CONNECTING STUDENTS AND REAL WORLD COMMUNITY PROBLEMS WITH SCIENCE LEARNING: USING RELEVANT ISSUES AND PRIOR KNOWLEDGE AS CONTEXTUAL SCAFFOLDS FOR SCIENCE ACHIEVEMENT

by

Brianna Jean James

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APPROVAL

of a thesis submitted by

Brianna Jean James

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citation, bibliographic style, and consistency and is ready for submission to The Graduate School.

Michael Brody

Approved for the Department of Education

Jayne Downey

Approved for The Graduate School

Dr. Carl A. Fox

STATEMENT OF PERMISSION TO USE

Brianna Jean James

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ABSTRACT

This article suggests a strong correlation between students believing that science is relevant and student achievement in science. Seventy two freshman students in a high school of 1800 students were surveyed and assessed on their experiences in science. The instructional method used through the course of the study was science taught through a relevant/authentic manner. The results of this study imply that if educators can tie their curriculum to science concepts, students will achieve higher in science.

INTRODUCTION

Background

It is becoming increasingly clear that science education is not appealing to all students. In a recent survey of a classroom at a high school, a bimodal distribution of students surfaced. There were about half of the students that thought science was “dull” and “not worth while” and about half that thought that science was “interesting” and “valuable”. (This survey was taken by the researcher a year prior to the study.) Students who do not see the value (or the relevance) in what they are learning may not learn the concepts nearly as well as those who see a value in their learning.

This lack of interest in science is leading to low numbers of students at or above proficient in science achievement according to federal standards. In the 2005 NAEP (National Assessment of Educational Progress), only 27% of students in the 8th grade scored at or above proficiency in science.

This issue needs to be addressed not only for the sake of attaining better prepared citizens but also to acquire higher funding for schools to be able to retain highly qualified teachers and obtain sufficient supplies for students to do meaningful learning activities. If the students are not learning, they will not perform well on the tests, and funding is lost; this means that teachers and materials for learning become less than desirable based on what schools can afford, leading to even less students performing at or above the proficient level.

Teachers can begin to determine what will help their students to better understand the subject they are teaching by using a scientific approach (AAAS, 1990). This entails teachers using the scientific method to methodically test their theories about education and adjust their methods based on their results. This will help to ensure students gain a sufficient level of understanding of science concepts.

Context of the Study

This study takes place in during the fall of 2010 in at Bozeman High School (BHS). The school’s 1800 students consist of a predominantly Caucasian population in a town (Bozeman, Montana) with a population of 39,282 (U.S. Census Bureau 2009 estimate). The Bozeman community is a college town and therefore one with a very high interest in education. The students involved in the study consisted of 72 freshman physical science students at Bozeman High School consisting of 35 male students and 37 female students (the average age of these students is 14 years). BHS has a total freshman population of 498 students. The students participating in the study were chosen first by whether or not they were in the researcher’s class. Then, students in the researcher’s classes were asked if they would like to volunteer for the study. In order to participate, the students and the parents were asked to sign a paper allowing the use of the student data for the research.

Problem Statement

Among the accepted principles in the literature related to science achievement are: putting science into context of the students’ prior knowledge and relating science to other subject areas to enhance the value of science knowledge to students (Hersek, Et. al., 2006). These principles were used in the design of this project to ensure that students are exposed to relevant learning topics in science. The problem is to see if the above recognized principles/strategies to teaching science work in my classroom to improve student achievement.

Purpose Statement

The purpose of this study is to improve my teaching through the use of action research and therefore improve student achievement in my classes. The changes that I make to better my teaching will are then founded on data from my students, not data that was collected in a different context.

Research Questions

By answering the below questions, science teachers will be able to get a better idea of how relevant learning works. They will be able to use the results to help students get a deeper, richer understanding of exactly what science is about and how they use science processes in their everyday lives even when they are not aware of it.

1. Is there a difference in achievement of students based on gender in this class?
2. Is liking/not liking science related to student achievement in science?
    a. When students like science, are they more likely to believe that it will be relevant in their career?
3. If students believe that science is relevant, are they more likely to achieve higher in science?

a. If students believe that science is relevant to their careers, are they more likely to achieve higher in science?

b. If students believe that science is relevant to their daily lives after high school, are they more likely to achieve higher in science?

4. How does a relevant curriculum effect student proficiency of specific content standards being assessed?

Limitations and Delimitations

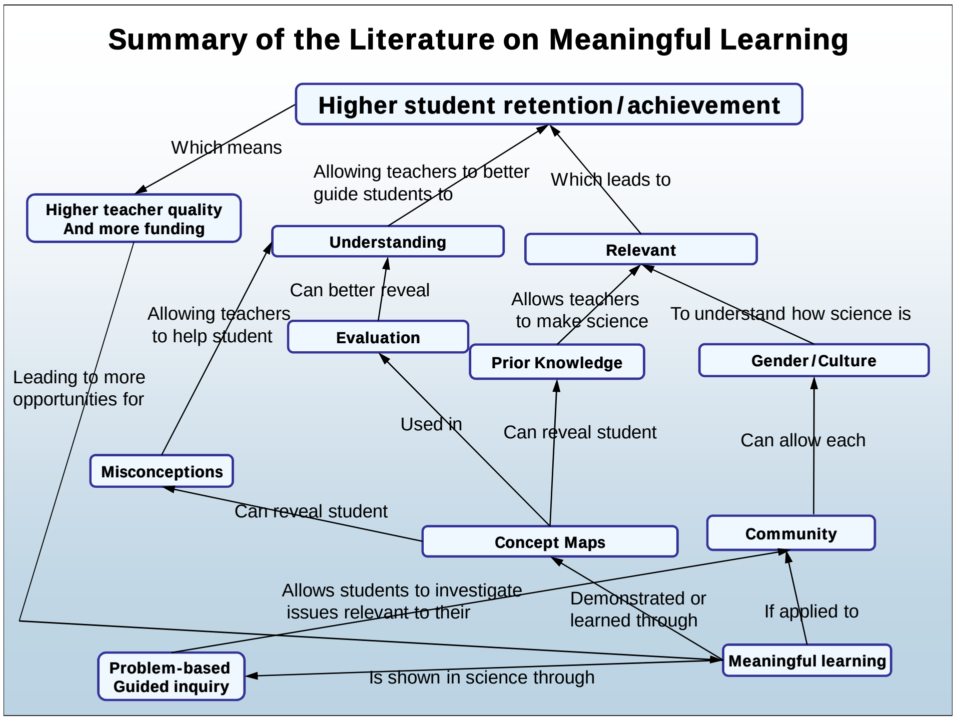
The general purpose of this study was to determine the effect of relevant learning on student achievement in science. The limitations of this study are that both the sample of convenience and the population demographics of the school population do not allow for the generalization of the data to the rest of the school or to any other high schools. This study suggests that further research with more schools and more teachers should be included in a more comprehensive study to give external validity to the data found.

The research will not address the following blind spots: 1) The cultural, race, and socioeconomic factors involved in patterns of engagement, because it is not feasible with so little variation in the population demographics. 2) The internal motivation or lack thereof in students because it is too problematic determining the factors affecting student motivation when there are so many variables that can affect student motivation. 3) The best method to make science relevant to “all” students when there are clearly other issues such as being homeless, etc. that are more important in some student’s lives (Barton, 1998). These areas provide potential areas for research in the future and would warrant further investigation into the literature.

The following is the literature that supports a classroom in which teachers give students information and inquiry-based learning experiences that make science relevant in any way, shape or form to their everyday lives.

LITERATURE REVIEW

Figure 1 illustrates the summary of the literature.



Action Research

Action research evolved in the mid-50s as a new methodology in the field of education research (Corey, 1953). It has changed the role educators to be one of both an educator and an investigator. This important transformation of teachers into researchers has allowed teachers to study and analyze their classroom methods and materials to determine how well they are working for the students and help the teacher develop new and improved classroom materials and methods. This has given teachers the ability to greatly enhance student learning and understanding.

The following action research will attempt to shed some light on the area of relevant/meaningful learning through student reported surveys in a course designed to teach through the use of guided inquiry and relevant/authentic learning experiences. Below is a review of the relevant literature.

Inquiry Based Instruction

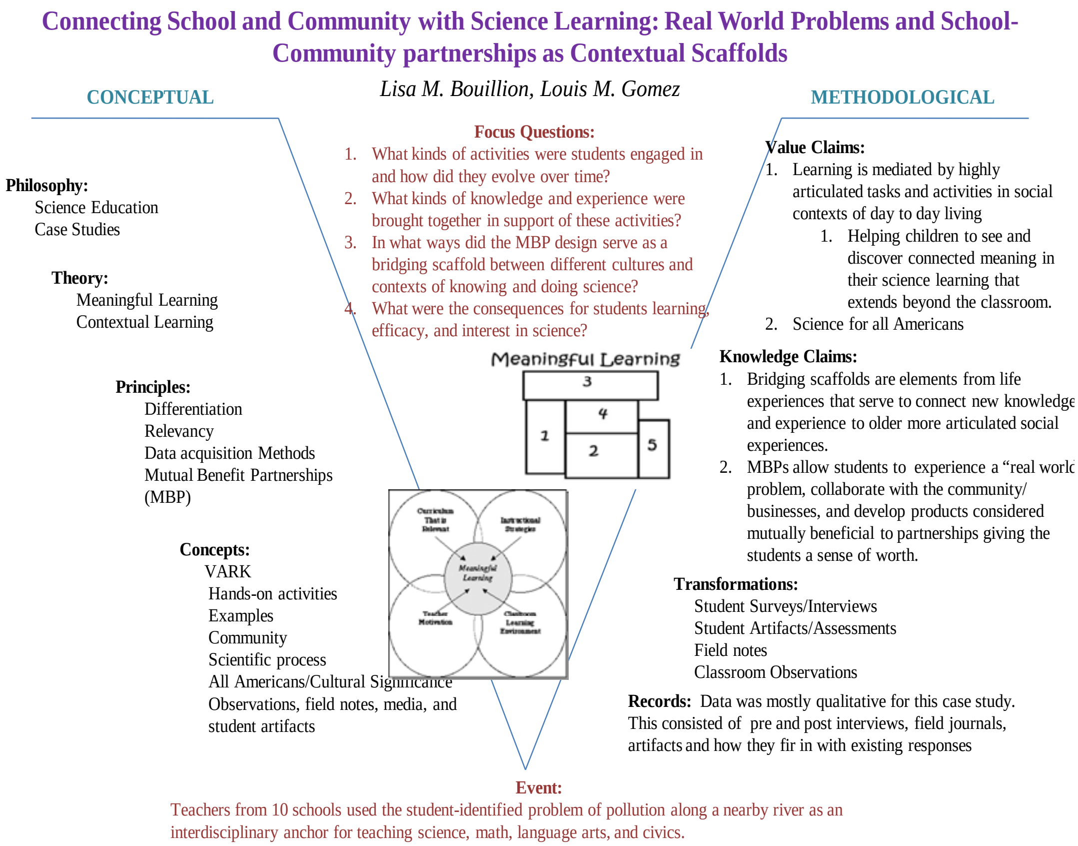
A problem that many educational institutions are currently confronting is the lack of connections between science education and topics that are relevant in students' lives. Even schools attempting to teach science through inquiry based instruction are not giving the learning any real meaning to students' everyday lives.

The four major types of inquiry, in order of increasing student independence are; confirmatory, structured, guided and open (Toth, 2009). It seems that the decrease in structure corresponds well with students developmentally as they go through school. Confirmatory seems more appropriate for elementary aged students as it is constrained to the pre-determined steps to obtain some form of data to evaluate and then explain. Structured seems more fitting for middle school students as they are able to independently develop inferences about the results and evaluations. Guided inquiry offers a great opportunity for students to prove their understanding of scientific processes as they are determining the methodology of how they will answer a pre-determined question and thus seems more proper for high school students. Finally, open inquiry is the most authentic inquiry experience that allows for higher level secondary education students and college aged students to independently come up with all aspects of the research. The following action research will focus on high school aged students and guided inquiry use, as it seems most appropriate.

It is well documented that inquiry, while a great tool for learning for some students, is an area in need of further research. Many students are unsuccessful in learning science through inquiry for several reasons. One reason is that they are ineffective at scientifically controlling the experiments that they are performing (Chen & Klahr, 1999). Because the students are ineffective at controlling the experiments, their learning is hindered. Another reason students fail to learn through inquiry is they have prior misconceptions that may misguide their conclusions from the experiments (Chinn & Malhotra, 2002). This bias keeps them from finding the true results of their experiments and truly understanding the science that has taken place.

One study by Bouillion and Gomez used problem-based learning, in a guided inquiry fashion, to help bring students and their community together through science research/activism. In the study, students from diverse backgrounds felt that science was separated from their lives. A disconnect such as this can cause many students to not have the thorough understanding that leads to long term retention of knowledge and of students in the field of science. Students, who had failed to see applications of their learning, had become unmotivated.

Figure 2 shows a detailed illustration of the study's methods.



The teachers in the Bouillion & Gomez study were able to reveal to the students through MBPs (mutual benefit partnerships) the importance of science not only to individuals, but to the community as a whole. More specifically, students in the study were able to come up with a problem in the community that needed solving (e.g. the creek in the community of the study) and begin to solve this problem through a teacher guided methodology and working with community organizations. This contextual scaffold encourages schools to work with communities and has been shown to help students to feel like an active, significant part of the community (Bouillion & Gomez, 2001; Radinsky, et al., 2001).

This made the students in the Bouillion & Gomez study realize how important it was for all Americans to have this content background (including them). When asked what they would say to a student, such as a younger cousin, who would be coming into the class next year one student said,

> *"[I would tell my cousin they could expect to learn] that even how small they are, they can make a different in the world."*

While another student said,

> *"[I would tell my cousin] that it's something you should really look forward to, something that when you believe that you're really doing something good in school, something that, like, it makes you feel good because you know you are helping out someone in your community."*

Bouillion and Gomez also discuss that each member of a team is essential to completing teamwork in science. This is especially important when thinking about all of those students that are not that interested in science. If you can show them the importance of their passion in science (such as those who like writing, scientific literature or those who are artists, diagramming/sketching) it may make the subject more relevant to their lives and the lives of community members.

Prior Knowledge Scaffolding

Most students are not able to make connections between their prior "real" knowledge and personal experiences to their new knowledge without proper scaffolding. Therefore, it can be argued that teachers need to provide students the proper tools to develop these connections. Prior research suggests that lecture is ineffective in engaging students in the curriculum (Hake, 1998). Research has also shown that in a college classroom, students feel more engaged in a science course when the teacher takes into account their prior knowledge and interests (Hersek, 2006).   Students in Hersek's study, learned science in ways relevant to them through cross-curricular materials and relationships with community organizations. Many of these students were non-science majors who found a use for science when they were taught how it related to their field of study (for example, musicians learning how sound, harmonics, waves, etc. work) and became more interested in learning science when they realized the relationship. This is what relevant learning will do for students; provide scaffolding for them to formulate the relationships between science, their communities and thus their lives (Bouillion & Gomez, 2001).

Relevant Learning Experiences

There are several different factors that account for relevant information in student's lives. The first is to determine prior knowledge to relate to what they already know. The second is to relate it to things that are important to them/use it in a real world context (Brown, Collins, & Duguid, 1989) (for example Newton's laws in relation to skate boarding or the above example of waves and music). The third is relating the science process to a decision making process or a way of thinking that may help them later on in life. Even if they are not "doing" science, they can use the scientific process, such as a way to determine what may be wrong with their vehicle.

Finally, it has been noted that students who feel they have an open dialogue among students and teachers

"…will see the allure of science and feel the thrill of discovery, and a greater diversity of intellects will be attracted to careers in science (Handelsman, Jo, Et. al. 2004)."

Noting the recent shortage of nurses and the various needs in medicinal, environmental, etc. research, this would be a distinct benefit to society.

Gender

In 1994, Sadker and Sadker used NAEP data to show that there was a divide in the genders. This divide showed that males were dominating females in the math and sciences. The 2005 NAEP report card for the state of Montana indicates no statistically significant difference between male and female students performing at or above proficiency. This is a great indicator that the achievement gap between the genders is closing. This will be tested in the study to rule out the possibility of students' gender playing a role in their achievement in science. It will also be important to separate male/female data because although the gender gap is closing in science achievement, some of the most recent statistics from the National Science Foundation (NSF) state that women represent about 20% of the math and science faculty at top research universities. According to a study by Catsambis, it appears that females sometimes have higher probabilities of enrolling in higher level science courses than their male peers, as well. These types of findings show a need to understand the reasoning behind limited participation of women in STEM careers. This presents a problem for females in these career paths by not having positive female role models and can cause these females to become less interested in careers in science and math after graduation.

Blind Spots

Concerning the research of relevant/meaningful learning, there are several blind spots. One of them concerns motivation. This specifically is in relation to students who have no internal motivation to do well in any subject for any reason, even if the material is relevant. Research by Anderson and Lee suggests that students with internal motivation but just lack interest motivation in science can change their attitude and progress in science. This is important for teachers to realize that even though students may not seem motivated to learn science, the student's passion for science can change drastically within a short period of time when it is presented in a way that is meaningful in their lives.

One other important issue that was established by Anderson and Lee is the patterns of student engagement based on race, culture, and socioeconomic status (SES). These factors were likely to predict which students would not be engaged in the science curricula, which has been shown in many previous studies as a direct result of students not seeing themselves as scientist material (Barton, 2000). There are some suggestive patterns in their data that gender is, to some extent, associated with the patterns of engagement as well. It is well documented that girls see themselves as outcasts to the subject of science (Brickhouse, 1994). However, this is less prevalent, maybe due to a small sample size, in the Anderson and Lee study than cultural, racial and SES effects. It seems that these patterns of engagement and the reasoning behind the patterns is a blind spot in the research that requires further attention, as well.

The background information suggests that teachers that can tap into their students' prior knowledge and reach them in ways that makes science relevant to their everyday lives through actual scientific investigations are more effective. After all, everything that students are taught is just information unless they 1) understand it, and 2) know what to do with it.

METHODS

Subjects of the Study

In the fall of 2010, 72 freshman physical science students at Bozeman High School were involved in this study. This sample consists of 35 male students and 37 female students. The population was the freshman physical science students at Bozeman High School (about 498 students). The above subjects were selected because the teacher involved in the study was also the researcher. The students in the researcher's classes were asked if they would like to volunteer for the study. In order to participate, the students and the parents were asked to sign a paper allowing the use of the student data for the research. The study will be helpful to the researcher in designing engaging lessons for the students involved.

Design

The overall design of this experiment is a non-experimental post-test only study. Because the study is not looking for a cause-effect relationship, but one of descriptives to be used to suggest other studies, this design is adequate. Also, the researcher believed it unethical for one group of students to receive an educational opportunity believed to enhance achievement and the other to not receive the educational opportunity. The students in the study received relevant science education throughout the course of the physical science class in the fall of 2010 and only were assessed through achievement on formative and summative assessments and were asked their opinion through a survey at the close of the study. This does present a threat to the internal validity of the study, however, because of the lack of a control group and therefore, lack of the ability to establish a cause-effect relationship.

The Montana Office of Public Instruction (OPI) standards and the Bozeman School District standards were used to design the curriculum that was used in the study. The Montana OPI standards are broader allowing for students to learn the standards for grades 9-12 in before the completion of grade 12. The Bozeman School District standards for the 9th grade curriculum are more specific (Bozeman Public Schools Science Standards, 9th grade). The students, throughout the course of the physical science course, learn chemistry concepts during the first semester and physics concepts with about 3 weeks of earth science concepts in the second semester. The summative assessments of each semester are the same for each class and each teacher of the class. Physical science teachers in the Bozeman School District may teach the concepts however they wish as long as the students master the concepts.

Most of the physical science teachers teach through traditional teacher centered teaching methods. This includes lecture, “cook book” or step-by-step labs, etc. While these methods are not ineffective, it seems that student-centered teaching (non-traditional methods) are more effective when time and circumstances allow.

Instruments/Data Collection

The following table is one showing the alignment of the summative assessment from the study (Appendix B) with the Montana Science Content Standards (Montana

Office of Public Instruction). This ensures that the assessment was measuring what was intended for students to learn.

Table 1
Alignment of Summative Assessment with the Standards

Question Number	Montana Standard
1	Content Standard 1: Benchmark 1: Essential Learning Expectation F, K Benchmark 2: Essential Learning Expectation B
2	Content Standard 1: Benchmark 2: Essential Learning Expectation G
3	Content Standard 1: Benchmark 2: Essential Learning Expectation E Benchmark 4: Essential Learning Expectation C
4	Content Standard 1: Benchmark 2: Essential Learning Expectation E Benchmark 3: Essential Learning Expectation E Benchmark 4: Essential Learning Expectation D
5	Content Standard 1: Benchmark 1: Essential Learning Expectation A
6	Content Standard 1: Benchmark 1: Essential Learning Expectation A
7	Content Standard 1: Benchmark 1: Essential Learning Expectation D
8	Content Standard 1: Benchmark 2: Essential Learning Expectation C
9	Content Standard 1: Benchmark 2: Essential Learning Expectation C
10	Content Standard 1: Benchmark 2: Essential Learning Expectation C
11	Content Standard 1: Benchmark 1: Essential Learning Expectation K
12	Content Standard 1: Benchmark 1: Essential Learning Expectation K
13	Content Standard 1: Benchmark 1: Essential Learning Expectation K
14	Content Standard 1: Benchmark 1: Essential Learning Expectation K
15	Content Standard 1: Benchmark 1: Essential Learning Expectation D
16	Content Standard 1: Benchmark 1: Essential Learning Expectation D
17	Content Standard 1: Benchmark 1: Essential Learning Expectation K

Note: Content Standards come from the Montana Office of Public Instruction. *Science Essential Learning Expectations.*

Students in the study took a survey self-reporting their opinions on a five point likert scale toward experiences in science (strongly agree, agree, neutral, disagree, and strongly disagree). The survey consisted of the following statements:

1. I like science.
2. I like to learn through labs the most.
3. I need to see diagrams to help me understand how things work.
4. I like to learn how things are relevant to my life, not just the facts.
5. When I learn how science relates to my life, it makes me more likely to remember it.
6. When I learn how science relates to my life, it makes me more likely to enjoy learning it.
7. I think I will use science after high school and/or college because of my job or career.
8. I think I will use science after high school and/or college in my daily life (NOT job related).
9. My opinion of science has been changing in a positive way through this class.

Data was also collected using both formative and summative assessments in the class.

These assessments resulted in the achievement scores (grades) in the class and the individual scores for each question in the summative assessment (to determine the specific content students struggled with). All of the assessments were created using Understanding by Design (UBD) to ensure that national, state, local standards were met.

The lessons for the unit were created with relevant learning styles in mind. First, the students learned that the science process was not just something that they would use in school. An example of a car that would not start was used to show the scientific process in action at a mechanics shop, and students came up with other examples in their daily lives where they have used the science process without thinking about it. The example was as follows.

Problem: The car will not start.

Background: A mechanic would have extensive background knowledge of what are the many possibilities that would result in this problem. They would have to gather knowledge from the car and come up with a hypothesis based on those facts.

Hypothesis 1: The battery is dead.

Experiment: Use a voltmeter to test the battery, get a new battery, or try to jump the car.

Results: The car still will not start.

Conclusion: There must be something else wrong with the car – come up with a new hypothesis.

The students, with guidance from the teacher, then came up with researchable questions for the stream that travels right outside the school (Mandeville Creek). Once the students came up with the research question (What is the quality of the water in Mandeville Creek?), the students came up with ideas on how to test the quality of water. The students were able to relate this information to real life after getting the results of the test by picking a form of communication to the community to let everyone know what the water quality of the stream was and how this affects the community. Students could pick from many things such as a letter to the mayor, a poster to hang in a building, etc. Students loved that what they were doing in school was something that was affecting the community in a positive way.

The data collection measurements are thought to be fairly reliable considering that the study's assessment methods are based on national, state and local standards. One thing that may be a problem is that the survey is self-reported. Not all students may have had the same interpretation of the likert scale. To one student, the scale measurements may not have been enough to choose from. Some students also may have been concerned that the teacher was going to see the data and wanted to do what they thought the teacher would want them to do. It was very clearly stated that the data would not affect their grade, yet there were probably still some students who just wanted to make the teacher happy.

Variables

The dependent variable was student performance/achievement in science. This was assessed by looking at the grade that they are earning in their physical science course and by analyzing the number of students proficient in each concept taught. This physical science course has been taught to ensure that the students understand the relevance of each topic that they are learning to everyday life. The assessments of student learning in the course are based on Montana and Federal standards.

The independent variables in the study are: gender (male or female), liking science, learning science through labs best, needing diagrams to help understand science, liking to learn how science is relevant to life, learning how science relates to life makes it more memorable, learning how science relates to life makes it more enjoyable, will use science in job or career, will use science in daily life, and throughout the class the opinion of science has changed for positive. All of the above variables, except for gender, are based on a likert scale and the data from the students was self reported.

The extraneous variables in this study are students knowing that they would need to put their names on the survey and knowing the teacher would be looking at them. The students were told that this would not affect their grade. However, they may have been looking for teacher approval when they came up with some of their answers to the statements.

A confounding variable to the study is that students were not assigned to the classes randomly. The students were assigned to the different classes based on their course schedule needs and also based on certain variables such as special needs (students considered gifted and talented are assigned to GATE (Gifted and Talented Education) classes, other students with special needs are assigned to co-lab classes (taught by both a special education and a regular education teacher).

Data Analysis

The data in the study was analyzed using the SPSS program. The first test done on the data was a means test to determine the relationship between the average grade (achievement level) and gender.

The second test that was run was a bivariate correlation using the Pearson correlation coefficient. The test of significance was two-tailed. A significance level of 0.05 was used, however relationships significant at the 0.01 level was marked as well.

RESULTS

The dependent variables in the study were student achievement (grade) in science and also student achievement on individual test questions. The students' grades in the class include how well they did on both formative and summative assessments. If the students did not turn in the assessment or take the assessment, they were given the grade of zero as it was assumed that the assessment was not understood. The independent variables in the study were: gender (male/female), liking science, relevant, relevance in their future career, and relevance to daily lives (all measured on a likert scale on a self reported survey). Also included in the data tables, but not used in the data analysis, are the variables of "easier to remember" and "more likely to enjoy". These variables are described as if science was made relevant to the student, they thought that it would be either easier to remember or that they would be more likely to enjoy learning science. The results are organized according to each of the individual research questions.

Is There a Difference in Achievement of Students Based on Gender in this Class?

Table 2
Grade vs Gender

Gender	Mean	*n*	SD
Male	83.4000	35	9.78955
Female	83.4865	37	9.59346
Total	83.4444	72	9.62082

Note: SD = Standard Deviation. *n* = number of participants.

Table 2 clearly shows that the mean grade/ achievement level is not dependent on gender. The females scored on average only 0.0865 % higher with the standard deviation (and thus the distribution of the scores) being very close to the same as well. Considering there has been an achievement gap in science between genders for a very long time, with males mostly achieving higher, this data is promising. From the data included in this study, there is not an achievement gap between the genders.

Table 3

Bivariate Correlations

Category	Correlation	Like Science	Relevant	Easier to Remember	More Likely to Enjoy	Relevant to Career	Relevant in Daily Life	Grade
Like Science	Pearson Correlation	1	.103	.095	.371**	.503**	.562**	-.290*
	Sig. (2-tailed)		.390	.428	.001	.000	.000	.014
	N	72	72	72	72	72	72	72
Relevant	Pearson Correlation	.103	1	.431**	.506**	.243*	.166	-.186
	Sig. (2-tailed)	.390		.000	.000	.040	.163	.118
	N	72	72	72	72	72	72	72
Easier to Remember	Pearson Correlation	.095	.431**	1	.628**	.351**	.201	-.076
	Sig. (2-tailed)	.428	.000		.000	.002	.091	.523
	N	72	72	72	72	72	72	72
More Likely to Enjoy	Pearson Correlation	.371**	.506**	.628**	1	.302**	.266*	-.033
	Sig. (2-tailed)	.001	.000	.000		.010	.024	.784
	N	72	72	72	72	72	72	72
Relevant to Career	Pearson Correlation	.503**	.243*	.351**	.302**	1	.534**	-.455**

Table 3 Continued

	Sig. (2-tailed)	.000	.040	.002	.010		.000	.000
	N	72	72	72	72	72	72	72
Relevant in Daily Life	Pearson Correlation	.562**	.166	.201	.266*	.534**	1	-.318**
	Sig. (2-tailed)	.000	.163	.091	.024	.000		.006
	N	72	72	72	72	72	72	72
Grade	Pearson Correlation	-.290*	-.186	-.076	-.033	-.455**	-.318**	1
	Sig. (2-tailed)	.014	.118	.523	.784	.000	.006	
	N	72	72	72	72	72	72	72

Note: The negative values in significance in the grade column are actually due to a positive correlation of the data. The highest value on the likert scale was the “strongly disagree” and the lowest was the “strongly agree” option. The positive correlations in the other columns are positive since both were on the same scale of values.
*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

Is Liking/not liking Science Related to Student Achievement in Science?

The effect of students’ liking/not liking of science on their achievement in science is significant at the 0.05 level. This makes sense because if a student likes science they are more internally motivated to learn more about the subject.

When Students like Science, are They More Likely to Believe That It Will Be Relevant in Their Career?

This study also found that if students liked science, they were significantly (at the 0.01 level) more likely to think that science would be relevant to their future career. This also makes sense because students who like science are more likely to choose a career in the STEM areas (Handelsman, Jo, Et. al. 2004).

If Students Believe That Science is Relevant, are They More Likely to Achieve Higher in Science?

The answers to the third set of research questions are interesting and require further scrutiny. Students that like learning how science is relevant in general do not significantly achieve higher in science than those who do not. This interesting inconsistency does not seem to support the study done by Bouillion and Gomez.

If Students Believe That Science is Relevant to Their Careers, are They More Likely to Achieve Higher in Science?

However, the students that believe science is relevant to their careers achieve higher grades in science at the 0.01 level.

If Students Believe That Science is Relevant to Their Daily Lives After High School, are They More Likely to Achieve Higher in Science?

Also, students that believe science is relevant to their daily lives after high school achieve higher in science. Both of these relationships are supportive of the Bouillion and Gomez study. This anomaly in the data made it clear that it was necessary to look into the bivariate relationships in between the independent variables of this question.

The bivariate relationship between whether students thought science was relevant in general and whether they thought it was relevant to their careers is still significant, but only at the 0.05 level. Interestingly, there was no significant bivariate relationship found between students who thought that science was relevant in general and students who thought that science would be relevant to their daily lives after high school. Finally, students who thought that science would be relevant to their careers also thought that science would be relevant in their daily lives (significant at the 0.01 level).

How does a Relevant Curriculum Effect Student Proficiency
of Specific Content Standards Being Assessed?

The achievement of students on the summative assessment from the unit (on the closed ended questions) is shown in the table below.

Table 4
Percentage of Students Proficient in Each Question

Question	Percentage
5	95%
6	93%
7	65%
8	93%
9	36%
10	98%
11	87%
12	93%
13	100%
14	93%
15	82%
16	84%
17	95%

Note: Refer to Appendix II to see each individual test question.

Table 4 illustrates the need for the teacher to find a better way to approach the concepts assessed by questions 7 and 9. The concepts in question 7 and question 9 that were not either not properly addressed are respectively: Content Standard 1: Benchmark 1: Essential Learning Expectation D – "Distinguish the independent and dependent variables by examining a scientific experiment/investigation" and Content Standard 1: Benchmark 2: Essential Learning Expectation C - "Apply the metric system by appropriate use of units and conversion factors” (Montana Office of Public Instruction). All other questions had an average above an 80%, which means that most of the students understood those concepts.

Summary

The above results show that for this specific sample, gender does not affect student achievement in science. It also shows that students liking science has a significant effect on how high they perform in science. Those students who liked science were also significantly more likely to believe that science would be relevant to their careers. It was interesting to find that students that believe science is relevant were not significantly more likely to achieve higher, but those who believed that it was relevant to their career or relevant to their lives after high school were likely to achieve higher. It seems that this relationship exists because students who thought that science would be relevant to their careers, also significantly thought it would be relevant to their daily lives after high school. Finally, it seems that a relevant curriculum, which is well planned out with the content standards, can help a majority of the students reach proficiency in each content standard.

DISCUSSION

The findings of this study clearly support what many others have found. Science achievement can be improved by helping students to understand how science is relevant to their daily lives and how it could be relevant to a future career (Handelsman, Jo, Et. al. 2004). This suggests that teachers should do their best to present the science content that they teach in a way that allows students to see the relationships between science and their lives. A good example of this might be using chemical reactions to explain why it is important to put baking soda in certain recipes or why you should be careful what cleaners you use together at home.

The above study also suggests that (at least at Bozeman High School) the gender achievement gap in science is closing. This has been speculated, for many reasons, to be happening across the country. According to National Center for Education Statistics (NCES), female graduates were 6 percent more likely than male graduates to have completed some advanced science course work. This implies that educators are doing a much better job of representing science a gender neutral subject. This does not mean that both genders are equally likely to choose specific disciplines of science, but does prove to be promising for the future.

Finally, the findings of the study suggest that internal motivation (liking science) may help students to achieve higher in science and that believing science is relevant to their daily lives/career is correlated to whether or not they like science. This ties back to the Bouillion and Gomez study and offers more evidence to support their theory of relevant/authentic learning experiences leading to higher student achievement in science.

It also supports their finding that relevant/authentic learning increases student efficacy in science. It is clear from this study that students who like science are more likely achieve higher in science, and are more likely to believe that they will use science in their daily lives after high school or in their careers after high school. These findings can help outline a better methodology in science education and perhaps help improve the deficit the nation is experiencing in this area.

Validity and Reliability

The threats to internal validity in this study are the non-experimental design (as described above), maturation (considering that this followed students over the course of 13 weeks), and experimental mortality. The threat of non-experimental design is already described above. The threat of maturation is a very real one considering that the students as freshman learn a lot in the beginning of the year that does not have to do with the class. Many students in their freshman year learn the importance of turning in assignments on time and studying. Finally, some of the students had to drop out of the study due to transferring classes.

The threats to external validity in this study include the sampling method and population demographics (proximal similarity). The sampling method was a convenience sample. This is therefore a non-random sample. Non-random sampling hurts the external validity of this study in that the sample may not be an accurate representation of the population of students. The students in some of the classes were placed in those classes specifically because they were co-lab classes (meaning there are a regular education content specific teacher and one special education teacher teaching the class).

Another problem with this sampling method is that none of the GATE students were represented. To get a more accurate representation of the population, random students from the entire class should have been studied to ensure an equal opportunity for all students to be part of this study. The population demographics in this study are also a threat to external validity. The population of this school may not be comparative enough to other schools to say with confidence that the data collected should describe other schools in the country, or even the state. The school's 1800 students consist of a predominantly Caucasian population in a town with a population of 39,282 (U.S. Census Bureau 2009 estimate). It would be necessary to study several other schools to ensure that the study was valid in other settings.

Theoretical and Practical Applications

The data from this study suggests that science teachers need to use relevant concepts to help students become proficient or above proficient in science. It seems that not only can teachers tie science to future career opportunities to help students understand science, but also tie it to daily life. Educators can use this study to help develop the lessons that they will use to teach specific topic areas in science. These lessons should appeal to students' prior knowledge and what they find relevant. A good way to determine how to best reach the class, teachers may want to take an interest inventory at the beginning of the year to help shape how they will teach those students that year.

A review of the literature by Osborne, Simon, and Collins (2003) reveals that over the last 30 to 40 years the studies of students' attitudes towards science play an important role in student achievement in science. This review of the literature also found that the following things are very important in student attitudes towards science: “the perception of the science teacher; anxiety toward science; the value of science; self-esteem at science; motivation towards science; enjoyment of science; attitudes of peers and friends towards science; attitudes of parents towards science; the nature of the classroom environment; achievement in science; and fear of failure on course (Osborne, 2003).” Student attitudes also change with the subject in science based on the perceived relevance to their lives. Students in Osborne and Collins (2000) identified sciences such as biology which they could see as relevant to their own bodies, etc. as more interesting than those such as chemistry and the periodic table, where the students could not identify any real life situations where they would use the table and its information.

Not only does the literature support that the use of relevance in science education improves student achievement, but the above study supports that a relevant curriculum improves student attitudes toward science. The data from this study will be used by the researcher to continue to develop the best possible lessons for interesting and motivating students in science using relevant to everyday life situations. Since the data suggests that there were specific areas that students are in need of more assistance in, these areas (Distinguish between independent and dependent variables and apply the metric system through appropriate units and conversion factors) will be further incorporated into the relevant learning curriculum. With the support from the study that these students learn best when they find learning relevant, the researcher will work on making the rest of the units that the students are taught relevant to their daily lives. The study also has helped the researcher to learn that the best possible approach to trying different teaching methods is action research. The action research method allows the researcher to determine if the method is working and helps to determine what really is and is not working for the students of the specific classroom.

The data from the survey especially will help form a new approach to teaching for the researcher. The data provides very strong suggestions that the relevant approach to teaching is beneficial to students when they can see how the science concepts relate to their future careers or use in daily life. The researcher will use this to continue to develop the lessons in the curriculum at Bozeman High School to best benefit the students' knowledge of science.

Recommendations for Future Research

The study is a good indicator that further research into relevant/authentic teaching in science is necessary. One very important study that needs to be done is a cause/effect study of students studying the same scientific concepts, one taught through more traditional methods and one through relevant/prior knowledge based methods. A study such as this could give more credibility to what students believe helps their learning (relevance to career and daily life, according to this study).

This study also suggests that it would be a great idea to research relevant learning with different sampling procedures to allow for a greater ability to generalize results to the population. Educators would then have a better theoretical framework to base changes in their lesson plans to provide more relevant learning experiences.

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APPENDICES

APPENDIX A

SCIENCE SURVEY

Science Survey Name ________________________

Please answer the following questions honestly by circling the one that you think best describes you. They have NO effect on your grade! ☺ They will help me to determine the best ways to teach you this year!

1. **I like science.**

Strongly Agree Agree Neutral Disagree Strongly Disagree

2. **I like to learn through labs the most.**

Strongly Agree Agree Neutral Disagree Strongly Disagree

3. **I need to see diagrams to help me understand how things work.**

Strongly Agree Agree Neutral Disagree Strongly Disagree

4. **I like to learn how things relevant to my life, not just the facts.**

Strongly Agree Agree Neutral Disagree Strongly Disagree

5. **When I learn how science relates to my life, it makes me more likely to remember it.**

Strongly Agree Agree Neutral Disagree Strongly Disagree

6. **When I learn how science relates to my life, it makes me more likely to enjoy learning it.**

Strongly Agree Agree Neutral Disagree Strongly Disagree

7. **I think I will use science after high school and/or college because of my job or career.**

Strongly Agree Agree Neutral Disagree Strongly Disagree

8. **I think I will use science after high school and/or college in my daily life (NOT job related).**

Strongly Agree Agree Neutral Disagree Strongly Disagree

9. **My opinion of science has been changing in a positive way throughout this class.**

Strongly Agree Agree Neutral Disagree Strongly Disagree

APPENDIX B

PHYSICAL SCIENCE CHAPTER 1 TEST

Name _________________ Class Period ________ Assign # _______ Date ________

Physical Science Chapter 1 Test

Short Answer: Answer the following questions in complete sentences.

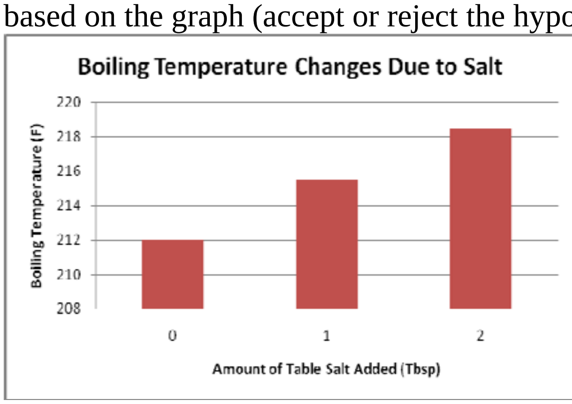
Jeremy decides to cook some pasta noodles. He notices that the directions say to add salt to the water before bringing the water to a boil The next day, Jeremy asks his science teacher, Ms. Jackson, a question: “How does adding salt affect the boiling temperature of water?” Of course, Ms. Jackson asks Jeremy to plan and conduct an experiment to find the answer.

The following questions are based on the experiment Jeremy does to find an answer.

1. Design an experiment for Jeremy to perform using complete sentences. Make sure to include in your answer what 1) the control group, 2) the experimental group, and 3) hypothesis is, and 4) whether he is collecting qualitative or quantitative data.

____
____
____
____
____
____
____
____
____

2. Below is a graph Jeremy created from the data he collected. Make a conclusion based on the graph (accept or reject the hypothesis and explain why).



____
____
____

3. When constructing a graph, what are the five things required for the graph to be considered well constructed? On which axis is each variable (independent and dependent) placed?

____

____

____

____

____

4. Sarah likes to race dirt bikes. She is trying to determine which bike she will buy and asks to test drive the two that she has narrowed it down to. Both times she presses the gas all the way and measures the distance that she is from the bike shop. Use the following information to create a graph. Make sure to have all five things required for a graph present.

Time(s)	Distance by bike 1 (m)	Distance by bike 2 (m)
0	0	0
10	15	18
20	30	36
30	45	54
40	60	72
50	75	90

How far has she traveled after 15 seconds on bike 2? ________________________

On bike 1? ________________________

Which bike should she buy? Why do you say that?

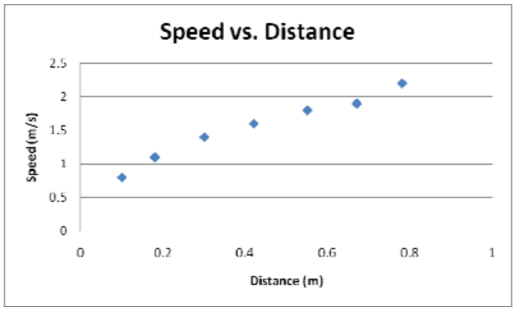
____

Multiple Choice: Circle the letter that best answers each question.

5. A control variable is:
    a. A variable that stays the same throughout an experiment.
    b. A variable that is changed in an experiment.
    c. The largest, most powerful variable in an experiment.
    d. Rarely used in scientific experiments.

6. Your motorcycle will not start. The process by which you solve this problem is called the:
    a. Hypothesis formulation.
    b. Data analysis.
    c. Scientific method.
    d. Engineering cycle.

7. On this graph, the dependent variable is:
    a. Distance.
    b. Speed.
    c. Acceleration.
    d. The slope of the speed vs. distance curve.



8. Which unit of measure would you use to BEST describe the distance from one town to another?
    a. Centimeter
    b. Meter
    c. Millimeter
    d. Kilometer

9. Which unit of measure would you use to BEST describe the mass of a penny?
    a. Milligram
    b. Kilogram
    c. Gram
    d. Centimeter

10. Which of the following is NOT a unit of the metric system?
    a. Meter
    b. Liter
    c. Gram
    d. Foot

Matching: Match the following terms with the correct definition.

a. trial
b. hypothesis
c. independent variable
d. dependent variable
e. procedure
f. valid
g. reliablity

11. _____ Occurs each time an experiment is run.
12. _____ A collection of all the techiques you use to do an experiment.
13. _____ An educated guess about what will happen in an experiment.
14. _____ If you have multiple trials that show the same data, this is showing _____________ in the experiment.
15. _____The thing that is changed by a scientist in an experiment.
16. _____ The thing that responds to the change made by the scientist.
17. _____ If your experiment is based on factual information, we say that it is __________.

APPENDIX C

WATER QUALITY PROJECT/LAB

Names ____ Class Period _______

Water Quality Project/Lab

Use the scientific method to complete the following project.

Problem:

____

____

Background information:

Temperature

Temperature is a very important aspect of water quality. Human activities should not change water temperatures beyond natural seasonal fluctuations. To do so could disrupt aquatic ecosystems. Temperature affects the solubility of oxygen and therefore affects fish. Good temperatures are dependent on the type of water body you are monitoring.

Nitrate

Nitrate is the byproduct of nitrifying bacteria breaking down ammonia and nitrite. Nitrate is used by aquatic plants and algae as a food source. High levels lead to excessive algae growth. The algae can use up the oxygen in the water and cause aquatic organisms to die.

Nitrite

Nitrite is a waste product produced by bacteria. It is extremely harmful to fish.

Hardness

Hardness is the measure of calcium and magnesium in the water. Water hardness affects the ability of aquatic life to maintain the correct balance between the body fluids and the environment. Hardness can also affect pH of the water.

Alkalinity

Alkalinity is the water's capacity to resist changes in pH that would make the water more acidic. Alkalinity of natural water is determined by the soil and bedrock through which it passes. The main sources for natural alkalinity are rocks which contain carbonate, bicarbonate, and hydroxide compounds. Borates, silicates, and phosphates also may contribute to alkalinity. Limestone is rich in carbonates, so waters flowing through limestone regions or bedrock containing carbonates generally have high alkalinity - hence good buffering capacity. Conversely, areas rich in granites and some conglomerates and sandstones may have low alkalinity and therefore poor buffering capacity.

Alkalinity is important for fish and aquatic life because it protects or buffers against rapid pH changes. Living organisms, especially aquatic life, function best in a pH range of 6.0 to 9.0. Alkalinity is a measure of how much acid can be added to a liquid without causing a large change in pH. Higher alkalinity levels in surface waters will buffer acid rain and other acid wastes and prevent pH changes that are harmful to aquatic life.

pH

pH is a measure of how acidic/basic water is. The range goes from 0 - 14, with 7 being neutral. pHs of less than 7 indicates acidity, whereas a pH of greater than 7 indicates a base. pH is really a measure of the relative amount of free hydrogen and hydroxyl ions in the water. Water that has more free hydrogen ions is acidic, whereas water that has more free hydroxyl ions is basic. Since pH can be affected by chemicals in the water, pH is an important indicator of water that is changing chemically. pH is reported in "logarithmic units," like the Richter scale, which measures earthquakes. Each number represents a 10-fold change in the acidity/basicness of the water. Water with a pH of 5 is ten times more acidic than water having a pH of six.

Pollution can change water’s pH, which in turn can harm animals and plants living in the water. For instance, water coming out of an abandoned coal mine can have a pH of 2, which is very acidic and would definitely affect any fish crazy enough to try to live in it! By using the logarithm scale, this mine-drainage water would be 100,000 times more acidic than neutral water -- so stay out of abandoned mines.

Turbidity

Turbidity is the amount of particulate matter that is suspended in water. Turbidity measures the scattering effect that suspended solids have on light: the higher the intensity of scattered light, the higher the turbidity. Material that causes water to be turbid include: Clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, plankton, and microscopic organisms.

Turbidity makes the water cloudy or opaque. The picture to the left shows highly turbid water from a tributary (where construction was probably taking place) flowing into the less turbid water of the Chattahoochee River in Georgia. Turbidity is measured by shining a light through the water and is reported in nephelometric turbidity units (NTU). During periods of low flow (base flow), many rivers are a clear green color, and turbidities are low, usually less than 10 NTU. During a rainstorm, particles from the surrounding land are washed into the river making the water a muddy brown color, indicating water that has higher turbidity values. Also, during high flows, water velocities are faster and water volumes are higher, which can more easily stir up and suspend material from the stream bed, causing higher turbidities.

Turbidity can be measured in the laboratory and also on-site in the river. A handheld turbidity meter (left-side picture) measures turbidity of a water sample. The meter is calibrated using standard samples from the meter manufacturer. The picture with the three glass vials shows turbidity standards of 5, 50, and 500 NTUs. Once the meter is calibrated to correctly read these standards, the turbidity of a water sample can be taken.

Hypothesis:
After reading the above background information and making initial observations of the stream, make a hypothesis concerning the stream's water quality.

____

____

____

Methods:

1. Observe the stream transect. What do you see? Which direction is the stream flowing? Is there anything that concerns you?

____

____

____

2. Draw a picture of the stream with any important details clearly shown on the drawing.

3. Use a meter stick to measure three meters along the stream. Use an object (rock, pencil) to mark the distance.
4. Choose a float that is only slightly buoyant to reduce wind effects. An orange, chunk of ice or a waterlogged stick are good options.
5. Place the float upstream of the defined starting point of the reach, so that the float is travelling at the velocity of the stream by the time it reaches the starting marker. Measure the time that the float takes to travel between the upstream and downstream markers using a stopwatch (start when it gets to the first marker and stop when it gets to the second). An average time (t) is obtained by taking multiple readings. Take 3 readings and record them in the Data section.
6. Remove one test strip from the bottle. Hold the strip at the end with no pads. Dip the strip (all pads) into the stream water and remove immediately.
7. **DO NOT** shake excess water from the strip.
8. Hold strip level to allow colors to develop. After 60 seconds, compare the pads to the freshwater color chart.
9. Record the results and dispose of the test strip.
10. Fill a cup with some water from the stream. Using a thermometer, find the temperature of the stream water in the cup right away. Do the same for an area upstream from the first area (as much as possible). Record the measurements below, find the temperature difference between the two.
11. For turbidity, take a cup and draw an X in the bottom. Put a sample of the water into the cup. If you can see the X through the water with no problem, the water is clear. If you can somewhat see the X, the water is blurry. Finally, if you cannot see the X at all, the water is opaque.

Data Collection:

Stream Velocity:

Distance between the starting and end point ______________________

Time it takes for object to move between two points. Trial 1 ___________________

Trial 2 ___________________

Trial 3 ___________________

Average time (add all three trials and divide by 3) ___________________

Velocity (distance/average time) _____________________

Temperature:

Temperature downstream ______________ Temperature upstream _______________

Change in Temperature ______________

Calculate the Water Quality Index: Circle the rating that fits your data the best. To calculate the water quality index, add the ratings together and divide by 4. Once you have calculated the index write it in the space provided and then write a short paragraph summarizing what you think that means (include the individual results of each test factor in your paragraph) in the ***Conclusion*** section of the lab.

Test Factor	**Result**	**Rating**
Temperature Change	0-2 C	4 (excellent)
	3-5 C	3 (good)
	6-10 C	2 (fair)
	> 10 C	1 (poor)
Nitrate	< 40 ppm	3 (good)
	> 40 ppm	1 (poor)
Nitrite	0 ppm	4 (excellent)
	0.5 ppm	3 (good)
	1-3 ppm	2 (fair)
	>3 ppm	1 (poor)
Alkalinity	0-40 ppm	2 (fair)
	40 – 80 ppm	3 (good)
	120-180 ppm	4 (excellent)
	>180 ppm	2 (fair)
pH	4	1 (poor)
	5	1 (poor)
	6	3 (good)
	7	4 (excellent)
	8	3 (good)
	9	1 (poor)
	10	1 (poor)

Turbidity	Clear (no blurring)	4 (excellent)
	Blurry (can see through but not completely)	2 (fair)
	Opaque (cannot see through at all)	1 (poor)

Data Analysis:

Water Quality Index Rating and Impact **Calculated Index__________**

4	Excellent	Total body contact (swimming) – **may** be ok for drinking
3	Good	Partial body contact (boating, surfing)
2	Fair	Limited body contact
1	Poor	No body Contact

Conclusions:

In this section, please include: 1) Talk about the results of the experiment, 2)Whether you proved or disproved your hypothesis, 3) What may have caused errors in the experiment and how you could fix them next time (what would make the experiment better), 4) What are the practical applications of the results? (This should be at least 10 sentences long.)

Communication:

This part of the assignment is putting together something that you might do to make the public aware of the research you have done; a few of the options are things such as a letter to the editor, a letter to the city, an advertisement, etc. All of these need to include a statement that is clear about your findings, and then the data to support your findings. This will be worth 20 points, so do your best!!!