students' environmental attitudes change after a single semester of an environmentally focused course. He believes these are positive findings for those who are concerned that environmental education has a pro-environmental effect on student attitudes. His research could be used to promote more integrated approaches, such as year-long, project-based learning experiences throughout the curriculum.

A Stewardship Council report (2009) which summarized the effects of short instructional units offered once or twice throughout a school year also concluded that they had little impact on student attitude and behavior towards the environment. It recommended that lessons be tied more closely with classroom content, be delivered in an outdoor setting, and be provided to schools at least monthly throughout the school year in order to be effective in influencing student attitudes and behaviors.

Chin (2004) suggests the need for collaboration and a common framework to allow environmental education organizations to align their efforts more easily. A common framework provides a basis for considering how systematic collection of evaluative data can inform future program planning and delivery. Through this effort, a framework was developed, with the intent of encouraging program providers to improve their programs and better coordinate their efforts, which is believed will lead to a stronger collective positive impact. This report documented the work of the learning community, describing the development of the program and the key strategies of the regional framework, which could be used as a model for Butte County.

The Center for Teaching, a program of Vanderbilt University, provides a “Service Learning Toolbox” with experiential teaching guides (Bandy, 2001) with step-by-step instructions for teachers interested in integrating service learning projects into their teaching. A series of guides and planning documents combining pedagogy and learning tools, including assessment and evaluation plans, are provided. The program stresses the importance of coordinating with the teacher to ensure that the curriculum needs are integrated. In addition, successful programs are collaborative and work with other environmental education efforts to achieve larger goals.

As teachers work to develop lessons and strategies that embrace student-centered, project-based learning that seeks to develop citizen students prepared to engage in a healthy, functional democracy, McTighe and O'Connor (2004) explain that deliberate and focused instructional design requires a shift in thinking. We must consider what is the specific learning we are seeking and what will be the evidence that learning occurred before we consider what practices we use. We must change our habits to think about what and how to teach, determining desired outcomes first, so that our methodologies assist us to meet the learning objectives. Our focus needs to be on learning and we should ask ourselves and be able to answer the question: Why are we having our students do this?

Assessment

In order to evaluate the effectiveness of education, pre- and post-knowledge surveys provide a means to assess changes in knowledge associated with a curriculum unit (Nuhfer, 2003). Most surveys assess low-level content knowledge, but if open-ended questions are used, they can evaluate higher levels of critical thinking based on Bloom's taxonomy. Nufher explains that a rubric can be developed to query responses to questioning prompts (explain, apply, distinguish, construct, justify) based on Bloom's reasoning levels (recall, comprehend, apply, analyze, synthesize, evaluate) to summarize student responses and correlate them to levels of reasoning.

Thompson and Hoffman (2005) note that low reliability of survey measures are associated with the poor wording of questionnaires, surveys, and tests. Meaningful surveys clearly state how the data will be used and the problem to be addressed. Clear directions should be provided to respondents and the wording of questions should be carefully considered to target the language level of the audience and avoid biased wording. Questions should begin with fact-based knowledge and go on to opinion-based questions.

CHAPTER III

METHODOLOGY

Introduction

The thesis's primary objective was to assess the effectiveness of storm water curriculum in improving student understanding. Pre- and post-surveys quantitatively measured the change in student understanding resulting from the curriculum by comparing student responses before and after instruction. Analysis included both descriptive and inferential statistics to analyze survey question responses and identify any patterns or distinct relationships concerning the strengths and weaknesses of lesson components.

Design of Research

Sample Population

Although nearly 80 students participated in this study, a representative population of 46 and 52 students was sampled to make generalizations regarding the efficacy of the lessons. The criteria used to select the representative population was to include only those students that had attended all three days of instruction and completed both the pre- and post-surveys. Students who missed one or more lessons were dropped from the analysis. A control group was not possible, and thus outcomes were based on the assumption that changes in student responses are due to the lessons and not other variables.

Demographic information for individual participants was not available and is based on California Department of Education statistics (2012) for the entire school (Figure 1). Gender was roughly equal with 47% male and 53% female, with 26% eligible for free lunches, indicating the socioeconomic status of the school.

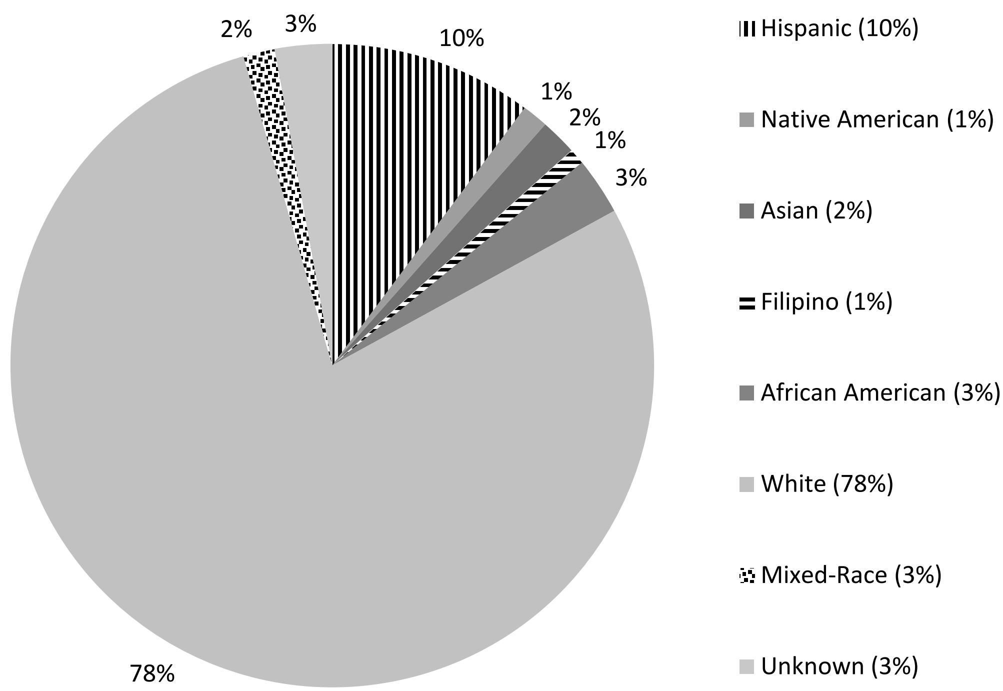

Figure 1. Participant demographics.

Written parental permission was obtained for all students who participated in this study, and a number code was assigned to each participant to ensure anonymity and facilitate tracking individual responses to evaluate and interpret the data.

The survey had only one demographic question, age of the respondent, which ranged between 15 and 17 years. Not all of the respondents answered this question and, as a result, age was not considered when comparing results.

Treatment

Storm water curriculum consisted of two classroom lessons and one field trip lesson. Classroom instruction was provided separately for each class of the participating integrated science courses, while field trip instruction was provided for all three classes as one large group. A pre-survey was administered prior to instruction and a post-survey at the end of instruction. The same students that participated in the pre-survey participated in the post-survey, which contained identical questions.

My role as teacher/facilitator focused on designing a sequence of hands-on activities, providing all material and supplies, such as watershed maps, water-testing equipment and handouts of background information. I also provided brief lectures, presented short introductory video clips, posed questions, and provided modeling of proper use of water testing equipment. In addition, I arranged the logistics for involving community partners during the field trip portion of the lesson.

Instruction centered on providing opportunities for students to interact within their own community, learning about issues impacting their local creek. Building strong bonds with natural places within one's community is an important prerequisite to students taking an active role in protecting those areas. Students gathered information regarding the health of Big Chico Creek and used the evidence to consider changing behaviors. Engaging students in identifying an issue and posing solutions is pedagogy grounded in democratic social constructivism, in which students play a pivotal role in identifying and addressing a problem (Smith, 2002) and developing solutions.

Teaching strategies included experiential learning, student-directed learning, paired reading, analyzing and graphing data, hands-on active participation, informal oral presentations, and group discussions. At all times cooperative learning groups were employed, which provided each student an opportunity to contribute (D. Johnson & R. Johnson, 1999) based on his or her unique perspective. Students were directed to work individually, then share their findings with the larger group, followed by teacher feedback to re-direct or correct misunderstandings.

For example, feedback was provided following an activity that involved testing the conductivity of natural creek water, comparing the results with samples of creek water that had been spiked with runoff pollutants such as yard waste, grass clippings, or household waste dishwater. Following the testing, a group of students summarized their findings, using incorrect terminology, referring to the "electricity in the water." Their misconception required an explanation about how conductivity meters work. Although handouts, which described how the meters worked, had previously been made available at each learning station, most students did not take the time to read them.

The curriculum included instructional materials for two classroom lessons and one field trip lesson, covering basic watershed function, terminology, sources of storm water runoff pollution, and prevention measures (Appendix A). Instruction was provided separately for each of the three groups of students from each of the participating sections of the Integrated Science courses, while field trip instruction was provided for all three sections as one large group.

The first lesson was implemented on April 3, 2012, in a classroom, and teaching methods included lecture, media, and hands-on group participation. The participating teacher introduced me to her class, and together we distributed the pre-knowledge survey. Students were directed to answer the survey questions as best they could, not to worry if they did not know the answers, told it would not be graded, and that the information gathered from the survey would be used to help me assess whether the upcoming lessons had an effect on providing them with a better understanding of storm water pollution as part of my master's degree project.

After collecting the surveys and checking for completion, I provided an overview of my role as a facilitator of a local citizen monitoring effort, including an invitation to help establish a Youth Stream Team for their school. Students were asked to raise their hands if interested and about one-third responded. A large map of the Big Chico Creek Watershed was then displayed in the front of the room and an overview was provided, including pointing out the headwaters, tributaries, and unique habitat features, such as spring-run salmon migration barriers, forest and foothill habitat areas, and the urban areas on the valley floor. Connections were made between the Big Chico Creek Watershed and the mouth where the creek empties into the Sacramento River Watershed, emphasizing that this local creek is part of a larger system. In order for students to get a broader geographic picture of how our area fits into the larger north state geography, I asked a series of questions designed to activate their prior knowledge, tracing the path of the Sacramento River from the headwaters located near Mt. Shasta, down through Red Bluff, Los Molinos, Hamilton City, Colusa, Sacramento, into the delta near Stockton, and out under the Golden Gate Bridge into the Pacific Ocean. I asked questions such as “Where are the headwaters of the Sacramento River located?” “Which part of the valley?” “ Where does the water in Shasta Lake come from?” “Where does the Sacramento River enter the ocean?” “If we tested water quality at the headwaters of a creek, would the samples be similar to those collected at the mouth?” Further questions followed, concerning land use practices occurring in those areas and the importance of Sacramento River water for agriculture, industry, and clean drinking water. I then redirected their attention to the Big Chico Creek map, reiterating that the water in Big Chico Creek ends up in the Sacramento River, and that students have an important role in taking care of the water that flows through their town to ensure clean water is available for uses that occur downstream.

In order to transition to the next part of the lesson, I ended by posing questions regarding whether water-testing results would be the same for samples collected at the headwaters and at the mouth. Why, or why not? Many of the student responses indicated they had prior knowledge that creeks pick up materials as they flow downstream, that erosion and other natural processes occur, and that dirt, trash, oil, and sewage are pollutants.

A short break was incorporated so students could move to a classroom next door where laboratory facilities were available. The next activity introduced the proper use of the water testing equipment that students would be using during the upcoming field trip, as well as provided examples of causes of storm water pollution. An overview and demonstration of the proper use of testing equipment was provided, as well as instructions for filling out a data sheet that would be used when testing water at the creek. Students worked in small groups and tested natural creek water and creek water spiked with various materials to mimic common runoff pollutants, such as grass clippings to represent yard waste and dishwater to represent household waste. During this activity, the participating teacher and I moved around the room answering questions and checking for understanding. After students had tested the water samples, each group provided their results orally, which were compiled in a table on the chalkboard showing the range of results for each parameter and sample tested for each group. It was intended that the students would then graph their results, but the end of the class period was approaching, so a quick graph showing the overall class results was drawn on the chalkboard. The class period concluded with a three-minute clip of the video *Slow the Flow* (a definition documentary featuring residential landscaping techniques that reduce urban runoff) (State Water Resources Control Board, 2011), an overview of the upcoming fieldtrip, and a reminder that those that had not turned in their permission slips needed to do so.

The second lesson was implemented on April 10, 2012, and consisted of a three-hour field trip. Teaching methods included brief lectures provided by professional scientists serving as learning station leaders, and active group and individual hands-on group participation. Studies of informal science programs have shown that adult mentors play an important role in developing positive identities for youth who may see themselves as future, capable scientists (Natural Resource Council, 2000). Luehmann (2001) found that students assimilate the work of good scientists mimicking their behaviors, which provided the theoretical basis for having community professionals, such as a working entomologist, explain how the diversity of aquatic insects are used to indicate stream health. The language used by professionals is also important, and learning station leaders were directed to use proper terminology and vocabulary so students could practice using the correct words to develop better understanding of the concepts. Students were also provided opportunities to work side-by-side, using scientific equipment such as kick-nets to gather stream bottom insects to identify, sort, and group those that were sensitive to pollution. A field trip guide (Appendix A) was also provided as an overview of what students were expected to learn.

Over 70 students participated in this field trip, which was within walking distance from their school, along the banks of Big Chico Creek. In order to organize student groups and develop a station rotation schedule, the participating teacher provided class lists. I also met with station leaders at the field trip site prior to the event to help them become familiar with the area, identify any special equipment needs such as tables, buckets, and waders, and to select appropriate sites for each learning station. The field trip guide was also discussed and their questions answered to focus their attention in addressing the content they were to cover at each station. The rotation schedule was also discussed.

On the day of the event, adult Stream Team volunteers and station leaders met prior to the students arriving, in order to set up stations, assign volunteers to assist each station leader, designate a time-keeper to signal rotations, and go over the goals for the day. During the event, the participating teacher and I frequently touched base with each station leader to handle any unanticipated issues. The following is a description of each learning station.

1. Bio-assessment and aquatic insect station. This station was intended to provide students with an opportunity to collect, touch, and sort aquatic insects, and learn how they are used as biological indicators to track stream health. A local entomologist employed by the Department of Fish and Game provided instruction, equipment, and supplies to facilitate student learning at this station. On the morning of the event, the station leader and I waded through the creek and collected insects, making sure there was a sufficient diversity of species represented for students to have a meaningful experience at this station. Insects were then separated by species into large trays filled with water and grouped according to their sensitivity to pollution. Two Stream Team volunteers were assigned to help at this station. When students arrived at this station, an overview of each category of insects was provided and connections were made to the types of water pollution that can impact conditions in the creek for their survival. The station leader also talked about different life stages of insects—egg, larva, and adult—stressing that the larval stage takes place in the creek, which makes them particularly good indicators of stream health. The station leader also discussed unique feeding strategies of the various orders, which serve to divide the resources available in the creek (scrapers, shredders, collectors, carnivores, predators). Students were then directed to get hand lenses with which to view the various insects and identify three orders used to track stream health: Ephemeroptera, Plycoptera, and Tricoptera. The station leader provided guidance on the taxonomic characteristics used to identify and differentiate one organism from another,

such as two-cerci or three-cerci, which are tail-like appendages, or gills present on the abdomen, and piercing mouth parts used by predators. Students also sketched the three insects and answered questions from their field trip guide. Students could also use nets to gather other insect samples to sort and add to the inventory for the next group of students. While adding to the inventory, students needed to recognize which of the macroinvertebrates were sensitive, moderately sensitive, or tolerant to pollution.

2. Stream flow monitoring. This station provided students with an opportunity to contribute real data for a local watershed assessment program. The Stream Team provided two citizen monitoring program volunteers to lead this station, waders, and all necessary equipment to facilitate student participation in collecting stream flow data. The station leaders gave a brief overview of Stream Team efforts and the importance of measuring stream flow. Students were divided into two teams, wet and dry. The wet team waded into the creek, measuring stream depth, velocity, and wetted width, while the dry team stayed on shore and recorded the field notes. Stream depth was measured by a yardstick at one-foot increments across the width of the stream. Velocity was measured by floating an orange on the surface of the water between two transects and checking the time it took to travel. Wetted width was measured using tape measures stretched across from the right to left banks.

3. Water quality testing. This station provided students with a chance to collect and test the water quality of their own local creek and provide data for a local water quality monitoring program. They also tested creek water spiked with runoff pollution and compared their results as they had done in the previous classroom lesson. The station leader

was a member of The Stream Team who reviewed testing procedures students had previously practiced in the classroom and directed students to a safe, gravel bar area of the creek to collect water samples. Students worked in teams of two to complete the water testing and answer questions on the field guide, which included recording observations and comparing their results with Basin Management Plan objectives, which had been provided in their field guide. At the end of this activity, students shared their results verbally and identified whether their results met the Basin Management Plan criteria for protecting aquatic life.

4. Watershed model. The Butte County Resource Conservation District provided their watershed coordinator to serve as station leader and also provided an Enviroscape watershed model to demonstrate the effects of storm water runoff. Students were provided with a brief overview of the district's education efforts to protect water quality. A brainstorming activity led by the station leader helped students list types of pollutants and their sources on their field trip sheets. Students then assisted in setting up the demonstration model, which included adding housing tracts, farms, and roads, and "sprinkling" materials representing potential pollutants around those areas, such as coffee grounds to represent dirt from an area without vegetation and syrup representing oil from automobiles. Students then sprayed water, representing rain, from squirt bottles onto the model, which carried the various pollutants into the models' waterways. A brief discussion followed, noting where the rainwater flowed and possible solutions to prevent runoff. Students were then directed to "fix" the areas to prevent runoff by adding riparian buffers and vegetative strips along parking lots, as well as provide other solutions for the

problem. Students then worked individually to complete their field trip guides and quickly shared some of the types of pollutants they listed, including the source and a solution.

5. Riparian habitat tour and native and non-native plant species identifications. Friends of Bidwell Park provided a college intern, working on a local vegetation survey, to lead this station. Students were provided with an overview of some of the common plants found along Big Chico Creek, including specimens to examine and with which to become familiar. Students made sketches and identified whether the plants were native, non-native, or invasive. Following a discussion of the issues associated with non-native and invasive plants, the station leader provided a walking tour of the riparian habitat along a reach of Big Chico Creek. Students carried some of the samples of plants they had sketched and located examples of them growing along the creek, seeing first-hand examples of areas where invasive species had taken over, compared with areas that were mostly composed of native species.

6. Storm drain outlet tour. This station provided students with an opportunity to locate a storm drain inlet capturing water from a large parking lot and the outlet where it drained to the creek. As the students walked to the site, the station leader provided a brief description of non-point source pollution, pointing out storm drain inlets and noting any pollutants noticed. Arriving at the parking lot, students were asked to look around for areas where water was pooling up and locate the storm drain inlet. Taking notes on their field trip guide, students listed the sources of runoff pollution they observed. They were then led down to an area near the creek where the storm drain outlet was located. After

observing the area, students listed the items that had been carried from the parking lot and dumped from the outlet into the creek. Huge amounts of trash were found in this area, and most of it came from this one parking area. Students discussed possible solutions to address this issue as they walked back to the main field trip area.

The final instructional unit was implemented on April 12, 2012, back in a classroom setting. Projecting the field trip guide onto a screen in the front of the room, a recap was provided of the field trip. Asking questions and having students call out answers, I filled in the sheet while discussing their answers. This allowed students that did not have a chance to complete the guide during the field trip to fill in missing information and also served as a review of the concepts covered during the previous lessons. A short video, *Devil Ducks/Ducky II* (Think Blue Maine, 2011), followed, which provided a fun depiction of pesticides and fertilizers being carried in residential runoff into waterways. These types of videos provide a tool for providing students with a lot of information in a short duration of time. The concluding lesson activity involved a group reading activity on sources of runoff pollution. Students worked in groups, shared what they read individually with group members, and then presented, as a group, their findings to the rest of the class. The post-knowledge survey was administered at the end of instruction. Teaching methods involved lecture combined with group and individual participation.

<u>Survey Tool</u>

To improve reliability of results, an existing survey provided by the City of Chico Storm Water Program was utilized, in which the wording of the questions had been considered and previously tested to ensure they were not too technical and used appropriate language (Appendix B). Questions regarding student age and name were added.

The questions in this survey were not specifically developed to assess the effectiveness of the project curriculum, but were designed to evaluate public knowledge of storm water runoff issues, which the curriculum intended to improve. In addition, the City often partners with community groups to provide school-based storm water education, and use of this survey opened up the possibility to inform modification of instructional materials.

To facilitate analysis, outcome indicators were selected to relate survey question responses with the curriculum content and activities provided, including the following.

1. Students will know where storm water runoff water goes.
2. Students will know the causes of storm water runoff pollution.
3. Students will know how to mitigate storm water runoff pollution.
4. Students will know watershed terminology and functions.

An account with Survey Monkey was purchased to enter survey data manually and to facilitate the downloading of student responses into Excel spreadsheets for analysis.

Data Analysis Procedure

Only the survey responses that were relevant to this study were analyzed, and, as a result, questions were renumbered. The questions included in the survey referred to storm drains, causes of storm water runoff pollution, and best management practices to prevent water pollution. The survey questions that were not analyzed were specific to the City's storm water outreach program referring to their program's educational messaging (poster, murals, radio broadcasts), and whether the public changed behaviors as a result of seeing or hearing them. In order to analyze the survey results, responses to questions were also scored as "correct" or "incorrect" and grouped by curriculum outcome indicator in order to evaluate the efficacy of the lessons in improving student understanding.

One multiple-choice question was analyzed which required students to select causes of pollution and "check all that apply." Four of the choices listed (pet waste, yard waste-grass clippings, soil, and auto fluids) were topics covered in the learning modules and were, thus, of interest for this study. For that question, the frequency of responses was ranked and a Spearman rank correlation coefficient (Choudhury, 2009) used to measure the degree of difference between pre- and post-survey responses. Responses that did not correlate before and after showed that the curriculum had an effect (Ho: X and Y are independent; H_1: X and Y are either directly of inversely related).

Descriptive statistics, including contingency tables and graphs, were used to describe the survey data results, including the proportions of correct and incorrect responses. A two-by-two contingency table analysis was used to display the frequency of distributions of correct and incorrect responses (pre- and post-), and to record the relationship between the responses. There were four possible combinations of responses that were of interest to this study which were used to indicate whether the curriculum influenced students answering the questions correctly. An example of a contingency table, showing the possible combinations of responses using this study's data from question 1, is provided in Table 1. The values in the table are obtained by tallying up the number of times each of the four possible combinations of correct and incorrect responses occurred before and after the curriculum. Adding up the number of responses from each row and column completes the table, and the value in the lower right hand corner is the total sample size.

Table 1

Example of Contingency Table

	Post-response		
Pre-response	Incorrect (I)[a]	Correct (C)	#
Incorrect (I)	2	8	10
Correct (C)	6	30	36
#	8	38	46

[a]Pre-incorrect and post-incorrect (II)=lesson had no effect
Pre-incorrect and post-correct (IC)=lesson improved knowledge
Pre-correct and post-correct (CC)=lesson did not change or harm
Pre-correct and post-incorrect (CI)=lesson had negative effect

Proportions of responses for each category were calculated (for example, CC/# = 30/36 = 83.3%, and IC/# = 8/10 = 80%). The significance of the difference between the proportions in each category was determined using inferential statistics. Confidence intervals were used to generate the expected range of likely proportions of responses within the population and determine the range of confidence the results displayed based on sample data (Table 1, Appendix C).

The margin of error determines the relative confidence of the results and is determined by the variance within the sample data. The narrower the range, the more confident one can be that the results are representative. In other words, if the lessons were provided to a similar population of students, the results would be expected to be similar. Wider ranges of intervals produce less confidence and result from variability within the sample data, which, in this case, is due to the small number of student responses in one or more of the response categories.

CHAPTER IV

RESULTS AND DISCUSSION

Presentation of Findings

Survey results are presented to highlight improved knowledge due to the educational intervention, drawing relationships between responses and the curriculum provided.

Figure 2 shows the total correct responses before and after the curriculum was provided for survey questions 1-14, which were true or false questions. Because there are only two possible responses, students had a 50% chance of guessing the correct answer. Results for most questions were greater than 50%, indicating that students answered correctly more often than if they were just guessing. Results below 50% indicate students either guessed incorrectly, or that they had an incorrect understanding of the storm water content addressed in those questions.

Only the results for question 11 indicate, within a 95% confidence interval, that the curriculum had a significant positive effect on improving student understanding that storm water is carried untreated directly to local creeks. Although post-responses for most of the other questions showed correct responses above 50%, with a slight increase between pre- and post-, this increase was not significant to indicate the lessons had an effect. Questions 13 and 14 refer to checking weather forecasts prior to applying lawn

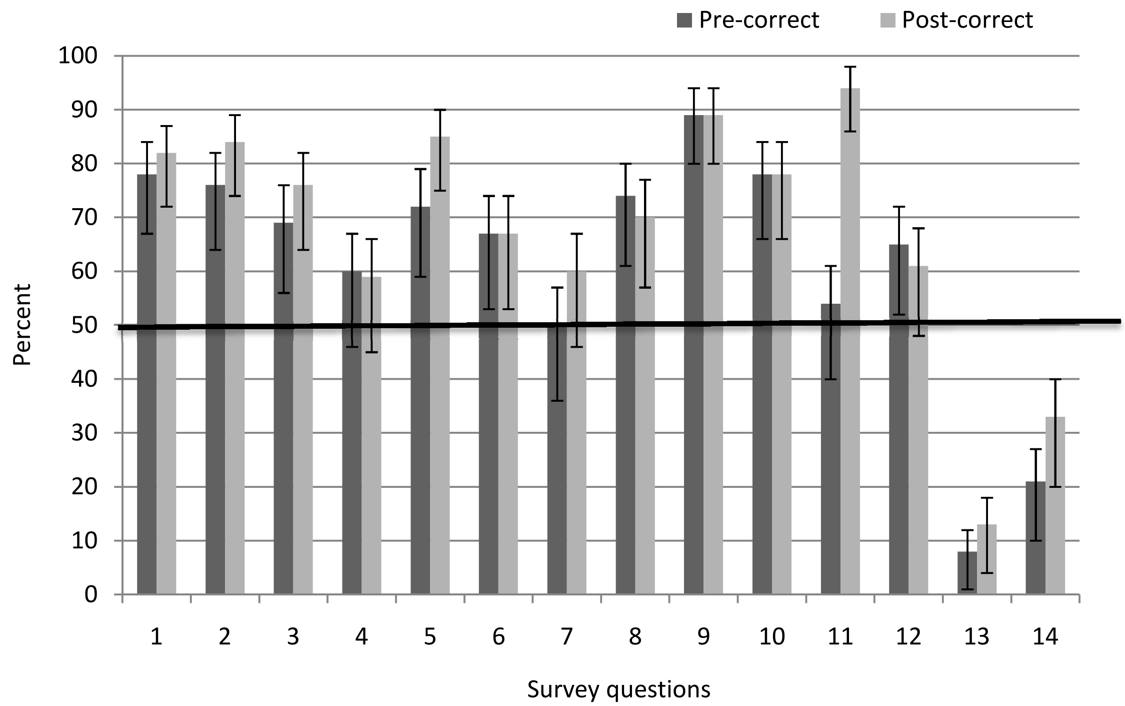

Figure 2. Percentage of correct responses for pre- and post-survey questions.

fertilizers and to washing cars on lawns, which were not covered in the curriculum. The results for these questions show low numbers of correct responses pre- and post-.

Responses to survey questions (pre- and post-) are dependent variables, meaning that those answers that were correct before the intervention had a better chance of being correct after. Because of this, simple *t* tests were not an appropriate measure of the statistical difference between the two samples (pre- and post-). In order to understand which questions showed a statistical improvement, contingency tables were developed for each question and confidence intervals (95%) were calculated for each category of responses (Table 1, Figures 1-14, Appendix C).

A confidence interval provides a range of values that would be reasonably expected as a result of the random sampling procedures. Sims and Reed (1999) explain that, in addition to showing the level of confidence that could be expected, confidence intervals indicate the variability of responses to survey questions. This is important for understanding the range of effectiveness the curriculum had in relation to each survey question. A narrow range indicates the curriculum could be expected to have a more predictable outcome, while a wider range indicates it would have more variable effects.

Figure 3 shows the results of contingency tables and displays response categories. Results for the pre-correct/post-correct (CC) category for most questions were better than if a student had merely guessed at the answer (>50%), and, for questions 1, 2, 6, 9, 10, 11, and 14, the results show responses above 70%. The pre-incorrect/post-correct (IC) responses either overlapped with the CC responses or fell below the 50% mark, and the data indicate, at a 95% confidence interval, that the lessons had no significant effect in increasing student knowledge.

The response category that provided the greatest insight for understanding whether the lessons had a positive impact is the IC response category, which reflects results for those students that were incorrect before and who became correct after the instruction. The other category of interest was the CC responses that reflect the proportion of students who answered correctly before and who remained correct after, indicating the lessons did not cause harm or confusion to student understanding.

Figure 4 displays the relationship between CC and IC responses. Results for CC responses were greater than 50%, which is within the threshold value, indicating

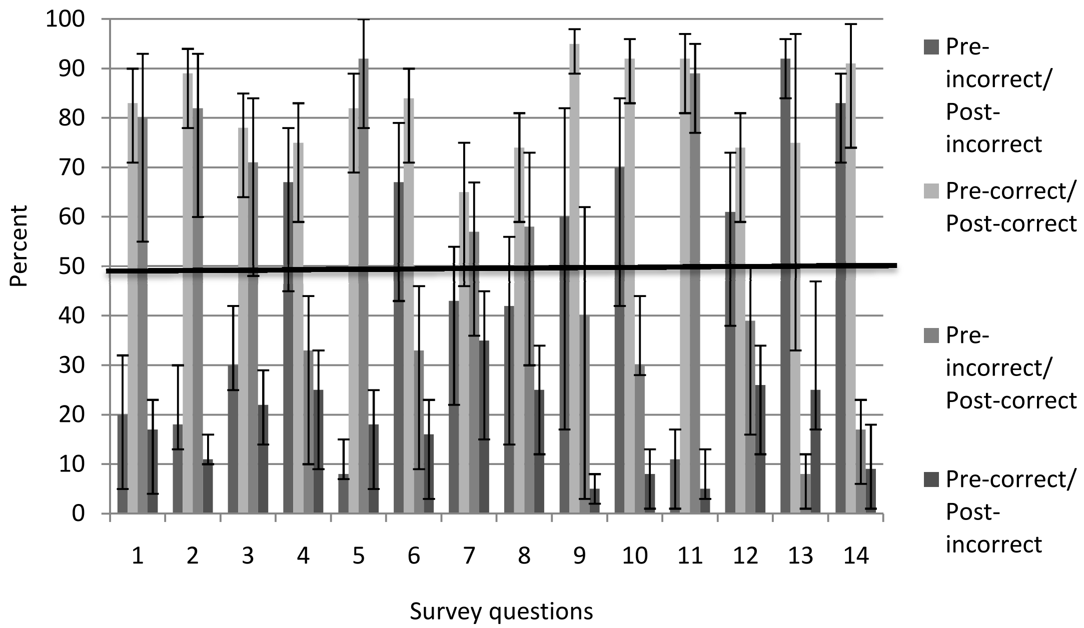

Figure 3. Pre- and post-survey responses by percent.

higher percentages than if students had just guessed, although the results for IC responses do not indicate a significant improvement post-curriculum. The IC results either over-lapped with the CC responses, indicating that there was no significant difference between the two categories, or the values of IC were less than 50%, indicating the results were no better than if students had guessed.

Further explanation of results, in relation to outcome indicators (Table 2), are provided, in order to identify factors in the lessons that may have influenced learning.

Figure 5 shows the results for five survey questions that indirectly identify students' knowledge that storm drains carry untreated runoff directly to creeks. The data indicate that roughly half of the students (23-27 students) for these questions regarding

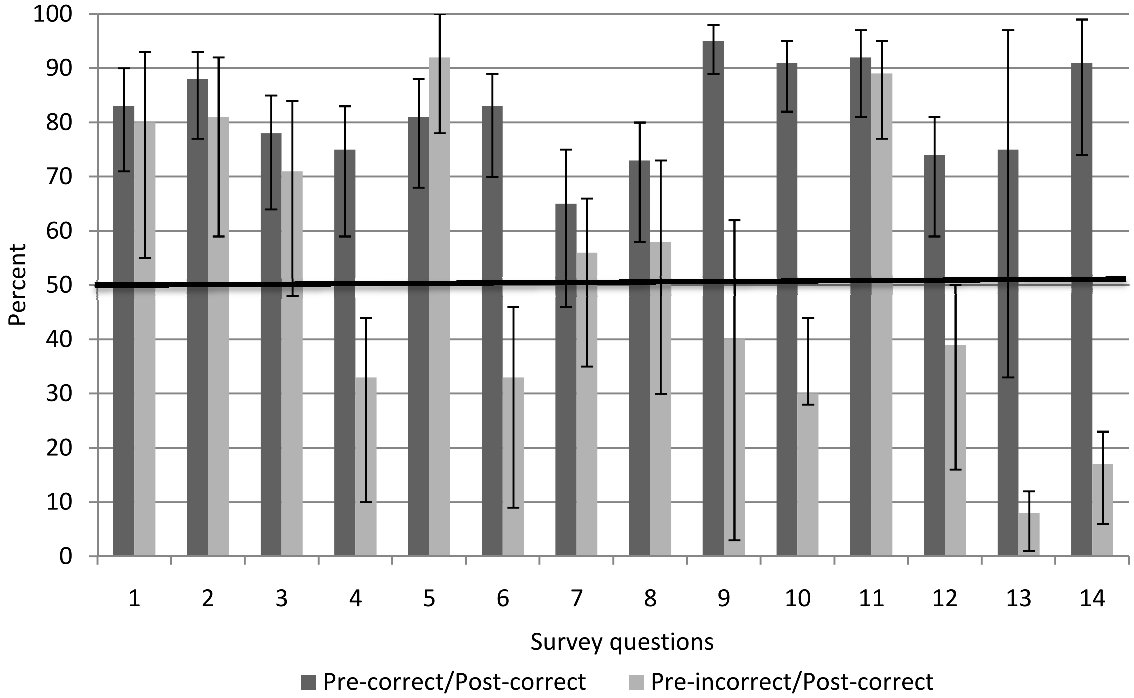

Figure 4. CC and CI responses by percent.

"where storm water goes" had prior knowledge above 50%, and did better on the post-test than if they had guessed, but the difference between CC and IC responses is not significant to indicate the lessons had an effect on improving learning. Question 5 shows the highest IC response, ranging between 78-100%, indicating 12 of the 13 students who answered incorrectly pre-test, but answered correctly post-test . Question 11 has a similarly high IC response, ranging between 78-95%, based on 24 of the 27 students who answered incorrectly pre-test, but answered correctly post-test . Data for questions 6, 8, and 12 show that the confidence intervals for IC and II responses actually overlap, indicating students had no better chance of answering correctly than staying incorrect post-instruction.

Table 2

Outcome Indicators

Outcome	Survey questions
Students will know where storm water runoff water goes	5, 6, 8, 11, 12
Students will know causes of storm water pollution	9, 10, 14
Students will know practices to prevent storm water pollution	9, 10, 13, 14
Students will know about watershed functions and terminology	1, 2, 3, 4, 7

These results are troubling because most of the instruction, such as storm drain tours, video clips, and water testing activities, highlighted information related to the fact that storm water drains into local creeks untreated, but the data do not indicate the lessons had a significant effect. It appears that the three-day curriculum unit was too short in duration and not tied well with classroom content, which influenced the lack of effectiveness of the curriculum (Stewardship Council, 2009). In addition, the short duration lessons did not allow enough time for students to process the content material and consolidate the information into memory (Bauer, 2012). Nuhfer (2003) further suggests that true-false knowledge surveys assess low-level content knowledge and that more open-ended questions are needed to better evaluate student understanding. If the survey questions had been modified to more closely align with the content being taught, rather than "retrofitting" and "grouping" the existing survey questions into various outcome indicator categories, the survey data may have shown that the curriculum had a greater effect.

Figure 6 show the results for the three questions that indirectly identify whether students knew causes of storm water pollution. For questions 9 and 10, the percentage of CC responses ranged from 83-99%, indicating a large proportion of students

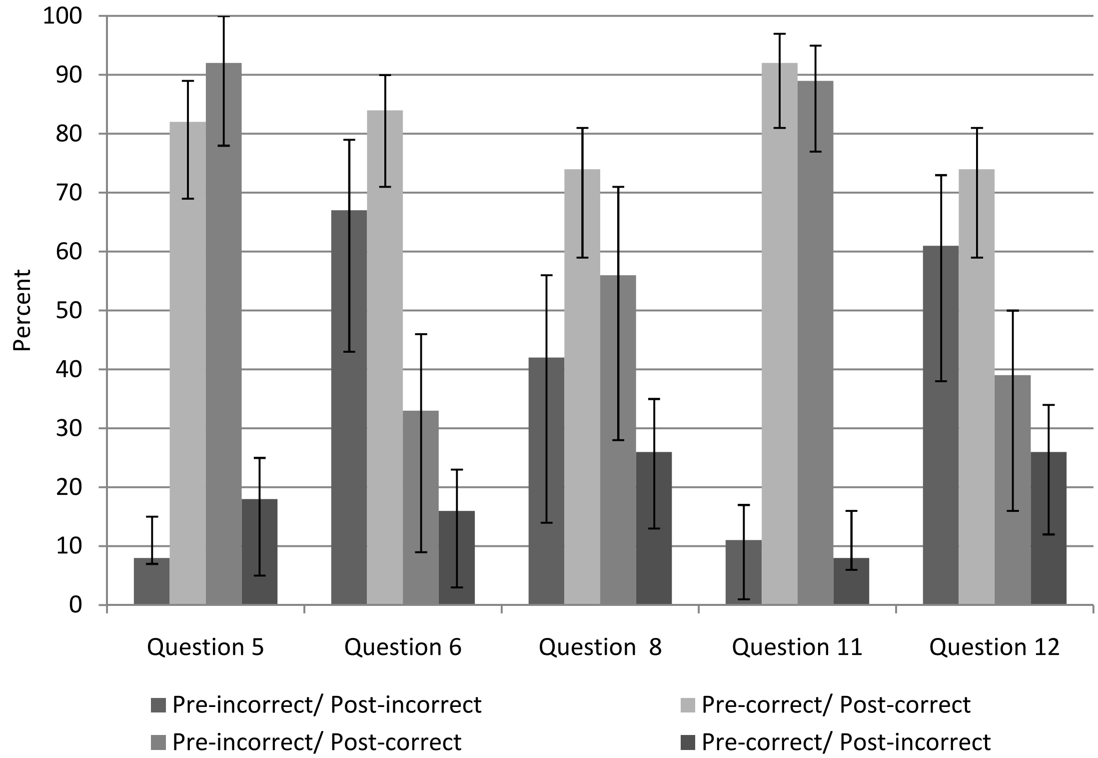

Figure 5. “Students know where storm water goes” outcome for questions 5, 6, 8, 11, and 12 by percent.

(39 and 33, respectively) had prior knowledge that pet waste and trash are pollutants that can cause harm to waterways. The IC and II responses for questions 9 and 10 are based on responses from less than seven students, and show variable ranges between 3-62% and 17-84%, respectively, indicating that for those few students who answered incorrectly before instruction, the data do not indicate a significant chance they would improve.

For question 14, the CC responses ranged between 74-99%, and, in contrast to questions 9 and 10, were based on a smaller sample size of ten students, indicating that students had less prior knowledge that car washing caused pollution. In addition, the incorrect-before/incorrect-after (II) responses overlap with the CC results, and the IC and

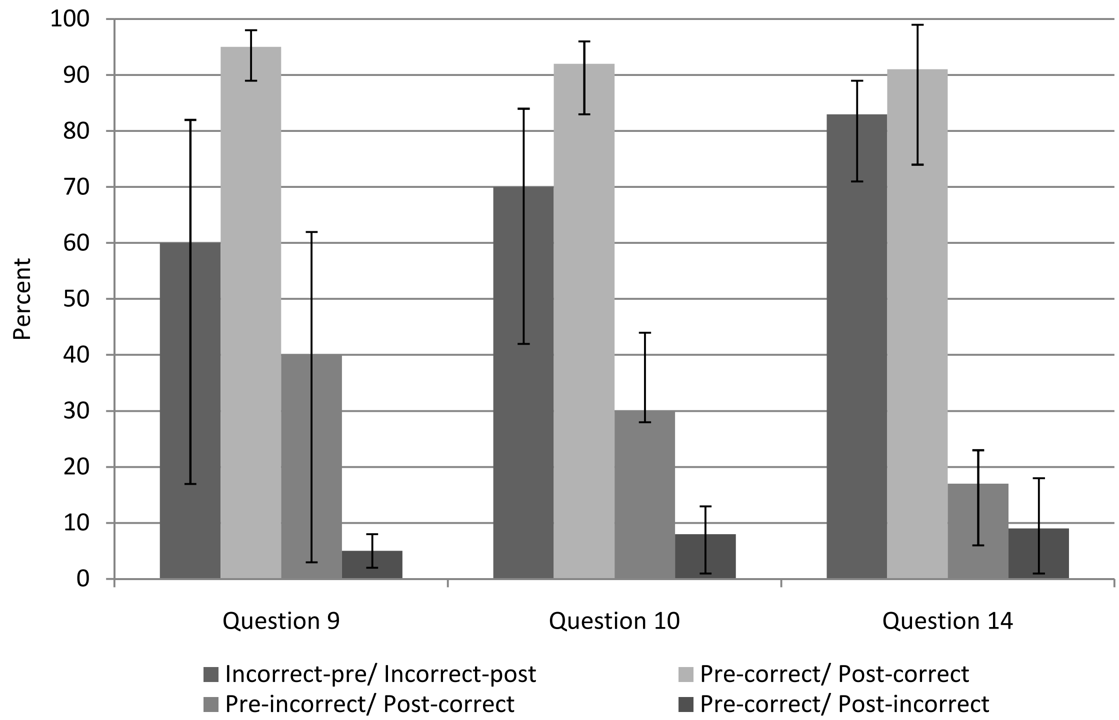

Figure 6. "Students know causes of storm water pollution" outcome for questions 9, 10, and 14 by percent.

correct-before/incorrect-after (CI) responses also overlap, which indicate that students had no better chance of being correct or incorrect before or after instruction. This is not surprising, because runoff from car washing was not covered in the lesson. In hindsight, this questions should not have been included in the survey or I should have covered the information in the lesson.

Figure 7 shows the results for questions that indirectly target student understanding of behaviors to prevent runoff pollution: properly disposing of pet waste and trash, checking the weather forecast before applying lawn fertilizers, and washing cars on lawns.

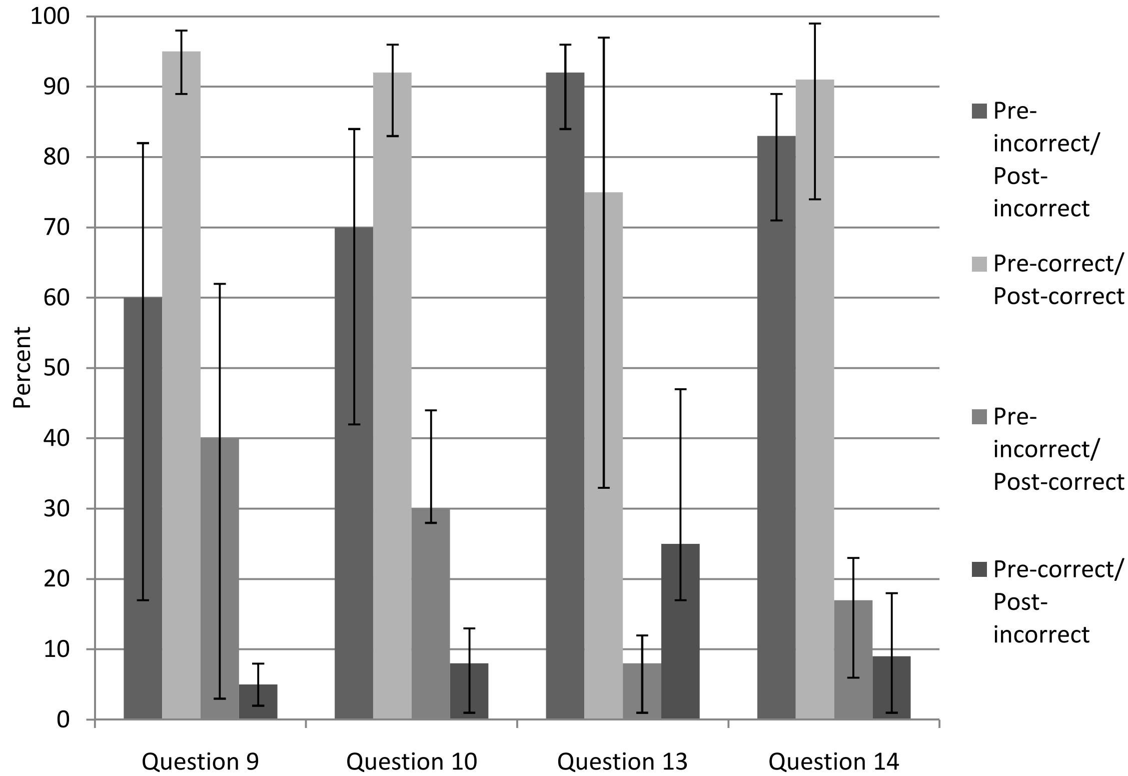

Figure 7. "Students know measures to mitigate storm water pollution" outcome for questions 9, 10, 13, and 14 by percent.

The results for questions 9, 10 and 14 were used to assess the outcomes of the lessons in relation to two indicator categories (students know causes of pollution and measures to mitigate), which are shown in Figures 6 and 7. The results are the same for each category, indicating the lessons had no significant effect in improving student knowledge of causes or mitigation measures.

Question 13 tested whether students knew how to prevent storm water pollution by checking weather forecasts before applying lawn fertilizers, which again was not addressed in the lessons. Thus, the results for CC responses ranged between 33-97% and were based on the responses of only three students, indicating most students did not have prior knowledge. In addition, the II responses ranged between 84-94%, based on 44 of 48 students who answered incorrectly before and remained incorrect after. The II and CC responses overlapped, indicating that there was very little chance of students answering correctly on this question before or after. The results for IC responses were very low, ranging between 1-12%, and are based on the response of a single student, indicating the lessons were not significant in improving student knowledge. Again, the question should have been removed from the survey or the information about checking weather forecasts should have been provided.

Re-wording the questions in the survey from "*do you* consider the weather forecasts," to "*should* weather forecasts be considered," might have improved the outcomes because the original wording may have overly personalized the action that needed to be taken. Literally, students may have been responding to the fact that they, personally, do not take time to read forecasts and are not in charge of taking care of lawns. In addition, the paired reading activity, in which students learned about various sources of pollutants, could have included more specific material regarding proper application of fertilizers. Although the video *Devil Ducks* did address the fact that fertilizers can be carried from lawns into creeks when it rains, there was no questioning or reflection activity following the video. Manzanal et al. (1999) suggest class diaries can be used as a reflection tool to help students synthesize information and develop an understanding of the importance of the content covered in the lessons. This was not possible, because the three-day lessons were not aligned with the regular classroom teacher's curriculum, and there was no time for follow-up activities. In addition, McTighe and O'Connor (2004) notes that covering too much content can overload students, and the data results indicate I should have presented fewer ideas in more depth in the three-day lessons. Ajzen and Fishbein (1980) add that predictors of a behavior, according to the theory of reasoned action, involve whether a person sees the behavior as good or bad. Integrating more activities that allowed students to practice beneficial mitigation measures would help them to assess and evaluate good versus bad practices. For example, I could have borrowed the City of Chico's car wash kit which contains equipment to divert wastewater to areas where runoff can soak into the ground rather than flow into gutters and creeks. This would have given students a chance to experience why washing cars on lawns prevents polluted runoff from entering the creek.

Figure 8 shows results for questions referring to watershed function and terminology. Questions 1 and 2 have the highest CC responses for this indicator category, ranging from 71-95%, indicating students were already familiar with the terminology of watershed functions addressed in these questions. In addition, these results show that it was unlikely that those students that answered correctly before would answer incorrectly after instruction (only 1-23% CI responses). Results for II responses were also low (5-30%), indicating that the two students who answered incorrectly before were unlikely to change their responses from incorrect to correct. Results for the IC responses ranged between 48-95%, but were also not significant. Although roughly 20% of the IC responses showed an improvement, the results overlapped with the CC responses, indicating students had no significant chance of becoming correct as a result of the lessons.

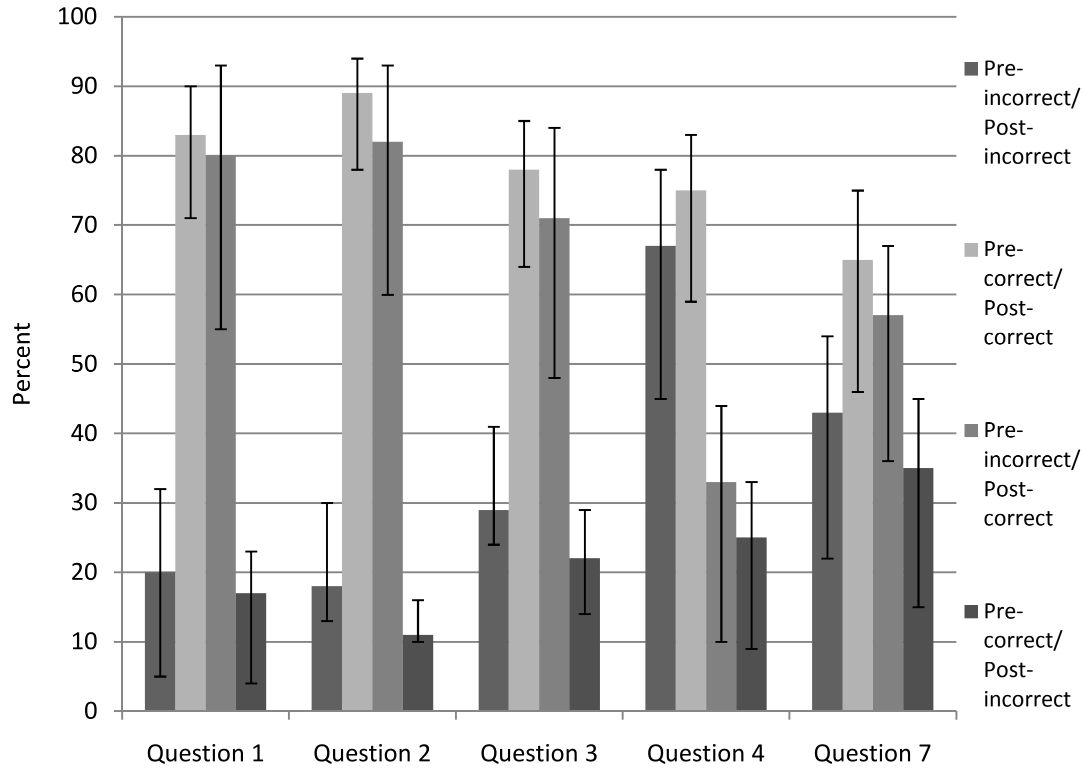

Figure 8. "Students know watershed functions and terminology" outcome for questions 1, 2, 3, 4, and 7 by percent.

Question 3 shows a somewhat similar response pattern to questions 1 and 2, but the data results for questions 4 and 7 indicate that a student is no more likely to go from incorrect to correct as to stay incorrect.

In summary, the data for this indicator category do not indicate the lessons improved student knowledge of specific watershed terminology associated with watershed and riparian habitats. Although during the field trip students identified native plants and then toured a section of riparian habitat, the lesson did not sufficiently stress functions of riparian habitats. In hindsight, although science professionals acting as field trip facilitators used proper terminology, they did not elaborate or define the terms. As a result, only a few of the students were able to link information in the lessons to the survey questions. In addition, as Powell and Kalina (2009) suggest, learning is a process of allowing new information to fit into what already exists in one's memory, suggesting that perhaps students needed more background information (schema) prior to the field trip in order to accommodate the new material.

Figure 9 shows the results of responses to question 15, which asked students to select the materials they believed were causes of pollution in local creeks. The pre- and post-results were ranked, and a Spearman rank correlation coefficient was used to indicate the curriculum's effectiveness (Table 2, Appendix C).

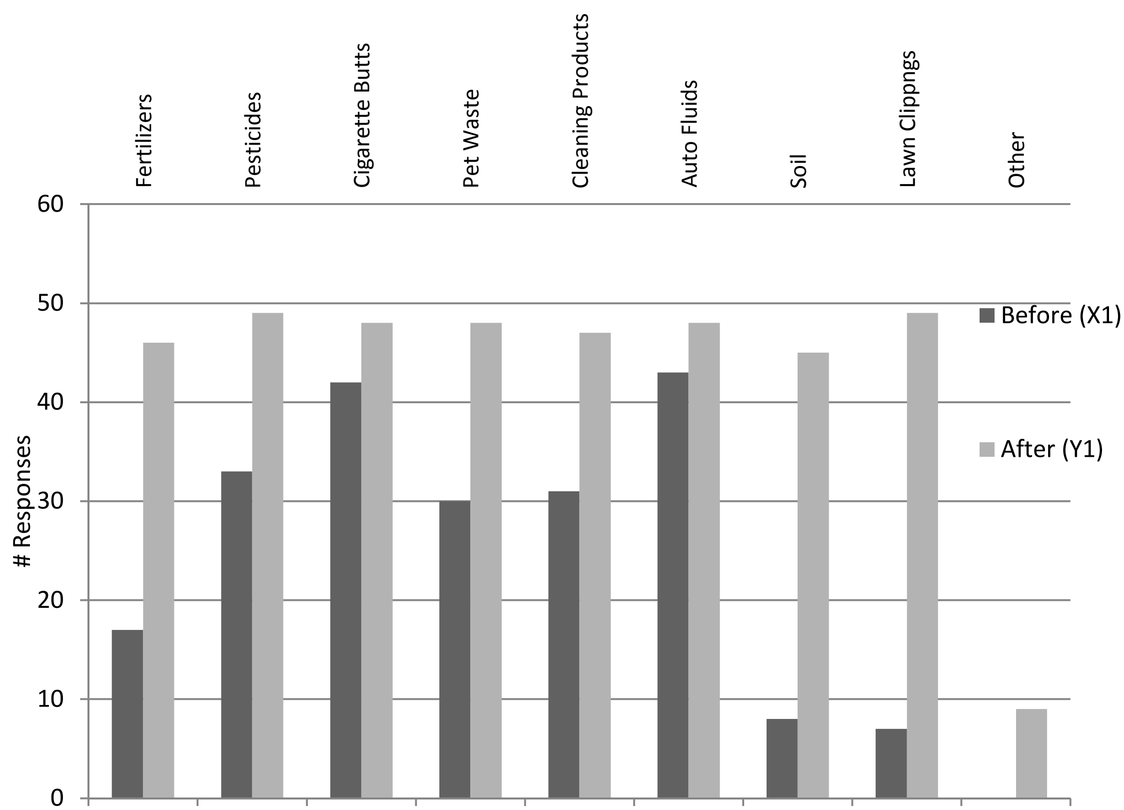

Figure 9. "Causes of storm water pollution" outcome for question 15 by percent.

Results show, at a 95% confidence interval, that the responses are independent of each other before and after, and the null hypothesis is rejected. In other words, the differences between the responses are in relation to the lessons. Of particular interest were responses for erosion (soil) and yard waste (grass clippings), which indicated an improvement in relation to prior knowledge, likely due to instruction. For example, only seven students selected lawn clippings as a pollutant on the pre-test, in contrast to the 49 students who selected it after. It appears learning was enhanced because students gathered empirical data associated with the ph and conductivity of samples spiked with runoff pollutants (grass clippings), and compared the results to those of clear creek water, drawing their own conclusions that these materials impair water quality (Manzanal et al., 1999).

This activity also involved group discussions prior to testing the samples, in which students brainstormed ideas about how these materials make their way into waterways. This provided an opportunity for students to make predictions prior to conducting the water testing. While making predictions, they accessed prior knowledge (Marx, 2008) of substances, such as auto fluids and cleaning products, that impact water quality and were made aware of other pollutants, such as lawn clippings, that they had not considered to be problematic.

CHAPTER V

CONCLUSIONS AND IMPLICATIONS

Conclusions

Although survey results were not uniform across all questions, the data do not indicate the curriculum had a significant effect on improving student knowledge of storm water runoff pollution and effective stewardship practices. The validity of the results could have been improved by conducting an exploratory study, or pre-test, before planning the curriculum to determine students' prior knowledge. This would have helped identify and target a population of students who did not already have ample environmental awareness. Such a population of students would have been a better test of the effectiveness of the curriculum. The results for most survey questions indicate a relatively large number of students were already familiar with the survey question content, and that there was no significant change in their answers after instruction. This left a very small population of students unfamiliar with the information addressed by the survey to test its effectiveness. This reduced the reliability of the results, which, in some cases, were based on a single student response.

Hands-on learning strategies, which connect with personal experience and allow students to apply their reasoning to a new application, were integrated into the lessons (Powell & Kalina, 2009). Also employed was student-centered learning, in which the teacher acts as facilitator posing problems and directing students to gather evidence

(J. Brooks & M. Brooks, 1993). Although these teaching strategies were employed, the assessment tool did not adequately match the curriculum and may have reduced the significance of the result. As Thompson and Hoffman (2005) note, low reliability of survey measures is associated with the poor wording of questionnaires. Also, Nuhfer (2003) notes that most surveys assess low-level content knowledge, but if open-ended questions are used, they can evaluate higher levels of critical thinking. It is possible that higher levels of thinking and learning occurred, but they were not tested and so could not be validated. My choice to use an existing survey was to link to the City of Chico's method of evaluation for assessing storm water knowledge.

As previously mentioned, the curriculum was developed based on social interactions and hands-on experiences (Kukla, 2000), which should produce effective results, yet the survey did not indicate success. This might also be because the three-day lesson format does not allow time for follow-up activities essential to learning (Manzanal et al., 1999). This is consistent with both Brown (2000), who points out that single lessons or one-time outdoor experiences have little effect, and Bauer ((2012), who states that information needs to go through a process of "refrigeration known as consolidation." The only area of successful learning, indicated by the results for survey question 15, point to the effectiveness of the water testing activity, which was a cooperative, hands-on experience. As a result of this activity, in which I successfully activated prior knowledge, students reevaluated previous ideas about which materials are pollutants. This is the type of learning advocated by Piaget (2006), who noted that learners construct a "schema" through a process of assimilation and accommodation, encountering new information and adjusting their mental outlook based on new experience (Powell & Kalina, 2009).

The point of this project was to test the effectiveness of the curriculum and use the results to begin conversations between community educators, teachers, and natural resource managers about the possibilities for improving curriculum and collaboration. Currently, schools are limited in their ability to provide place-based learning to implement student-centered, hands-on teaching strategies using nature as a classroom. Collaborative education projects between community organizations and schools provide an important link in the effort to improve both student achievement and resource management goals (Posnick-Goodwin, 2005). Sharing various organizations' expertise optimizes educational resources and builds trust among participants, leading to an improved likelihood that collaborative educational efforts will inform decisions for protecting watershed health. The information gathered in this project points to the need for a better survey tool and more formal connections with schools to produce more effective curriculum and achieve desired outcomes.

Collaborative efforts require significant contact and communication with community partners and teachers. Bandy (2001) stresses the importance of coordinating with the teacher to ensure that curriculum needs are integrated. The three-day lesson could have been more effective if more background information had been provided to the cooperating teacher. In this way, she could have activated the students' prior knowledge, enabling them to be more receptive to the information. Also, the timing of the three-day lesson should have linked closely to what was being taught at that time; for example, this project would have fit well into the classroom teacher's unit on the biological classification scheme. Students identified and classified insects in the field, which would have supported the teacher's present curriculum. Follow-up activities also would have been beneficial; for example, the teacher could have had students test storm water runoff on campus and report their findings to the entire school population, in order to influence change.

Because community organizations, teachers and administrators change over the years and along with them their goals, an umbrella of collaborative educators and community members, aligned in a more formal partnership, is necessary to develop the type of continuity required for effective environmental education. Until such time as that occurs, it will be difficult to bring resource managers, teachers, and community groups together to achieve common goals.

Population growth in the Sacramento Valley is projected to double by 2040 (Johnson & Hayes, 2004), which implies that associated sources of urban runoff pollutants from small tributaries, such as Big Chico Creek, will become increasingly important to pinpoint and control. For this reason, projects which increase students' environmental awareness are critical to achieve resource management goals.

REFERENCES

REFERENCES

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ: Prentice-Hall.

American Institutes for Research. (2005). Effects of outdoor education programs for children in California. Retrieved from http://www.peecworks.org/PEEC/PEEC_ Research/01795C0D-001D0211.9/AIR%202005%20Outdoor%20School.pdf

Bandy, J. (2001.) Center for Teaching Service Learning Toolbox: Work pages and checklists to help you get started and keep you going. Portland, OR: Northwest Regional Educational Laboratory. Retrieved from http://cft.vanderbilt.edu/teaching-guides/teaching-through-community-engagement/community-engaged-teaching-step-by-step/

Bauer, M. (2012). *New York Times.* Retrieved from http://well.blogs.nytimes.com/2012/06/11/the-makings-of-our-earliest-memories/

Bloom, B. S. (1956). Taxonomy of educational objectives: The classification of educational goals. *Handbook I. Cognitive domain*. New York: David McKay.

Brooks, J. G., & Brooks, M. G. (1993). *In search of understanding: The case for constructivist classrooms.* Alexandria, VA: Association of Supervision and Curriculum Development.

Brown, F. (2000, Spring). Characterizing effective environmental education and its impact on pre-service students' environmental attitudes. *Journal of Elementary Science Education, 12*(1), 33-40. Retrieved from http://scholar. google.com/scholar?hl=en&lr=&ie=UTF-8&sa=X&oi=scholart&q=Shymansky,+1984,+and+inservice+learning

California Department of Education. (2012). Data quest educational demographics. Retrieved from http://dq.cde.ca.gov/dataquest/Enrollment/EthnicEnr.aspx?cYear=2011-12&cGender=B&cType=ALL&cChoice=SchEnrEth&cSelect= 04614240120394,Inspire%20School%20of%20Arts%20and%20Sciences

California Department of Transportation. (2003). *Stormwater quality handbook*. Sacramento: Government Printing Office. Retrieved from http://www.dot.ca.gov/hq/ construc/stormwater/CSBMPM_303_Final.pdf

Chin, J. (2004). *Final report of the Bay Area environmental education evaluation learning community. Bay Area environmental education: How do we know we're making a difference?* San Francisco: Blueprint Research & Design, Inc.

Choudhury, A. (2009). Spearman rank correlation coefficient. Retrieved from http:// explorable.com/spearman-rank-correlation-coefficient.html

Christ, G. M. (1995). Curriculums with real-world connections. *Educational Leadership 52*(8): 32-35.

Cleaver, S. (2007). Classrooms are going green: How green classrooms are reconnecting kids with nature. *Instructor, 117*(3), 20-24.

Crawley, F. E., & Koballa, T. R. (1992). Hispanic-American students' attitudes toward enrolling in high school chemistry: A study of planned behavior and belief-based change. *Hispanic Journal of Behavioral Sciences, 14,* 469-486.

Duschi, R., Schweingeruber, H. A., &, Shouse, A. W. (2007). Taking science to school: Learning and teaching science in grades K-8. National Research Council. Washington, DC: The National Academies Press.

Environmental Protection Agency. (2003). *Getting in step*: *A guide for conducting watershed outreach campaigns.* EPA 841-B-03-002. Retrieved from http:// water.epa.gov/learn/training/wacademy/upload/2008_09_12_watershed_wacademy_acad 2000_gettinginstep_getnstepguide.pdf

Fernandez-Gimenez, M. E., Ballard, H. L., & Sturtevant, V. E. (2008). Adaptive management and social learning in collaborative and community-based monitoring: A study of five community-based forestry organizations in the western USA. *Ecology and Society, 13*(2), 4. Retrieved from http://www. ecologyandsociety.org/vol13/iss2/art4/

Friedman, A. (Ed.). (2008, March 12). Framework for evaluating impacts of informal science education. Projects [On-line]. Retrieved from http://insci.org/resources/Eval_ Framework.pdf

GLOBE Program. (2002). *Global learning and observations to benefit the environment program* [Teacher's guidebook]. Retrieved from http://www.globe.gov/web/hydrology/overview

Glynn, S. M., & Winter, L. K. (2004). Contextual teaching and learning of science in elementary schools. *Journal of Elementary Science Education, 16*(2), 51-63.

Heberlein, T. A. (1989). Attitudes and environmental management. *Journal of Social Issues, 45*(1), 37-57.

Johnson, D. W., & Johnson, R. T. (1999). Making cooperative learning work. *Theory Into Practice, 38*(2), 67. doi:10.2307/1477225

Johnson, H. P., Hans, J. M. (2004). The Central Valley at a crossroads: Migrations and its implications. Policy Institute of California. Library of Congress Cataloging in Publication data. Retrieved from http://web.ppic.org/content/pubs/report/R_1104HJR.pdf

Keilsmeir, J. C., Scales, P. C., Roechlkepartain, E. C., & Neal, M. (2004). Preliminary findings: Community service and service-learning in public schools. In National Youth Leadership Council (Ed.), *Growing to greatness* (pp. 6-11). St. Paul, MN: National Youth Leadership Council.

Kim, B. (2001). Social constructivism. In M. Orey (Ed.), *Emerging perspectives on learning, teaching, and technology*. Retrieved from http//www.coe.uga.edu/epltt/ Socialconstructivism.htm

Kukla, A. (2000). *Social constructivism and the philosophy of science*. New York: Routledge.

Lieberman, G. A., & Hoody, L. L. (1998). *Closing the achievement gap: Using the environment as an integrating context for learning. Executive summary.* San Diego: Science Wizards. Retrieved from http://www.seer.org/extras/execsum.pdf

Louv, R. (2009). Do our kids have nature-deficit disorder? *Educational Leadership*, *67*(4), 24-30.

Lucile Packard Foundation. (2009). *High school dropouts*. Retrieved from Kidsdata.org

Luehmann, A. (2001). *Factors affecting secondary science teachers' appraisal and adoption of technology-rich project-based learning environments* (unpublished doctoral dissertation). The University of Michigan. Retrieved from http://scholar.google.com/ scholar?hl=en&lr=&ie=ISO-8859-1&q=project-based+learning%2C+April+ Luehmann+&btnG=Search

Manzanal, F., Rodriguez Barreiro, L. M., & Casal Jimenez, M. (1999). Relationship between ecology fieldwork and student attitudes toward environmental protection. *Journal of Research in Science Teaching, 36*(4), 431–453.

Marx, J. (2008). The effect of initial conditions and discussion on students' predictions for interactive lecture demonstrations. *AIP Conference Proceedings, 1064*(1), 143-146. doi:10.1063/1.3021238

McTighe, J., & O'Connor, K. (2005). Seven practices for effective learning. *Educational Leadership, 63*(3), 10-17.

National Research Council. (2000). *How people learn: Brain, mind, experience and school.* Washington, DC: National Academy Press. Retrieved from http:// www.csun.edu/ ~sb4310/How%20People%20Learn.pdf

Noddings, N. (2005, September). What does it mean to educate the whole child? *Educational Leadership*, *63*(1), 8-13.

Nuhfer, E. (2003). The knowledge survey: A tool for all reasons. University of Colorado at Denver and Delores Knipp, United States Air Force Academy. *To Improve the Academy*, *21*, 59-78.

Piaget, J. (2006). Reason. *New Ideas In Psychology, 24*(1), 1-29. doi:10.1016/ j.newideapsych.2006.04.003

Posnick-Goodwin, S. (2005, April). High schools on the hot seat. *California Educator, 16*(7), 6-19.

Posnick-Goodwin, S. (2012, April). Green the new color of learning. *California Educator*, *16*(7), 6-9.

Powell, K. C., & Kalina, C. J. (2009). Cognitive and social constructivism: Developing tools for an effective classroom. *Education, 130*(2), 241-250.

Remington, R. D., & Schork, M. A.(1985). *Statistics with applications to the biological and health sciences* (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall.

Rigney, M. (1997). *Final report volunteer monitoring in the San Francisco Bay*. Richmond CA: San Francisco Estuary Institute.

Scales, P. C., & Roechikepartain, E. C. (2005). Toward research-based standards for K-12 service-learning. Excerpted from *Growing to greatness*. NYLC Resource Center. Retrieved from www.nylc.org

Sims, J., & Reid, N. (1999, February). Statistical inference by confidence intervals: Issues of interpretation and utilization. *Physical Therapy, 79*(2), 186-195.

Smith, G. A. (2002). Place-based education: Learning to be where we are. *Phi Delta Kappan*, *83*(8), 584-594.

Spretnak, C. (1997). *The resurgence of the real: Body, nature, and place in a hypermodern world.* New York: Addison-Wesley.

State Water Resources Control Board. (2009). Clean water team compendium. Retrieved from http://www.waterboards.ca.gov/water_issues/programs/swamp/cwt_volunteer.shtml

State Water Resources Control Board. (2011). *Slow the flow* [DVD]. Retrieved from http:// www.swrcb.ca.gov/stormfilm/

Stewardship Council. (2009). *State of the great outdoors.* Retrieved from http://youth. stewardshipcouncil.org/documents/RFF-RPT-ORRG-State-of-Outdoors.pdf

Think Blue Maine. (n.d.). *Devil Ducks/Ducky II* [DVD]. Retrieved from http://www. thinkbluemaine.org/index.htm

Thompson, G., & Hoffman, J. (2005). Measuring the success of environmental education programs. Canadian Parks and Wilderness Society. Retrieved from http:// cpawscalgary.org/ education/pics/ee-success.pdf

Vygotsky, L. S. (1962).*Thought and language* (E. Hanfmann & G. Vakar, Trans.). Cambridge, MA: MIT Press.

Weinstein, M. (2008). Finding science in the school body: Reflections on transgressing the boundaries of science education and the social studies of science. *Science Education, 92*(3). Retrieved from jttp://dx doi.org/sce.20267 2008

APPENDIX A

CURRICULUM DESCRIPTION

April 3

Concept of Lesson 1: “What Is Stormwater?“

Activities included:

1. Pre Knowledge Survey
2. Watershed Map - Overview of Stream Team monitoring sites and some of the unique habitat features including a brief brainstorming activity aimed at linking human land use practices with urban run-off pollution prevention measures.
3. “What’s in the water? “ Practice proper use of monitoring equipment, test creek water “spiked” w/runoff pollutants, and graph results.
4. Inspire High Youth Stream Team Endangered Species Faire Participation. “Follow the Flow” display - http://www.thinkbluemaine.org/toolbox/display.htm
5. EPA Rachael Carson Contest, “Sense of Wonder” http://www.epa.gov/aging/resources/thesenseofwonder/
6. Overview of upcoming field trip
7. “Slow the flow,” 10 minute video of sources of runoff and measures to prevent: http://www.swrcb.ca.gov/stormfilm/
8. Other fun video clips:

April 10

Concept of Lesson 2: “Get To Know Your Creek”

Activities included:

1. Introductory team building activity
2. Overview of field day activities, stations
3. Learning Stations: 1) water quality; 2) map reflection; 3) physical habitat; 4) aquatic insects; 5) storm drain tour; 6) watershed model
4. Closing team building activity

April 23

Concept of Lesson 3: “ Cause and Effect of Water Pollution”

Activities included:

1. Sectors of Society That Generate Water Pollution
2. Brainstorming / Venn diagram
3. Group reading activity / 3-minute poster presentation
4. 2 minute videos:
   rubber ducky: http://media.maine.gov/cgibin/vid?id=utCwkeLRt3cLdLY
   devil ducks: http://media.maine.gov/cgi-bin/vid?id=mcazTfheJ2C71yl

5. Post Survey
6. “Making a difference” - Letter to the editor

Field Trip Guide:

Stream Team Analysis
First Name: ______________Last Name:_______________ Date: ________ Period: _____

<u>Water Quality Station</u>:

What are the physical and chemical conditions of the stream (pH, TDS, EC, Temp)?

Parameter	Sample #1	Sample #2	Sample #3	Sample #4
	Creek Water	Creek Water w/____________ (type of pollution)	Creek Water w/____________ (type of pollution)	Creek Water w/____________ (type of pollution)
Observations (clear, murky, foamy, smells like, etc……)				
	Measure 2x	Measure 2x	Measure 2x	Measure 2x
pH	/	/	/	/
TDS	/	/	/	/
EC	/	/	/	/
Temp	/	/	/	/

What is the surrounding land use, or how is this section of the creek used?

What are the weather conditions today?

How do our chemical tests compare to the state standards?

Acceptable range, pH: 6-5 to 8-5? _______________________________________

Acceptable range, TDS: 80 to 200? ______________________________________

Acceptable range, EC: 100 to 180? ______________________________________

Acceptable range, Temp: < 16 °C? _______________________________________

Is the creek ecologically healthy? please explain.

Aquatic Station:

How many different types of macroinvertebrates are present?

What portion of the macroinvertebrates collected are sensitive, moderately sensitive, or tolerant to pollution?

What are the percentages for the different macroinvertebrate feeding groups (omnivores: scrapers/ shredders/collectors, carnivores: predators)?

What are the names of the three organisms used to track stream health?

What are two characteristics of the organisms below that help you differentiate if from other organisms?

Ephemeroptera Common name: Mayfly	Plecoptera Common Name: Stonefly	Tricoptera Common Name: Caddisfly
1.		
2.		
Who eats them?	Who eats them?	Who eats them?
What do they eat?	What do they eat?	What do they eat?

Sketch each EPT insect: (Sketches need to be detailed enough to identify insect specimens)

Ephemeroptera (Mayfly)

Plecoptera (Stonefly)

Tricoptera (Caddisfly)

Watershed Model Station:

What is storm water runoff?

Name six (6) types of urban storm water runoff pollution:

Pollution Type	Source of Pollution	What can you do to prevent this pollution from entering the creek?
1.		
2.		
3.		
4.		
5.		
6.		

What impact do humans have on the health of Big Chico Creek?

Flow Measurement Station:

Site Name: **Date:** **Time:** **Team Members:**

Cross Sectional Area: Record depths at 1-foot intervals. Depth in inches = D

Wetted Width ________ Cross Section 1 (Upstream)

	#	D	#	D	#	D
_____bank (right/left)	1	0	21		41	
	2		22		42	
	3		23		43	
	4		24		44	
	5		25		45	
	6		26		46	
	7		27		47	
	8		28		48	
	9		29		49	
	10		30		50	
	11		31		51	
	12		32		52	
	13		33		53	
	14		34		54	
	15		35		55	
	16		36		56	
	17		37		57	
	18		38		58	
	19		39		59	
	20		40		60	
			Sum of section 1 =			in.

Wetted Width _________ Cross Section 2 (Downstream)

	#	D	#	D	#	D	
_____bank (right/left)	1	0	21		41		
	2		22		42		
	3		23		43		
	4		24		44		
	5		25		45		
	6		26		46		
	7		27		47		
	8		28		48		
	9		29		49		
	10		30		50		
	11		31		51		
	12		32		52		
	13		33		53		
	14		34		54		
	15		35		55		
	16		36		56		
	17		37		57		
	18		38		58		
	19		39		59		
_____bank (right/left)	20		40		60		_____bank (right/left)
			Sum of section 2 =			in.	

Convert inches to decimal feet

Section 1: ( )/12 = __________ ft.

Section 2: ( )/12 = __________ ft.

Average Cross Sectional Area =
(sum1)+(sum 2)/2

$$\frac{(\quad) + (\quad)}{2} = \underline{\qquad}\ ft^2$$

Average Surface Velocity = [ ] = [ ] X (.8) = [ ] ft./sec.

distance / avg. time ft. / sec. **Avg. Corrected Velocity**

Stream Flow = [ ] ft./sec x [ ] $ft.^2$ = [ ] **CFS**

Avg. Corrected Velocity Avg. Cross Sectional Area (Cubic Feet / Sec.)

<u>Storm Drain Tour Station:</u>

Where are storm drains typically found?

What is the purpose of a storm drain and how does it relate to a storm?

Where does the water go after it enters a storm drain?

What other materials can enter storm drains along with stormwater?

What does non-point source mean?

Name six (6) types of non-point source pollutants that enter storm drains.

Type of non-point source pollution	What can you do to prevent this pollution from entering a storm drain?
1.	
2.	
3.	
4.	
5.	
6.	

Stream Vegetation Station: (Naughty or Nice)?

1. Describe the vegetation in and around the stream, including the banks.

2. Sketch a picture of one plant or tree that you found interesting.

3. Name six (6) Native Plants and Non-native Invasive Plants

Plant name	Native / Non-native or invasive
1.	
2.	
3.	
4.	
5.	
6.	

APPENDIX B

PRE- AND POST-STORM WATER

KNOWLEDGE SURVEY

True or False: Circle the correct answer:

1. A watershed is a building in which one can store water bottles. T / F

2. A watershed is an area of land where rainwater and snow falls, and then drains into streams, creeks, rivers, lakes and oceans. T / F

3. oil, minerals, native plants, fish, wildlife and people are all part of a watershed. T / F

4. The riparian zone is a wildlife habitat found along the banks of a river, stream or creek. T / F

5. In cities and towns there are storm drains that lead to pipes underground that capture the rainwater and water from driveways, streets and sidewalks, and then drain directly to our creeks. T / F

6. Water that flows into storm drains goes through treatment before it enters our creeks and rivers. T / F

7. Plants, rocks and soil can clean polluted runoff water before it enters our waterways or trickles down into our water table. T / F

8. Big Chico Creek drains to the Sacramento River, which drains to the ocean. T / F

9. It is important to pick up your pet's waste so that it doesn't pollute our local waterways. T / F

10. Litter and soda pop should be dumped in the gutter, so that they can go down the storm drain. T / F

11. (Renumbered) In your opinion, where does most of the ***runoff water*** from your yard, gutter, street, or road end up?

☐the city sewage treatment plant ☐outlying farmland
☐local creeks and streams ☐a septic tank
☐other ____________ (please specify) ☐Don't know

12. (Renumbered) In your opinion, where does most of the ***waste water*** from flushed toilets, kitchen sink, and bathtub drainage end up?

☐the city sewage treatment plant ☐outlying farmland
☐local creeks and streams ☐a septic tank
☐other ___________ (please specify) ☐don't know

13. (Renumbered) Do you consider the weather forecast before applying or having someone apply pesticides and fertilizers to your lawn, garden, or outside plants?

☐Yes ☐No ☐Don't know ☐Doesn't apply

14. (Renumbered) Where do you wash your motor vehicle, lawn mower, camper, and/or RV ***most of the time***?

☐On the driveway ☐On the street
☐On the lawn ☐Commercial car wash
☐Other ___________ (please specify) ☐Doesn't apply

15. (Renumbered) Which of the following do you think causes pollution of our local creeks? (Check all that apply)

☐Fertilizer ☐Pesticides
☐Cigarette butts ☐Pet waste
☐Cleaning products ☐Automobile fluids
☐Soil ☐Lawn clippings (green waste)
☐Other ___________ (please specify)

Remaining survey questions were not included in project analysis:

6. Which of the following messages about keeping our gutters and local creeks free from pollution (such as litter, auto fluids, pet waste, fertilizer, and/or pesticides) did you hear or see recently? (Check all that apply)

☐Television commercial ☐Radio commercial
☐Daily newspaper ads ☐Weekly newspapers ads
☐Posters ☐Murals (downtown Chico)
☐Booth at a public event ☐Information from my child's classroom
☐Chico Clean Creeks Calendar
☐Internet site (www.keepchicoclean.org)
☐Storm drain markers with messages "No Dumping, Drains to Creek?
☐Environmentally-friendly car wash fundraiser

☐Stanky the Butt (In person and/or on Facebook)
☐The Stream Team website (www.thestreamteam.org)
☐Other ___________ (please specify)

7. Which of the following activities have you changed as a result of local messages about protecting our creeks and streams from water pollution within the past year? (Check all that apply)

Now I do:

☐Wash my vehicle on lawn or car wash.
☐Recycle used automobile fluid.
☐Prevent runoff from the lawn.
☐Compost or mulch lawn-clippings.
☐Dispose of pet waste in the trashcan.
☐Use *green* cleaning products.
☐Use *green* gardening methods.
☐Volunteer at Eco-friendly car wash fundraisers.
☐Volunteer to protect water quality._________ (please specify)
☐Other _________ (please specify)

Now I do not:

☐Dump anything into gutters or drains.
☐Dump anything into creeks or streams.
☐Over-fertilize my lawn.
☐Apply fertilizer or pesticides when rain is predicted.
☐Over-water my lawn.
☐Litter (e.g. cigarette butts and/or trash)
☐Other _________ (please specify)

Please answer if appropriate:

☐I did not hear or see any messages
☐I did not make any changes

8. What is your zip code? _________________

9. What is your age? ___________________

10. Have you ever participated in The Stream Team Citizen Monitoring Program?

Yes ____ No ____

If yes, When?

(Mark years you participated)

2011_____ 2010 _____ 2009 ____ 2008____ 2004-2008____

APPENDIX C

CONFIDENCE INTERVALS AND GRAPHS OF

INDIVIDUAL SURVEY QUESTION RESULTS

Table 1

Confidence Intervals For Expected Ranges by Percent

	Expected range of responses at 95% confidence interval			
Question	II	IC	CC	CI
1	5-33	55-93	71-91	4-23
2	0-30	60-93	78-94	1-17
3	5-41	48-84	64-85	8-29
4	45-78	12-44	59-83	9-33
5	0-15	78-100	69-90	9-33
6	43-79	9-46	71-90	3-23
7	23-54	36-67	46-75	15-45
8	30-73	59-81	59-81	12-34
9	17-82	0-62	89-98	0-8
10	42-84	2-44	83-96	0-13
11	0-17	77-95	81-97	0-13
12	39-73	16-50	59-81	12-34
13	84-96	1-12	33-97	0-47
14	71-89	6-23	74-100	0-18

Note: II=pre-incorrect/post-incorrect; IC=pre-incorrect/post-correct; CC=pre-correct/post-correct; CI=pre-correct/post-incorrect

Values were calculated using the following formula:

$$p_s \pm Z_{\alpha/2}\sqrt{\frac{p_s(1-p_s)}{n}}$$

Where p is the proportion of survey responses categories (II, CC, IC, CI)
Z depends on the level of confidence desired (95%)
n is the sample size (46 or 52)

Source: Remington, R. D., & Schork, M. A. (1985). *Statistics with applications to the biological and health sciences* (2nd ed.) (pp. 127-159). Englewood Cliffs, NJ: Prentice-Hall.

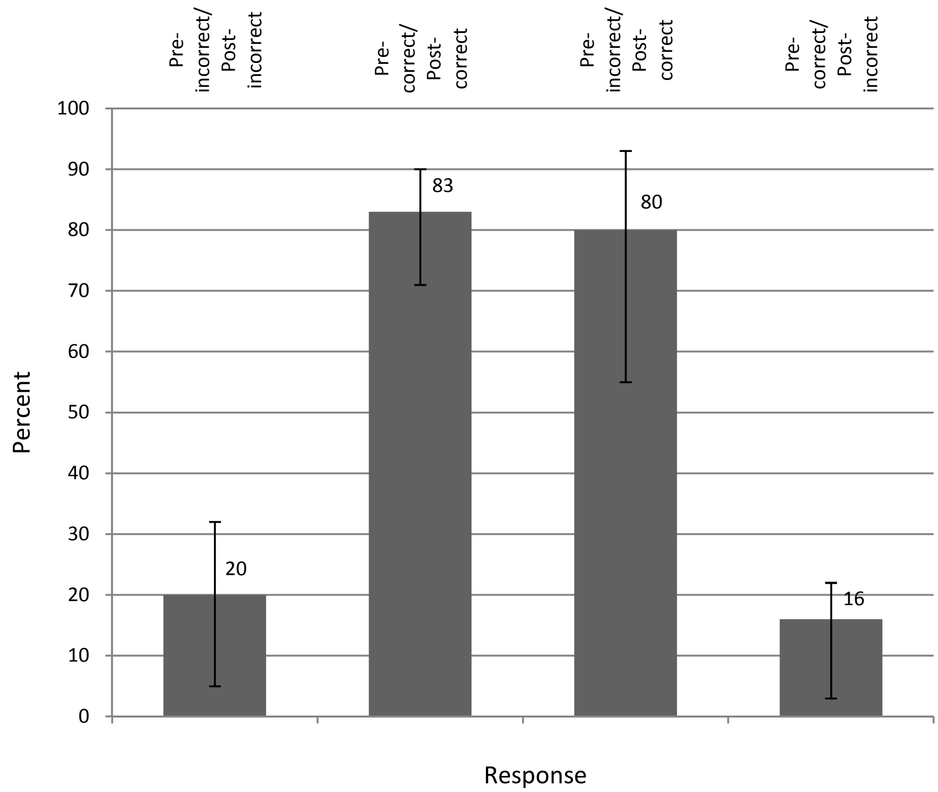

Figure 1. Survey question 1: A watershed is a building where one can store water bottle.

Question 1 Contingency Table

Response before	After		
	Incorrect	Correct	#
Incorrect	2	8	10
Correct	6	30	36
#	8	38	46

Proportion unchanged (not harmed): CC/# = 30/36 = 83.3%,
Z-interval = (.712, .955)
Proportion changed (improved): IC/# = 8/10 = 80%,
Z-interval = (.478, .951)

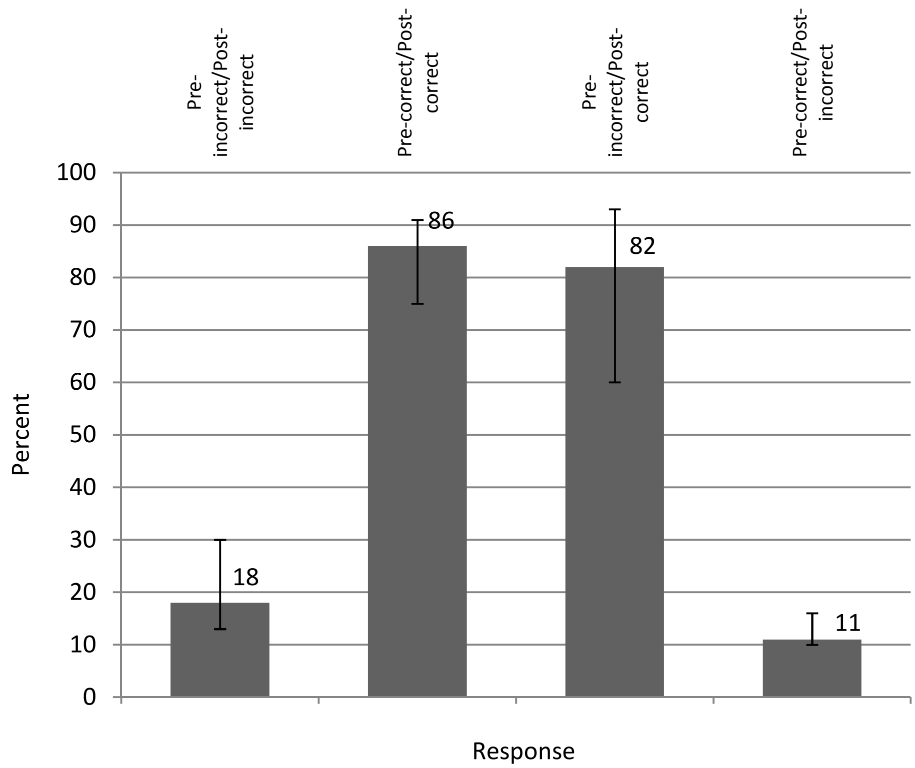

Figure 2. Survey question 2: A watershed is an area of land where rain-water and snow falls, and then drains into streams, creeks, rivers, lakes, and oceans.

Question 2 Contingency Table

Response before	After		
	Incorrect	Correct	#
Incorrect	2	9	11
Correct	4	31	35
#	6	39	46

Proportion unchanged (not harmed): CC/# = 31/35 = 88.5%
Z-interval = (0.78, .939)
Proportion changed (improved): IC/# = 9/11 = 81.8%
Z-interval = (0.59, 0.934)

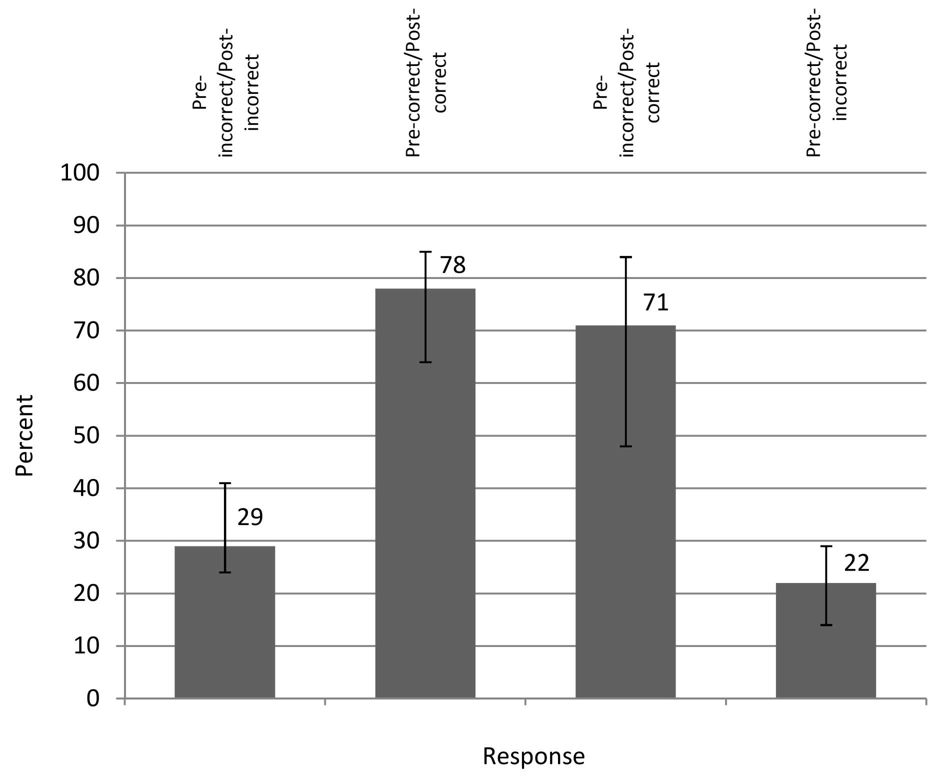

Figure 3. Survey question 3: Soils, minerals, native plants, fish, wild-life, and people are all part of a watershed.

Question 3 Contingency Table

Response before	After		
	Incorrect	Correct	#
Incorrect	4	10	14
Correct	7	25	32
#	11	35	46

Proportion unchanged (not harmed): CC/# = 25/32 = 78%
Z-interval = (0.638, 0.854)
Proportion changed (improved): IC/# = 10/14 = 71%%
Z-interval = (0.478, 0.835)

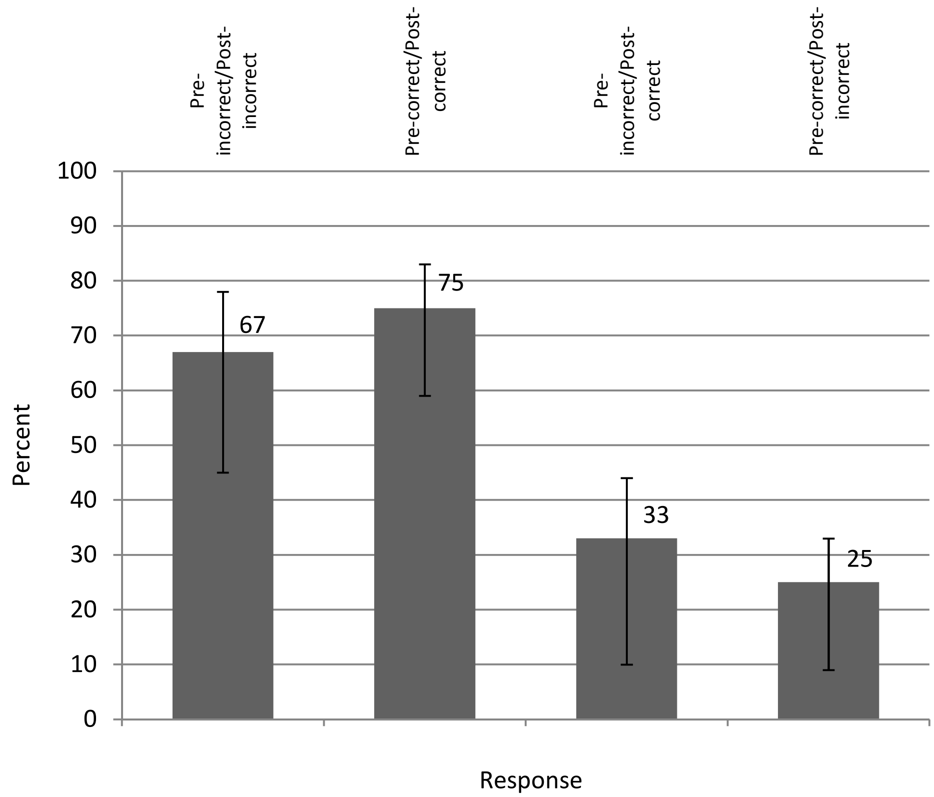

Figure 4. Survey question 4: The riparian zone is a habitat found along the banks of a river.

Question 4 Contingency Table

Response before	After		
	Incorrect	Correct	#
Incorrect	12	6	18
Correct	7	21	28
#	19	27	46

Proportion unchanged (not harmed): CC/# = 21/28 = 75%
Z-interval = (0.59, 0.832)
Proportion changed (improved): IC/# = 6/18= 33.3%
Z-interval = (0.116, 0.59)

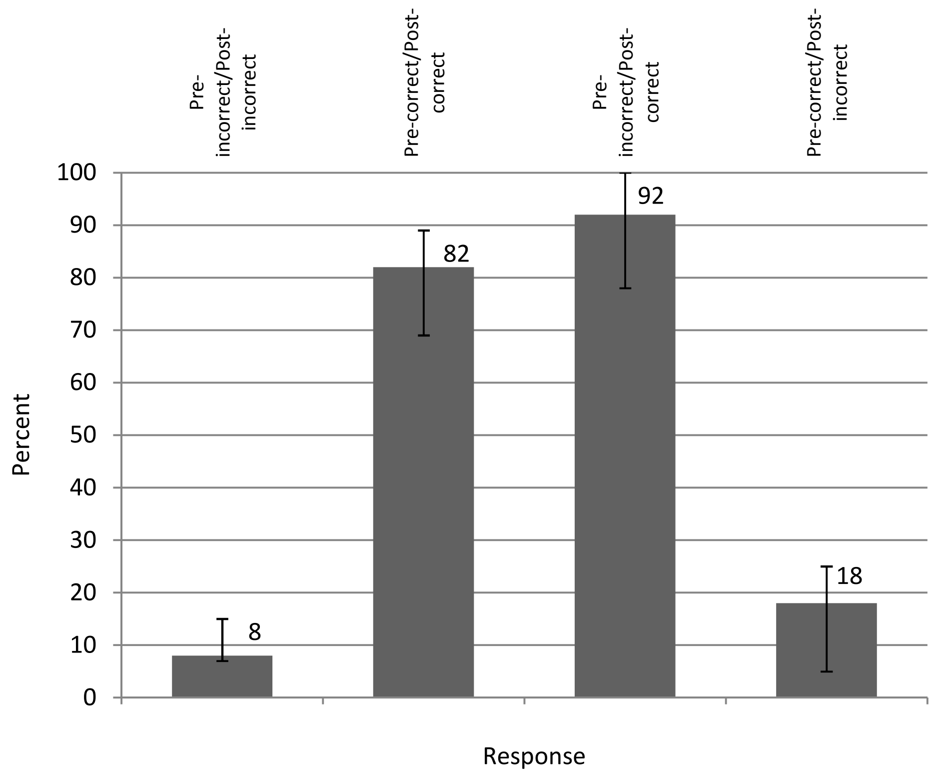

Figure 5. Survey question 5: In cities and towns there are storm drains that lead to pipes under the ground that capture the rainwater and water from driveways, streets and sidewalks, and then drain directly to our creeks.

Question 5 Contingency Table

Response before	After		
	Incorrect	Correct	#
Incorrect	1	12	13
Correct	6	27	33
#	7	39	46

Proportion unchanged (not harmed): CC/# = 27/33 = 81.8%
Z-interval = (0.678, 0.885)
Proportion changed (improved): IC/# = 12/13= 92.3%
Z-interval = (0.778, 0.997)

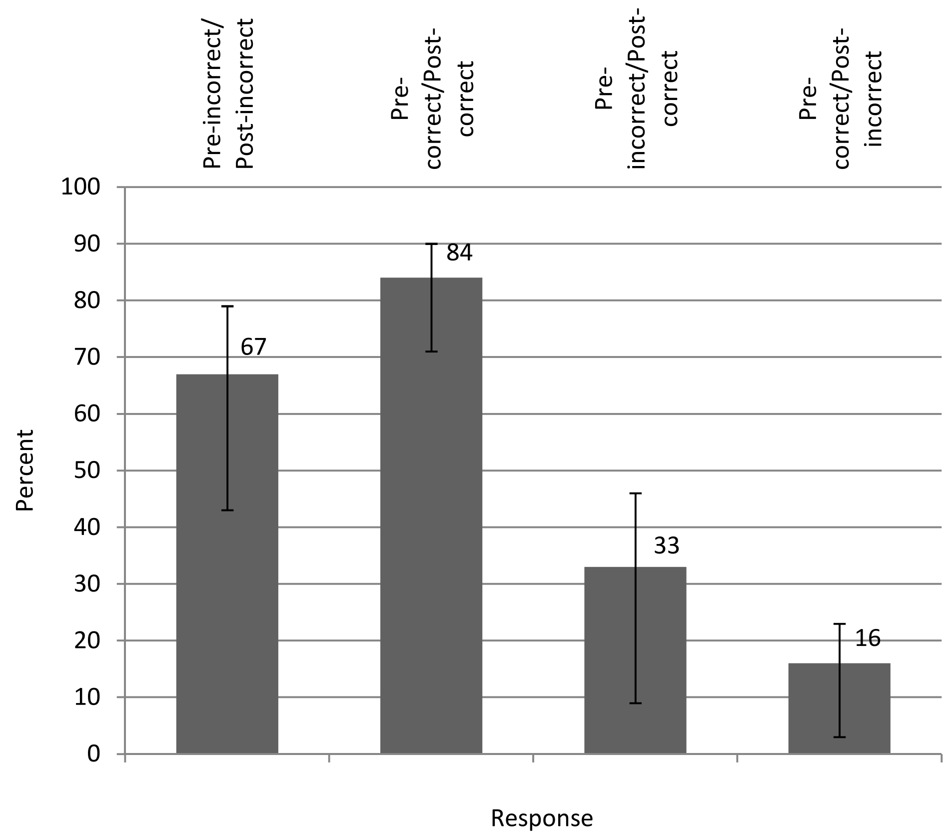

Figure 6. Survey question 6: Water that flows into storm drains goes through treatment before it enters our creeks and rivers.

Question 6 Contingency Table

Response before	After		
	Incorrect	Correct	#
Incorrect	10	5	15
Correct	5	26	31
#	15	31	46

Proportion unchanged (not harmed): CC/# = 26/31 = 83.8%
Z-interval = (0.709, 0.905)
Proportion changed (improved): IC/# = 5/15= 33.3%
Z-interval = (0.095, 0.455)

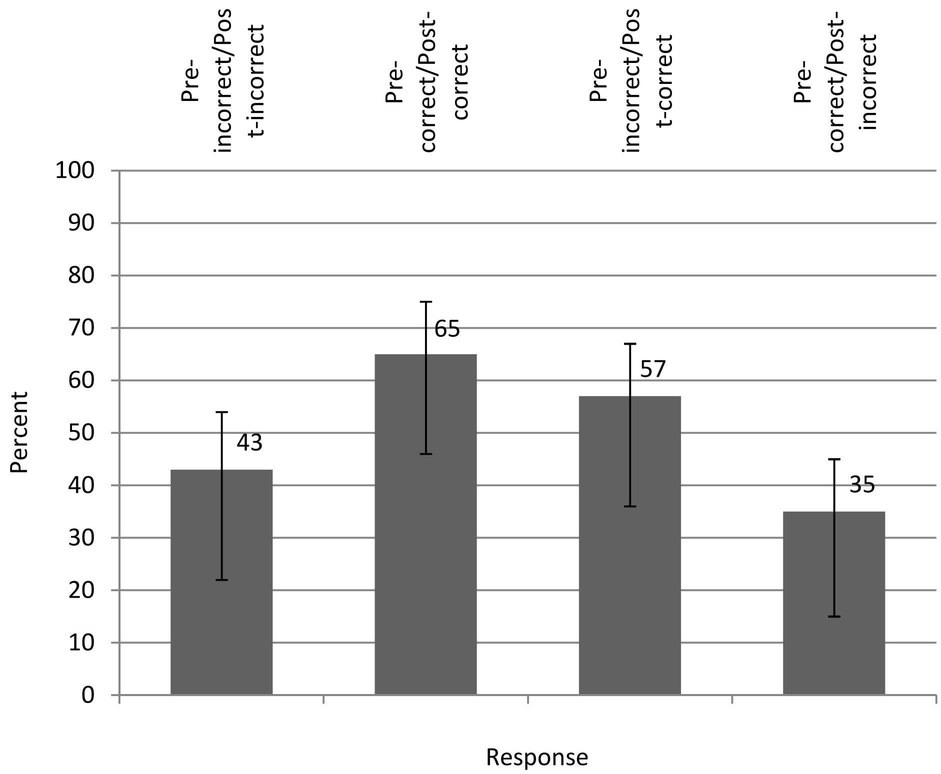

Figure 7. Survey question 7: Plants, rocks and soil can clean polluted run-off water before it enters our waterways or trickles down into our water.

Question 7 Contingency Table

Response before	After		
	Incorrect	Correct	#
Incorrect	10	13	23
Correct	8	15	23
#	18	28	46

Proportion unchanged (not harmed): CC/# = 15/23 = 65.2%
Z-interval = (0.458, 0.751)
Proportion changed (improved): IC/# = 13/23= 56.5%
Z-interval = (0363, 0.669)

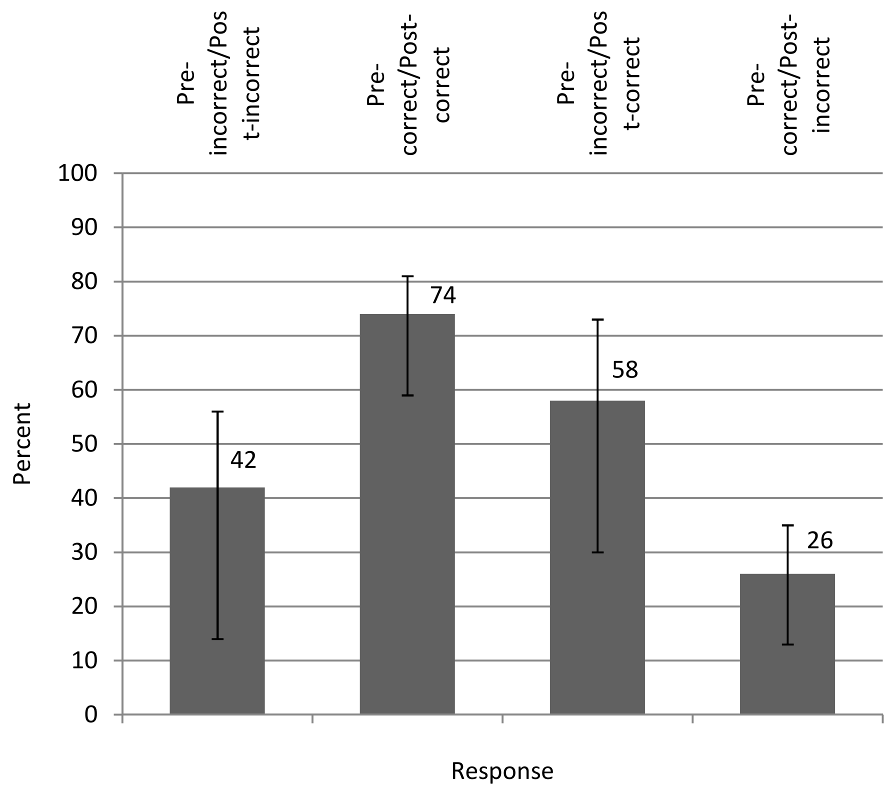

Figure 8. Survey question 8: Big Chico Creek drains to the Sacramento River, which drains to the ocean.

Question 8 Contingency Table

Response before	After		
	Incorrect	Correct	#
Incorrect	5	7	12
Correct	9	25	34
#	14	32	46

Proportion unchanged (not harmed): CC/# = 25/34= 73.5%
Z-interval = (0587, 0.811)
Proportion changed (improved): IC/# = 7/12= 58.3%
Z-interval = (0.304, 0.726)

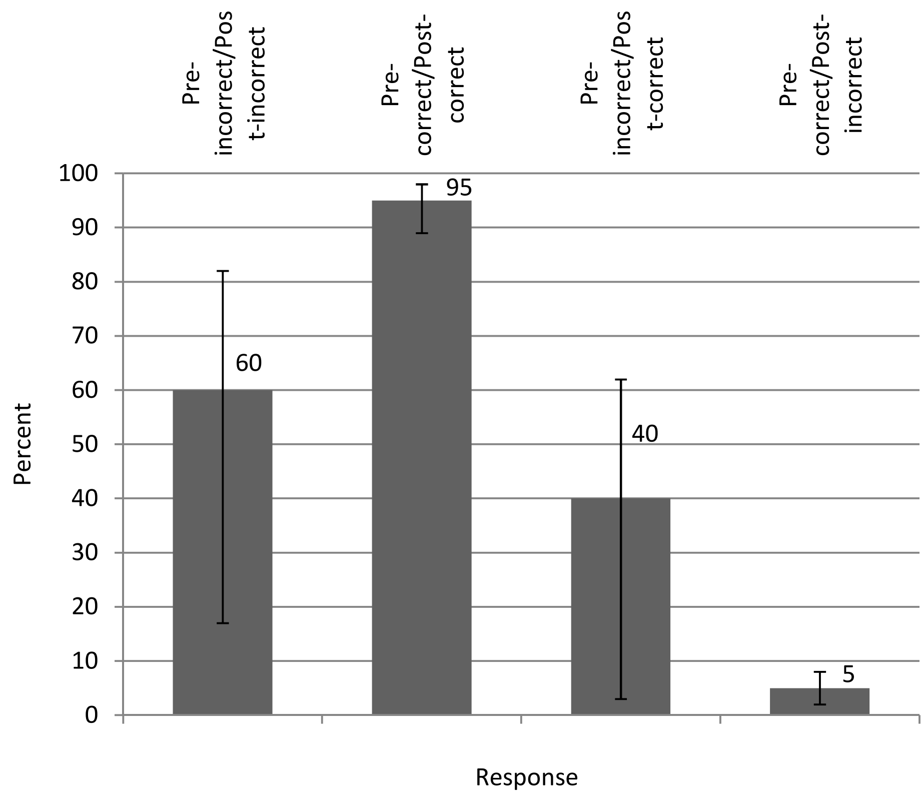

Figure 9. Survey question 9: It is important to pick up your pet's waste so that it doesn't pollute our local waterways.

Question 9 Contingency Table

Response before	After		
	Incorrect	Correct	#
Incorrect	3	2	5
Correct	2	39	41
#	5	41	46

Proportion unchanged (not harmed): CC/# = 39/41= 95.1%
Z-interval = (0.885, 0.985)
Proportion changed (improved): IC/# = 2/5 = 40%
Z-interval = (-0.03, 0.619)

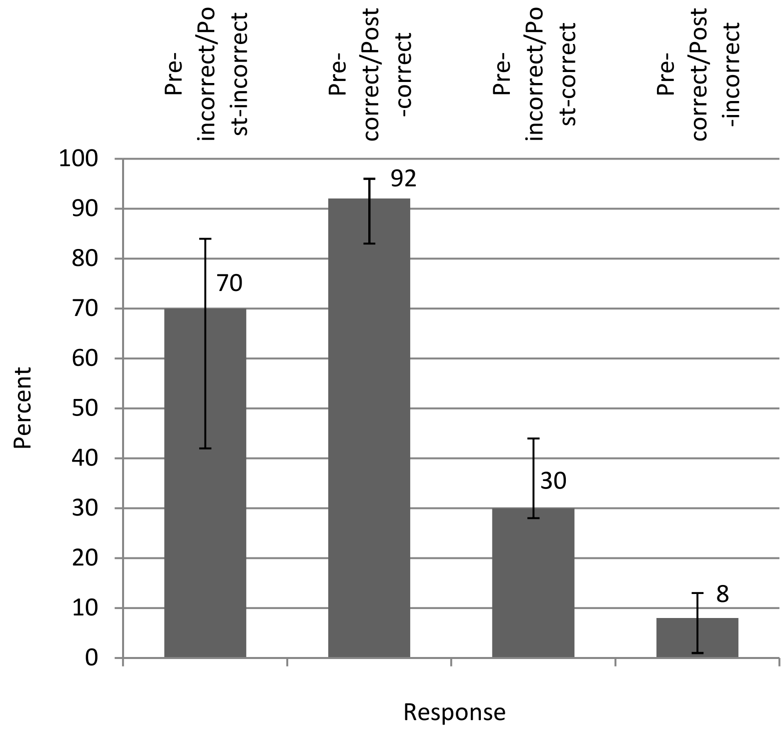

Figure 10. Survey question 10: Litter and soda pop should be dumped in the gutter so that they can go down the storm drain.

Question 10 Contingency Table

Response before	After		
	Incorrect	Correct	#
Incorrect	7	3	10
Correct	3	33	36
#	10	36	46

Proportion unchanged (not harmed): CC/# = 33/36 = 91.6%
Z-interval = (0.826. 0.963)
Proportion changed (improved): IC/# = 3/10 = 30%
Z-interval = (0.016, 0.445)

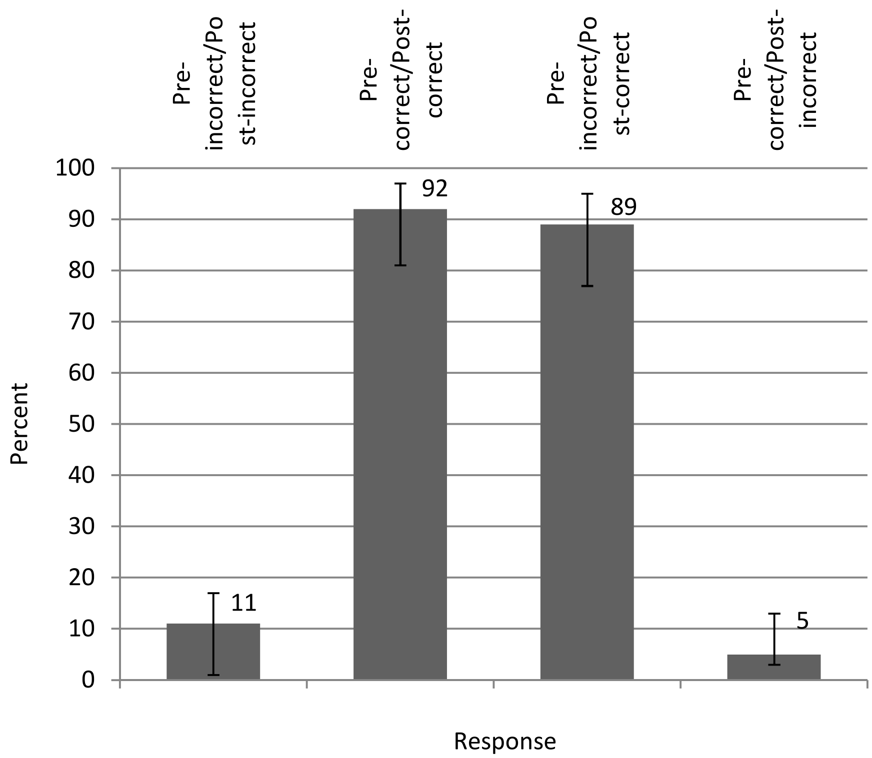

Figure 11. Survey question 11: In your Opinion, where does most of the runoff water from your yard, gutter, street, or road end up?

Question 11 Contingency Table

Response before	After		
	Incorrect	Correct	#
Incorrect	3	24	27
Correct	2	23	25
#	5	47	52

Proportion unchanged (not harmed): CC/# = 23/25 = 92%
Z-interval = (0.814, 0.974)
Proportion changed (improved): IC/# = 24/27 = 89%
Z-interval = (0.77, 0.949)

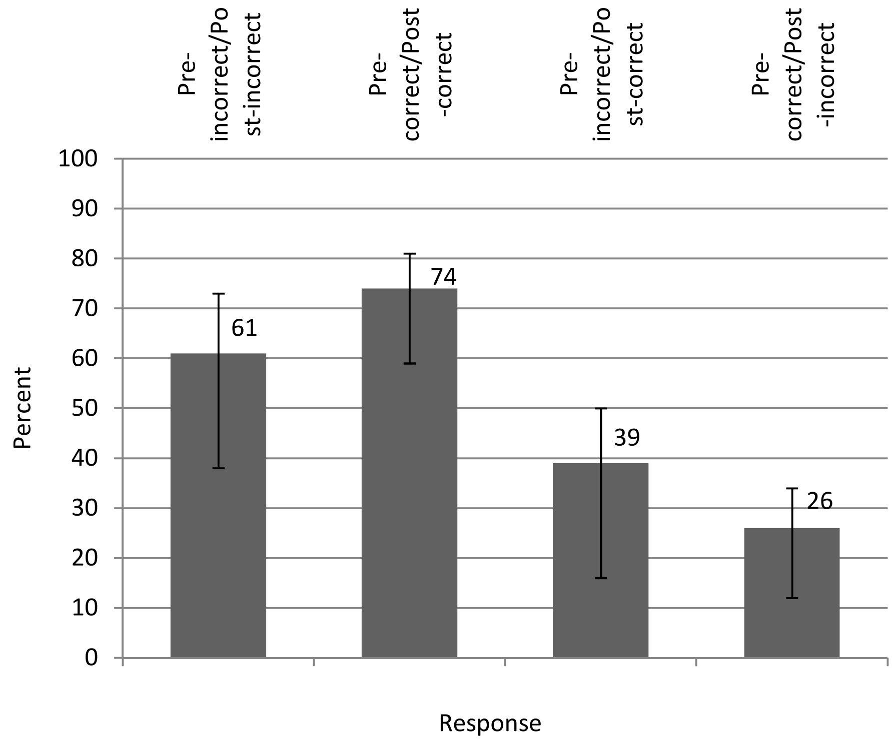

Figure 12. Survey Question 12: In your opinion, where does most of the wastewater from flushed toilets, kitchen sink, and bathtub drainage end up?

Question 12 Contingency Table

Response before	After		
	Incorrect	Correct	#
Incorrect	11	7	18
Correct	9	25	34
#	20	32	52

Proportion unchanged (not harmed): CC/# = 25/34 = 73.5%
Z-interval = (0.587, 0.811)
Proportion changed (improved): IC/# = 7/18 = 38.8%
Z-interval = (0.164, 0.504)

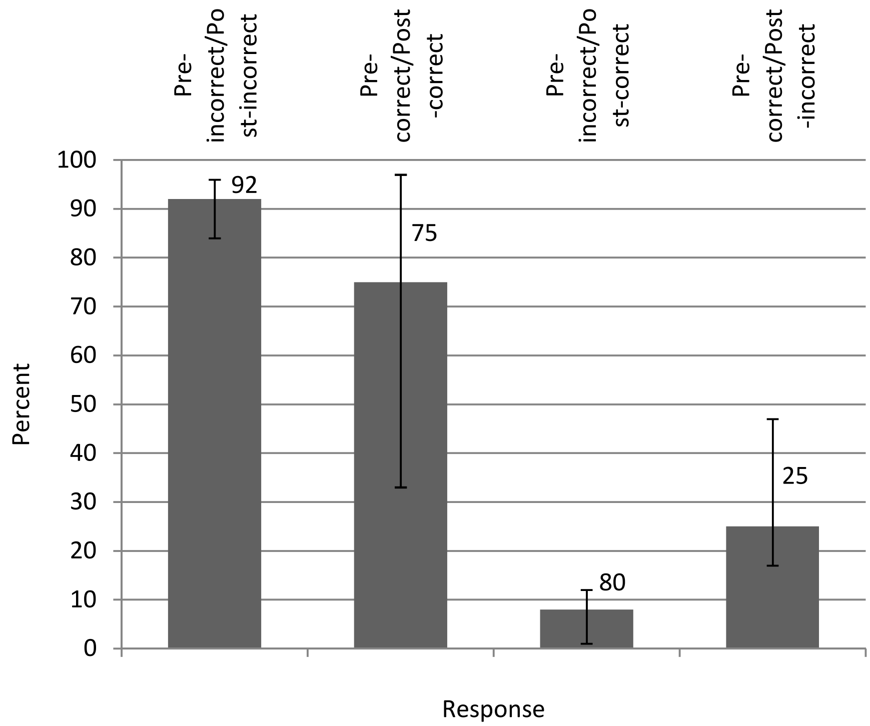

Figure 13. Survey question 13: Do you consider the weather forecast before applying or having someone apply pesticides and fertilizers to your lawn, garden, or outside plants?

Question 13 Contingency Table

Response before	After		
	Incorrect	Correct	#
Incorrect	44	4	48
Correct	1	3	4
#	45	7	52

Proportion unchanged (not harmed): CC/# = 3/4 = 75%
Z-interval = (0.326, 0.967)
Proportion changed (improved): IC/# = 4/48 = 8%
Z-interval = (0.005, 0.123)

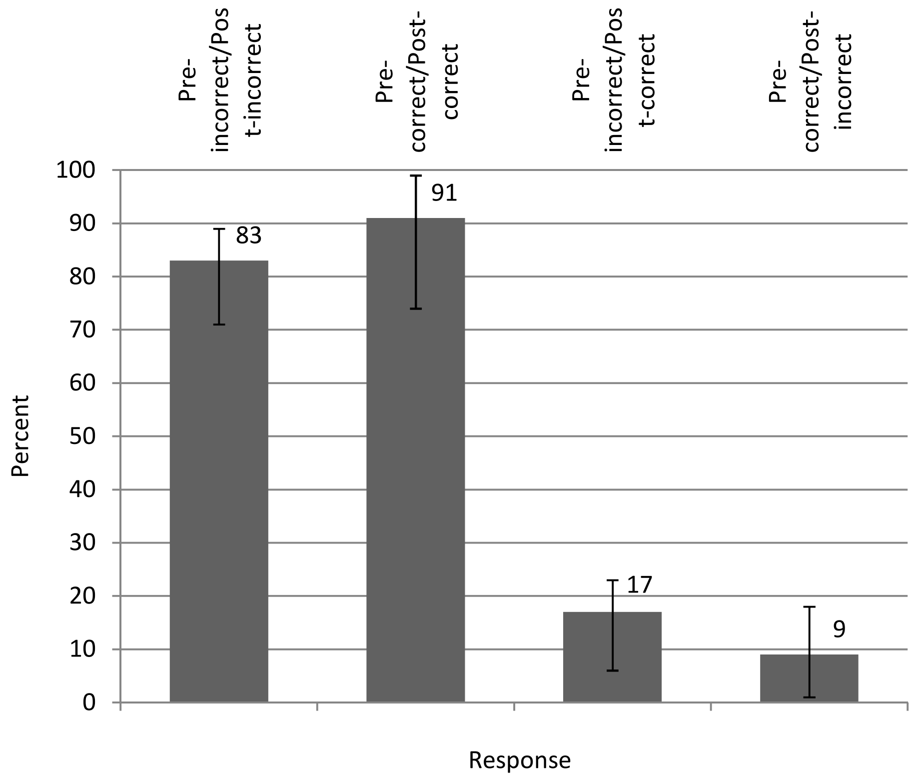

Figure 14. Survey question 14: Where do you wash your motor vehicle, lawn mower, camper, and/or RV most of the time?

Question 14 Contingency Table

Response before	After		
	Incorrect	Correct	#
Incorrect	34	7	41
Correct	1	10	11
#	35	17	52

Proportion unchanged (not harmed): CC/# = 10/11 = 90.9%
Z-interval = (0.739, 0.996)
Proportion changed (improved): IC/# = 7/41 = 17%
Z-interval = (0.156, 0.229)

Table 2

Spearman Rank Correlation Coefficient

r_s	Before	After				
Pollutant	(X_1)	(Y_1)	$R(X_1)$	$R(Y_1)$	$d_1=R(X_1)-R(Y_1)$	$(d_1)^2$
Fertilizers	17	46	6	7	-1	1
Pesticides	33	49	3	1.5	1.5	2.25
Cigarette butts	42	48	2	4	-2	4
Pet waste	30	48	5	4	1	1
Cleaning products	31	47	4	6	-2	4
Auto fluids	43	48	1	4	-3	9
Soil	8	45	7	8	-1	1
Lawn clippings	7	49	8	1.5	6.5	42.25
Other	0	9	9	9	0	0
					$Sum=(d_1)^2$	64.5
$r_s=6(\Sigma(d_1)^2 / (n) (n^2-1)$						
r_s =6(64.5)/9(80)=	0.538					
z =0.5375*SQRT(8)=	1.52					
P =	0.1285			alpha=0050		

Source: Choudhury, A. (2009). Spearman rank correlation coefficient. Retrieved from http:// explorable.com/spearman-rank-correlation-coefficient.html