

HOW DOES THE USE OF CASE STUDIES, AS AN INSTRUCTIONAL STRATEGY,
AFFECT THE PERCEPTION OF RELEVANCE OF SCIENCE IN A HIGH SCHOOL
CONCEPTUAL SCIENCE CLASS?

by

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DEDICATION & ACKNOWLEDGEMENTS

I would like to dedicate this paper to my extremely supportive husband, Mark and my two awesome children, Benjamin and Angela. All of whom encouraged me and helped with stuff around the house more than usual while I worked on my master's degree. I also want to thank my parents for their endless support and encouragement as I pursued advancing my education. I would also like to acknowledge my colleagues in this process whose encouragement really helped along the way.

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ABSTRACT

Students in junior level Conceptual Science at Manteno High School consider science irrelevant and are not motivated to learn the content. The goal of this research project was to incorporate a learning strategy that would increase student perception of the relevance of science to their lives and thereby increase their learning of the content. Case studies were incorporated into the two sections of Conceptual Science at Manteno High School for two units during the spring semester of 2013. Pre- and post- assessments were given to the students to measure their understanding of the content. An online survey was given to the students before and after the intervention to see how it affected their perception of relevance. Student interviews were conducted following the treatment as well.

Evidence collected during the study showed that while student learning increased during units when case studies were used, the perception of relevance of science was virtually unchanged. Students expressed in the survey and in the interviews that they like using the case studies in class because they feel it connects science to the real world even though no measurable difference in their perception of relevance of science was observed through the Likert style survey. Using case studies in a class like Conceptual Science increases student interest enough that it increased their learning. Even though student perception of relevance of science is unaffected, incorporating additional case studies in science courses should be considered because of the increase in learning.

INTRODUCTION

Working with students who are disinterested in science can be challenging. Much of this disinterest stems from the fact that students are unable to see the relevance of science to their everyday lives. One of my primary teaching goals is to communicate to my students the relevance of what they learn in class to their reality outside of class. The goal of this research study was to examine the effectiveness of one possible instructional strategy, using case studies, on increasing student learning and engagement in science. In the junior level Conceptual Science classes at Manteno High School, where I teach, many of the students seem disinterested in science and are not motivated to participate in class or complete homework. Many at this point have decided that they do not like science and it does not have anything to do with them or their everyday life. Students at Manteno High School are required to take three years of science to graduate. Those who are not planning to go to a four-year college take Conceptual Science as juniors to complete their third science credit. Some of these students have IEPs and there is a special education co-teacher in the classroom.

Manteno is a rural community in Illinois, near Chicago. The high school has an enrollment of 670 students, 9-12th grade. The student population of Manteno is 81.6% White, 4.9% Black, 9.5% Hispanic, and 1.1% Asian. 21.6 percent of our population is considered low income. Even though labs, hands-on activities, cooperative learning and interactive notes with an electronic student response system (Activotes), have been incorporated into the science teaching with the hope of stimulating interest, students still seem disengaged and disinterested in the lessons. This is especially true during the chemistry units, which is why I chose to focus my intervention on them.

This research project was conducted among the 43 students making up two Conceptual Science classes taught by myself at Manteno High School during the spring 2013 term, over a period of nine weeks. The main idea behind my intervention was incorporating problem-solving case studies related to the chemistry content matter to increase the levels of student learning and engagement in my science class. My primary research question was: How does the use of case studies, as an instructional strategy, affect student perception of relevance in the science classroom? Secondary research questions I investigated were: Does using case studies affect student perception of relevance? Does using case studies increase student learning? And, how does using case studies impact teacher attitude?

CONCEPTUAL FRAMEWORK

Using case studies to teach science could be a useful method for helping high school students understand the content, develop higher order thinking skills, and improve their perception of the relevance of science to their everyday lives. Case studies have been used to teach law, business, and medicine for many years and have recently been used to teach science, especially at the college level (Herreid, 1997). According to Herreid (2007), case studies are stories with a message that are used to educate. In the medical field cases are often real stories of real people having some health issue and the medicine students must solve the individual's problem to determine diagnosis and treatment. Business cases are often problems to be solved but may not have a particularly correct answer. Case studies in the science classroom are usually stories about people or fictional characters that have a dilemma or problem of some sort. Case studies can be

created in different formats for different purposes with the ultimate result of educating those who work through them.

Teaching with case studies addresses the need to teach science in a way that matches the National Science Education Standards. Learning science is something students do rather than having it done to them. It is an active process that gets them to ask questions, acquire knowledge, analyze and test natural phenomena and then report their findings to others (National Research Council, 1996).

Research in the use of case studies at the college level is more extensive than that at the high school level. In the 2009 study by Chaplin, research showed that the college biology course taught lecture style had significantly different outcomes compared to the case based course. In the lecture-based class, only 50% of students maintained or improved scores by 9 points from first to last exam, while the other 50% decreased performance an average of 13 points. In the case-based class, 80% of students maintained or improved scores by 9 points, while the other 20% saw a decrease of less than 3 points. The case-based class also saw more students earning higher percentages on their final exam and fewer failing. The conclusion of this study was that the use of case studies improved student achievement, understanding, and application of scientific concepts (Chaplin, 2009).

Another group of researchers were interested in surveying college faculty who had been trained in the use of case studies to see what they thought were the benefits and barriers to using case studies in their classes. The findings showed that there were many benefits. These include stronger critical-thinking skills, the ability to make connections across multiple content areas, a deeper understanding of concepts, better connections to

textbook readings, more retention and improved test scores, a better grasp of core course concepts, an appreciation of real world relevance, and an increase in student participation (Yadav et al., 2007). Some of the barriers reported by faculty in the study were a lack of time to prepare good case studies and a lack of already prepared good case studies.

A recent study at the high school level done by Kendra Eneroth (2011), showed the usefulness of case studies in a high school biology classroom. Students showed a greater amount of improvement in areas of knowledge, comprehension, and analysis in the units that were taught using case studies, as compared to the units taught with traditional methods. The study also revealed a greater level of engagement in the units that used case studies. However, the data regarding student motivation is somewhat mixed, partly because students had trouble connecting the cases to the content, even though they found the cases interesting.

A study carried out in Israel among high school students who weren't interested in science revealed that the use of case studies produced significant improvement in students' knowledge and understanding, and higher order thinking skills at all academic levels. Differences between low achieving and high achieving students were decreased. The students in the study reported that topics were interesting and relevant and that they felt group and class discussions were valuable (Dori, Tal, & Tsaushu, 2003).

According to a study done in 2003 at the high school level, another important aspect of using case studies is the increased level of engagement of students. If students feel that they are being challenged and having to use their skills they are more likely to be engaged. This is especially true if it is connected to a lesson that they perceive as being relevant (Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2003). Case studies are

intended to do just that by connecting the student to a story that makes the content they are learning more relevant.

Another study followed the use of case studies in an elementary school setting. The three elementary teachers involved in the study used primarily their own observations as a method of interpreting the effectiveness of the use of case studies in their classrooms. Students were exposed to four different case studies and over the course of the study, the students exhibited higher order thinking skills and more engagement with their classmates (Gabel, 1999).

Teaching with case studies leads to questions of how to implement them effectively. Flynn and Klein (2001) studied the effects of using case studies with and without small group discussion. Both groups were using case studies and worked with the case study on their own first, but the second group then met with a small group to finish their analysis of the case. The results showed that even though there wasn't a big difference in student performance on the case analysis, the students who worked with a small group preferred their method of instruction over those students who had to work alone.

Deciding whether using case studies makes a difference in student achievement, development of higher order or critical thinking skills, and perception of relevance requires the researcher to develop pre- and post- assessments to evaluate student achievement. Another useful tool for measuring student perception of relevance is student surveys or interviews. Rybarczyk, Baines, McVey, Thompson, and Wilkins (2007) were hoping to find out if the use of case studies in a college level cell biology course would diminish misconceptions that are common in this course and improve

higher order thinking skills. They used pre- and post- assessments and a post-activity survey to measure these two variables. The study indicated there was little difference in clarifying misconceptions between the experimental and control groups. But they did find that students in the case-based class experienced greater collaboration and the use of higher order thinking and critical thinking skills.

Using pre- and post- assessments and post- surveys as assessment tools is common among researchers testing to see if case-based learning makes any difference. Eneroth (2011), Rybarczyk et al. (2007), and MacDonald & McKee (2011) all used pre- and post- assessments with post- surveys with questions using Likert scale responses. In 2011, MacDonald & McKee used these measuring tools in a college psychology course and discovered that students in the case based section had significantly greater gains in content knowledge compared to students in the traditional section. They concluded that the inclusion of cases was helpful in student learning and made the class more enjoyable. This is not what they were expecting to discover according to the title of their article. They were concerned that the use of case studies could be merely a waste of time.

Siegel and Ranney (2003) developed their own tool for measuring student attitudes toward science for use in a high school classroom. They examined the reliability of their instrument of measurement through statistical analysis and found it to be mostly reliable in measuring student's perception of relevance of science to their lives. Another conclusion was that the perception of relevance of science can be altered in one semester just by using realistic, issue-oriented science activities. This would seem to support the use of case studies and possibly provide a tool to measure high school students' attitudes toward science.

C. F. Herreid (2005), distinguished teaching professor at the University at Buffalo, State University of New York, has published many articles on case studies and oversees a national clearinghouse for case studies. He maintains that case studies can be implemented in a variety of ways. Lecture, whole class discussion, small groups, individual case instruction, or a combination of these have all been used successfully. There are several characteristics necessary for a good case study. A case study should be short, controversial, have interesting characters with dialogue, be relevant to the students, and have a dilemma to be solved. Most of the available literature on case study teaching focuses on implementation at the college level. There are not many studies carried out in a high school science classroom, and the few available, like Eneroth's (2011) are often done in the context of biology, rather than chemistry. However, findings like those in the Rybarczyk (2007) and Chaplin (2009) studies of increased student learning with case studies can probably be extrapolated to the high school setting and to any science discipline. With such strong evidence of their effectiveness in increasing higher order thinking skills and perception of relevance among higher education students, there is a need for more studies like this one focusing on high school chemistry or conceptual science courses.

METHODOLOGY

According to the findings from studies by Herreid (2007), Chaplin (2009), and Yadav (2007), using stories to connect students to science can be an effective method of increasing problem-solving skills and perception of relevance of scientific topics. When selecting and modifying the case studies I would use in my intervention, I chose those involving real people as well as fictional characters that find themselves in an authentic

trouble situation or face a realistic problem of some sort. The task for my students was to creatively solve problems that were presented in the case studies.

Participants

The participants for this study were students in two of my Conceptual Science classes during the spring of 2013. This course fulfills the third credit of high school science for juniors who are struggling or reluctant learners. The course is divided into physics content (fall semester) and chemistry (spring semester). Many of these students have little interest in school or science and have trouble grasping any relevance of science to their everyday lives, particularly chemistry. This course is typically co-taught with a special education teacher since several of the students in this course have IEPs. The two participant classes had a total of 43 students, with approximate male to female ratio of 3:1. The demographics of the classes in terms of ethnic diversity was representative of that of the school.

Student perception of relevance of science to their everyday life and degree of student learning were measured while using case studies as an instructional strategy two units in the 3rd quarter with my Conceptual Science classes. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

Implementation of the use of case studies

The implementation of this research project took place over a period of nine weeks during the 3rd quarter of the Conceptual Science course. Case Studies were integrated into two chemistry units and during that time student perception of relevance

of science to their everyday life and degree of student learning were measured. I decided to implement the use of case studies in one class section at a time. This would allow me to compare the growth of the group that received the treatment with the group that did not receive the treatment. Group 1 received the treatment (the use of case studies) during the Atomic Structure and the Periodic Table unit. Group 2 was used as a control for this unit and taught in a traditional manner, without the use of case studies. During the next unit on Bonding, Group 2 received the treatment and Group 1 served as the control. This helped provide data to compare the use of case studies with one group that received the treatment and another group that did not receive the treatment on the same content. I chose to switch which group received the treatment so that both groups would have an opportunity to work with a case study.

The first case study used as treatment with Group 1 was a true story about a tragic accident involving college students who worked at Yellowstone National Park. (Appendix A) The case study guided students through several skill-building questions including reading comprehension, graphing skills, data analysis to predict other outcomes, and characteristics of elements. This case study launched the unit on Atomic Structure and the Periodic Table. This unit was two and one half weeks long.

The second case study used as treatment with Group 2 was a fictional story about a young man named Bill who was trying to decide whether he should try a new dietary supplement called SAME (Appendix B). The case study guided students through several skill-building questions including reading comprehension, describing atomic structure as it relates to bonding, explaining covalent bonding, and critical thinking in evaluating

supplements. This case study was used during the Bonding unit which lasted 3 weeks and was taught right after the Atomic Structure and the Periodic Table unit.

When students were working with the case studies, they did some individual reading, as well as small group discussion surrounding the questions related to the case study. This was then followed by whole class discussion. Each case had a follow up assignment that both classes had to complete regardless of their participation in that particular case. The assignment during the atomic structure unit had the students complete a table that asked the students to determine the number of protons, electrons, & neutrons, as well as the atomic number and mass number of several elements. The assignment during the bonding unit required students to compare covalent bonding and ionic bonding.

When students were not doing the case studies, the rest of the instruction was the same for the two groups. The only difference was whether or not the class used the case study to introduce the new topic.

Data collection tools

Prior to the intervention, students took an online survey (Appendix C) to get a baseline on their perceptions of the relevance of science to their own lives. This survey was then repeated after the completion of both units with both classes. Pre- and post-content assessments (Appendix D-E) for each unit were administered in both classes before and after each unit. Following the case studies, students were asked to write One Minute Papers (Angelo, 1993), for informal assessment on their understanding of the content being covered.

Another data collection tool used was student interviews near the end of the last treatment unit to see how the students felt about the use of case studies and whether they felt case studies affected their perception of relevance of science. Six students were chosen for the interviews, three from each class. The interviewees represent low, middle, and high achievement students based on their first semester grade. The interview questions can be found in Appendix F. I kept a journal with my observations and my own feelings and attitudes during both units. Since I have a co-teacher in this class I interviewed her after both treatment units. The data collected from the interview will address both student perception of relevance of science and teacher attitude toward using the case studies.

Table 1 shows the triangulation matrix of the data tools used to answer the research questions.

Table 1
Data Triangulation Matrix

Focus Questions:	Data Source 1	Data Source 2	Data Source 3
<i>Primary Question</i> 1. How does the use of case studies, as an instructional strategy, affect student perception of the relevance of science?	Student interviews post treatment	Student surveys measuring perceptions of relevance of science pre-treatment	Student surveys measuring perceptions of relevance of science post-treatment
<i>Secondary Questions:</i> 2. Does using case studies affect student perception of relevance?	Student interviews post treatment	Student surveys Pre- treatment measuring perceptions of the relevance of science	Student surveys Post- treatment measuring perceptions of the relevance of science
3. Does using case studies affect student learning?	Pre- assessments measuring prior knowledge and growth of knowledge during the unit.	Post- content assessments measuring prior knowledge and growth of knowledge during the unit.	Student created One Minute Papers
4. How does using case studies affect teacher attitude?	Personal journaling during the non treatment unit	Personal journaling during the treatment unit	Co-teacher interview

DATA AND ANALYSIS

The purpose of this study was to determine the effects of using case studies in a junior conceptual science course on student learning, perception of relevance of science and teacher attitude.

Impact of Using Case Studies on Student Perception of Relevance of Science

The first question addressed by the data in this study is whether or not student perception of relevance of science is affected by using case studies. Before using case studies in my Conceptual Science classes, students took an online survey to see how relevant they perceive science to be to their everyday life. The survey was then given to the students again after the two units that included the case studies. The online Perception of Relevance Survey (Appendix C) was given through Google forms and the tallying of the student's responses was done for me. I assigned scores of 1-5 to the responses to establish a numerical value. I then compared the value of each question's responses before treatment and after treatment to determine if there was any statistically significant difference and to see if there was any change in their perception of relevance of science over time.

Overall, the survey doesn't completely support or refute the use of case studies in making science relevant to the students in my Conceptual Science class. But, the survey was not the only measurement of this factor. Students gave an extended response on the survey and six students were interviewed. The data collected from these methods support the use of case studies to increase student perception of relevance.

In the survey, most of the shifts in student responses are not statistically significant. The mean of student responses to all of the survey questions before using case studies, and the mean of student responses after using case studies are nearly identical. See Figure 1.

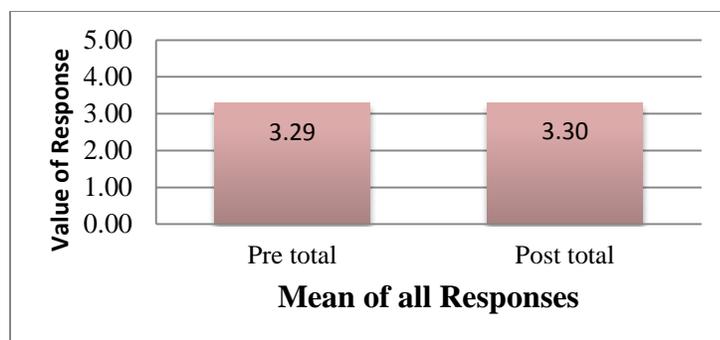


Figure 1. Perception of relevance survey overall mean of student responses, ($N_{pre-treatment}=41$, $N_{post-treatment}=37$).

The use of case studies, however, increased student perception of relevance of science especially among students who tend to be negative toward science in the first place. Students who answered negatively, strongly disagree or somewhat disagree, in the pre-treatment survey shifted away from negative perceptions in all but four questions. This shift was important in that it showed that students had become more neutral to the idea of science being relevant in their daily lives. Table 2 shows a sample of survey questions and the percent shift away from negative responses.

Table 2
Shift Away from Negative Responses

Questions from Survey	Shift away from negative response
Much of what I learn in science classes is useful in my everyday life today.	9.56%
The things I do in science have nothing to do with the real world.	9.89%
Science helps me make decisions that could affect my body.	15.23%
I do not expect to use science much when I get out of school	18.79%
Science can help me to make better choices about various things in my life.	11.40%
Learning science enables me to explain my thoughts better to others	12.79%

With the shift away from negative responses, it would seem that the overall results of the survey would show a positive shift in the perception of relevance of science, but this did not happen. Actually, students who had originally responded positively, somewhat agree or strongly agree, shifted toward neutral and did not respond as positively that science was relevant to their lives after the case studies were used in the class. This shift from both the positive and negative attitudes to a more neutral view of science is definitely an unexpected result.

The choice of the case studies used for this research influenced the student responses for Question 4 that stated, “Science helps me to make decisions that could affect my body”. This question shows the largest positive difference in the shift in student responses before and after using these case studies. ($M_{pre-treatment} = 3.05$, $SD = 1.20$ and $M_{post-treatment} = 3.68$, $SD = 1.27$). This difference is statistically significant, $t(41) = 2.24$, $p = .028$, between the pre-treatment and post-treatment surveys. Considering that one of the case studies had to do with whether or not a person should use a supplement and the other case study was about understanding the damage that can be done to your body by extreme temperatures of water, this is not a really surprising result.

The next question that showed an increase had to do with science enabling them to explain their thoughts better to others. When I ran the t-test, however, on these numbers, $t(41) = .86$, $p = .394$, it was determined that this was not a statistically significant difference possibly due to the small sample size. In both case studies, students had to think about how the situation would affect those in the case study as well as themselves; and then discuss their opinions in a small group setting and with the larger group.

The question that shows the largest drop in negative responses before and after the use of case studies in class was question number twelve which states, “Science teaches me to think less clearly than I already do.” Using case studies forces students to think critically about the situation presented in the case study. It is possible that the case study made them less confident of the “right” answer. However, this drop is not considered statistically significant $t(41) = 1.48, p = 0.14$.

Even though the student responses to most of the survey questions do not show any significant shifts in perception of relevance, some of their comments do. At the end of the survey students were invited to respond to whichever of the statements of the survey that they chose. The extended responses were categorized by being either ‘no response’, a ‘positive response’ that indicates science is important and helps them in their life, or a ‘negative response’ that indicates science is not important and doesn’t help them in their life. Figure 2 shows these responses.

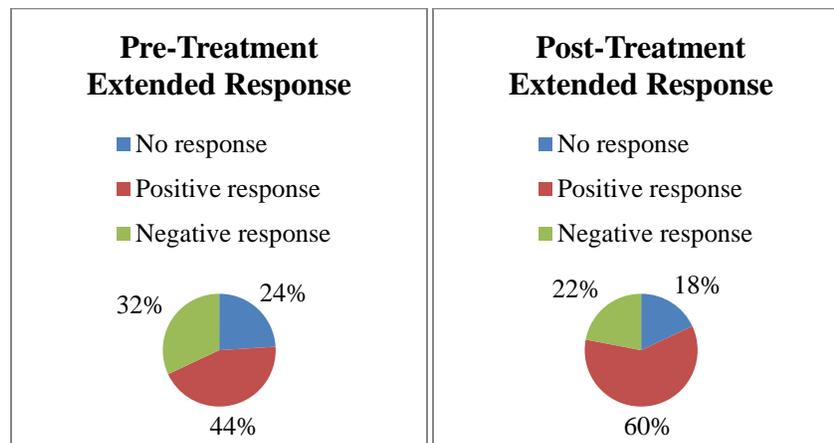


Figure 2. Survey extended responses, ($N_{pre-treatment}=41, N_{post-treatment}=37$).

Reflecting on the data gathered from the extended responses, it is clear that some students feel that science is relevant to their lives and some do not. According to the post treatment extended responses, after the use of case studies, more students have a positive impression of the relevance in science.

Student interviews were also used in determining whether a shift in student perception of relevance in science took place after using the case studies in class. All of the students interviewed felt that using the case studies made science more interesting and helped them learn about the chemical concepts. One student commented that using the case study made science more relevant and showed how it helps people. When asked if there are certain times when science seems more connected to the rest of his life, a student said that using stories and the lab activities make it seem more real. One of the students said the stories, “make science make more sense” and “it (the story) raised my curiosity about what we were learning.”

The format of discussing the case studies was critiqued as well. One student said he really liked discussing it in the large group and another student said she thought the large group discussion was a terrible idea. The latter student was frustrated with the lack of focus of her classmates and expressed that she would rather have done the case study and accompanying questions on her own. In the interview with my co-teacher after the first case study was used, she stated, “The students seemed interested and the story grabbed their attention.” She then elaborated that the use of anything that makes science connect to the real world for these students helps them get more out of it. “The more relevant it is it will keep their interest and they could relate to it”.

Impact of Using Case Studies on Student Learning

The second question addressed in this study was to see if and how the use of case studies affected student learning. To answer this, pre- and post- assessments were given to the students for both units of the study. The individual scores were placed into an Excel spreadsheet. I was then able to determine the mean and the standard deviation for each group of assessments. See Table 3.

Table 3

Mean and Standard Deviation for Pre- and Post- Assessments during Treatment and Non Treatment Units

Atomic Structure Unit			Chemical Bonding Unit		
<i>NonTreatment</i>	<i>Pre-</i>	<i>Post-</i>	<i>NonTreatment</i>	<i>Pre-</i>	<i>Post-</i>
<i>Mean</i>	43.5%	64.8%	<i>Mean</i>	38.4%	61.28%
<i>Std Dev</i>	19	21	<i>Std Dev</i>	23	28
<i>Treatment</i>			<i>Treatment</i>		
<i>Mean</i>	35.0%	65.2%	<i>Mean</i>	26.6%	67.9%
<i>Std Dev</i>	17	18	<i>Std Dev</i>	19	19

After looking at this, I realized the best method of comparing the two group scores was to calculate the gain score for each class during both the treatment and non-treatment unit. Then, each class was compared with the other class to see if there were any significant differences since only one class experienced the treatment during a given unit. Both classes have a higher gain score for the unit that had a case study as part of the curriculum. This indicates that using these case studies during these units of study increased student learning. Group 2 shows a larger gain than Group 1. See Figure 3.

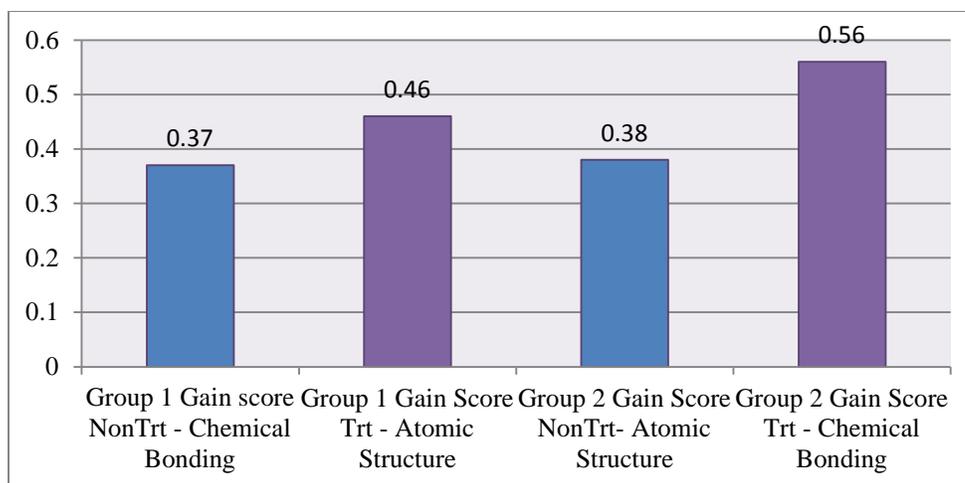


Figure 3. Gain scores for pre- and post- assessments for students in conceptual science. group 1, ($N=19$), group 2 ($N=21$).

After doing the case study, students were asked to write a One Minute Paper summarizing what they had learned during the case study. Six students in Group 2 discussed what they had learned about supplements in general. They wrote about how important it is to know about a supplement before you take it. Eight students specifically focused their attention on SAME and that they had learned that it is an antidepressant. Three students also gave their opinions that Bill, the fictional character in the story, should take the supplement. Four students said he should not and gave reasons why it could be unsafe for him to take. These responses showed an interest in the topic and an increase in learning as many said they did not know much about SAME or the concerns about taking supplements prior to the case study.

Students in Group 1 also showed an increase in learning because they answered correctly a series of questions as part of the case study. Students were organized into six small groups of three students each. All of the groups were able to answer all of the questions successfully.

Impact of Case Studies on Teacher Attitude

The last study question for this research was to see how the use of case studies affected the teacher. My reflections before using the case study, showed a concern for connecting the case study to the content. I had difficulty finding a case study that was already written and that would be feasible for my students to use. Even though neither case directly taught content, students seemed temporarily more interested in what we were studying in class.

The other concern I reflected on in my journaling was how to balance the time in my two classes. Since one class had a whole period devoted to working with the case study and the other had an extra period, I did not want to spend extra time on the content with the class that did not have the case study. I was concerned that doing so would skew the data. However, due to other disruptions in the school schedule (ie. snow days, and absences), the time spent on content was nearly equal between the two groups.

After using the case studies in class, I reflected on the student reactions to the case studies. In both classes, students were reluctant to do the necessary reading and writing to answer the questions. This was not unexpected as this is a common pattern for these students. After using the Yellowstone case study, on January 28th, I wrote in my reflections that I was surprised that students were not more anxious to find out what happened to the people in the story. I was disappointed that what actually happened was the students complained that there was more work to do, rather than anticipate the final outcome of the story.

For the most part I enjoyed using the case studies in my classes. Both case studies got students to ask questions and think about science in a way they did not

previous to this study. My reflection after Group 2 on February 27th, showed that I was excited about the response the students had to discussing the SAME Case Study. Several students had questions immediately after reading the article, which led to an energetic whole class discussion. Three to five of the students told me after the class they really liked discussing the case because it seemed really applicable to their own lives. Another student told me she found the discussion very frustrating because students were not participating in the discussion in a respectful manner. I felt the same way about some of the discussion as well. This class tends to have trouble with whole class discussions in the first place, but what made this discussion different was that they all wanted to discuss the case together. Usually, they want to discuss something unrelated to what we are doing in class and getting them to discuss content can be difficult.

The co-teacher in both classes is a special education teacher. She often looks for ways to make the science we are learning in class connect to the real world either by giving examples in our discussions or bringing in articles off the internet. I asked her after each class used the case study how she felt they impacted student learning. Her comment was that she felt using the case studies got the students interested and grabbed their attention.

INTERPRETATION AND CONCLUSION

This study provides evidence that using case studies as an instructional strategy in a junior level conceptual science class does impact student learning. The quantitative evidence from the pre- and post- assessments used during the units of study show a significant gain in student learning during the units with a case study verses the units without a case study.

The evidence for whether it affects student perception of relevance is somewhat divided. The quantitative data does not show any significant change in the perception of relevance of science by using case studies, however, the qualitative evidence from interviewing students and reading their extended responses on the survey indicate that using case studies and real life stories helps students relate science to the real world.

Enough evidence about the positive impacts of using case studies with this group of students encourages me to continue to seek out case studies that can relate real world stories that connect with the content. Students feel like the stories connect science to the rest of their world and make it more interesting. The fact that it also shows an increase in student learning is significant too. Many of these students are not strong learners and anything that can help motivate and interest them so that they learn the material is probably worth my time.

One of the things I learned using these case studies is the importance of planning how to debrief students and lead discussions. Group 2 is a particularly energetic group of students and leading that discussion was very difficult for several reasons; students were spread out in small groups all over the room, students are generally disrespectful to each other, and my co-teacher and I have had difficulty in the past with large group discussions in this class. With a group like this, it might be better to let the discussion stay in the small groups and then have each group take turns reporting back to the large group and submit additional questions at that time.

I will need to make a few adjustments to the use of these same case studies next year. I will do this by adding more information to the case and make some needed

changes to some of the questions in the case studies. I want to make a stronger connection of the case study to the content we are studying.

VALUE

Conducting action research in my own classroom has been a very rewarding, learning experience. I have developed some skills that I can use in the future when I learn about a new method of teaching that I want to test in my own classroom. In fact, already this spring I have conducted a much shorter version of an action research project addressing 1:1 technology with students bringing their own devices. I was able to use some of the same methods of measurement and analysis in that project that I have used in this one.

Using case studies as an instructional method in my classes has been like adding an arrow to my quiver of useful strategies. I enjoyed using the cases and my students did too. Learning was positively impacted and they learned about some real world situations where science was being applied. I have also added the use of case studies to the other courses I teach for these very reasons. Using case studies does seem to make real world connections to the science they are learning in the classroom.

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APPENDICES

APPENDIX A

“TRAGEDY IN YELLOWSTONE” CASE STUDY

The case study below is the one I used in the Atomic Structure unit. The “Tragedy in Yellowstone” story was obtained from the website <http://www.outdoorplaces.com/Features/Backcountry/thermal/>, most of the pictures and all of the questions are my own.

Tragedy In Yellowstone



Every summer thousands of college students go to work in our National Parks serving millions of visitors. Some students become seasonal rangers for the National Park Service doing a wide variety of duties from interpretive programs, administration, search and rescue prevention, and manning entrance stations. Thousands of others go to work in the restaurants, lodges, and gift shops providing meals, film and clean rooms to a range of quests from around the world working for park management companies.

Amfac Parks & Resorts is the largest park management company in the United States and the company's roots go back to 1876. They manage the resorts and lodges at some of the country's most popular parks including Zion, Grand Canyon, Bryce Canyon and Yellowstone.

The jobs are very attractive to young students. Relatively short hours, room and board in dormitory style housing that offers opportunities to make lifetime friendships, and plenty of free time to explore the wilderness around them. Although an experience of waiting tables may not help get you into an internet startup at graduation, it is a welcome change of pace to the hectic and stressful life of college. At Yellowstone National Park there are over 3,000 seasonal Amfac employees on the payroll.

For eight of these employees the afternoon of August 21st, 2000 in Yellowstone National Park started out like so many others. Parking their cars on Fountain Flat Drive they took the well-worn trail into the dangerous regions of the Lower Geyser Basin. Home to some of the largest and hottest springs in Yellowstone National Park, including famous Grand Prismatic Spring.

Question Set 1 - Answer these on a separate sheet of paper.

1. *In your own words, why are the jobs at Yellowstone attractive?*
2. *What do you know about the geysers and hot springs of Yellowstone?*
3. *What is the difference between a qeyser and a hot spring?*
4. *Look at the picture of Grand Prismatic Spring. What do you think is responsible for the colors in this spring?*
5. *Do you think you could go for a swim there? Do you think anything could live there?*



Part 2

The half-mile long trail through the Lower Geyser Basin is popular among anglers and bathers alike, who take the journey to the Firehole River to fish and swim in the water that is warmed by overflow from the nearby springs. Aquatic life teems in the mineral rich water attracting trout. A swim in the warm water is a welcome relief from icy Yellowstone Lake.

As the hours ticked away the afternoon of innocent fun on the banks of the Firehole soon turned into dusk, and dusk soon turned into night. As the last shred of light faded from the horizon the group decided to head back to their cars in the darkness. None of them had a flashlight and the moon had not risen. It would be like walking through the Lower Geyser Basin with your eyes closed.

Three choose a different route from the rest of the group. Lance Buchi and Sara Hulphers both work at the restaurant in the Old Faithful Lodge. Sara had been working at the park for only six weeks. Tyler Montague cleaned rooms at Old Faithful Lodge. Eighteen-year-old Lance and Tyler are both from Salt Lake City and had just graduated from high school. Twenty-year-old Sara, from Oroville, Washington, was on her way to being a Junior studying biology at Western Washington University.

We take hot water for granted. Hot water heats our houses, cooks our food, keeps our cars cool in a radiator, runs power plants as steam, we even bathe in it. People around the world revel in natural hot springs like 110° F. Lava Hot Springs in Idaho and world famous Hot Springs, Arkansas. But as the water temperature continues to creep up, the risk for being scalded grows.

If you were to sit in a pool of water at 113° F. for three hours, you could receive a debilitating and life threatening third-degree burn. The entire thickness of your skin would be burned through, the blood vessels and nerve endings would be dead, and the damage would extend into your muscles and even your bones. Turn the temperature up to 120° F., and the time becomes eight minutes. Turn the temperature up to 140° F. and the time becomes just five seconds. Make the temperature 156° F., and it is only one second. Any higher and the time is measured in fractions.

Hot water burns are very common, especially among young children. Thousands of scalding injuries happen each year ranging from errant hot water heaters to a hot cup of coffee spilling over in bumper-to-bumper traffic. Victims of severe scalding by hot water or steam talk of incredible pain. The heat from the water soaks into your body and you continue to burn, even when the hot water is removed from you. The heat is soaked into your clothes and hair. It is a horrible, painful injury.

Question Set 2

1. *Why do people like to swim in the Firehole River?*
2. *Briefly describe what happens to the human body if it sits in a pool of water at 113° F for three hours.*
3. *Make a data table that shows how long it would take for the human body to have these effects at four different temperatures and the time it would take. Determine the independent and dependent variable. Make a graph of the data. Be sure to label the axes and put a title on your graph.*
4. *Make a prediction about the story and what you think will happen.*
5. *If the hot springs are that hot, do you think anything could live there? Recall the colors of Grand Prismatic Spring, what is causing the different colors?*



Part 3

The springs of Yellowstone National Park are also rich with dissolved carbon and sulfur making some of the pools very acidic. Acidity is measured using a scale called pH. If something is neutral, like pure water, it is said to have a pH of 7. If something is acidic it has a lower pH. Dirty rainwater loaded with carbon and sulfides might have a pH of 5. Vinegar on a salad might have pH of 3. Battery acid in your car might have a pH of 1. Some of the springs in Yellowstone National Park have a caustic pH of 1.75 and even lower.

The first group of five made it to the cars parked on Fountain Flat Drive. It was about that time, close to 11:00 at night, it happened. Something went terribly wrong. Desperate cries for help suddenly shattered the night. The cries came from the Lower Geyser Basin.

Question Set 3

1. *What is pH? How do we know if something is acidic?*
2. *What is the pH of some of the hot springs in Yellowstone?*
3. *What causes the acidity of the springs?*
4. *Look at the data provided from the thermal features of Yellowstone National Park. Draw conclusions about the elements present in the features where the data isn't given.*

Find out more about the tragedy in Yellowstone...

Part 4 -Tragedy In Yellowstone (continued)

The group ran toward the shrill voices. Lance Buchi and Tyler Montague had just pulled themselves from 178° F. Cavern Spring. Sara Hulpher continued to flounder in the near boiling acidic water. Risking their own lives in the darkness, the group pulled Sara out of the seething spring. What had been a day of fun had turned into an experience that could only be conceived of by a Hollywood scriptwriter in a movie like, *The Bone Collector*, or a vicious pit demon from the bowels of hell.



Incredibly all three were still conscious despite being horribly injured. Lance and Tyler walked back to Fountain Flat Drive with assistance and were driven back to the Old Faithful Lodge. Sara, who had been fully submerged in the water, was in grave condition. Carrying her back to the parking lot her friends put her in the waters of the Firehole River where she had been swimming just a couple of hours before; to help soothe her injured body.

Lance, Tyler, and Sara aren't the first victims of a thermal pool accident in Yellowstone. To date 19 people have died in the thermal regions, including seven children. The last death occurred in 1988 when a cross-country skier fell through into a hot pool. In 1981 a 24-year-old man willingly leapt to his death in Celestine Spring in a hopeless attempt to save his dog. During all of 1999, eight people were injured in the thermal regions of Yellowstone. Never before had three people been injured at the same time, and never before had three people fallen into a pool and been so gravely injured.

When rescuers arrived about thirty minutes after the accident, the critically injured trio was prepared for transport to West Yellowstone, Wyoming. Sara Hulpher, seeming to know she was mortally injured, made several requests to her friends and drifted into unconsciousness. Lance and Tyler both told rescuers they thought they had come to a creek while navigating in the darkness and holding each others' hands attempted to jump across it, not knowing they were actually jumping into ten-feet deep Cavern Spring. The mystery of how three people willingly jumped into a boiling pooling of water started to become clearer.

Arriving in West Yellowstone the three were flown by advanced life support helicopter to Idaho Falls, Idaho. From there they were transferred to a waiting airplane that took them to the Salt Lake City Burn Center. Lance and Tyler had come home but the precious golden hour for treatment in a trauma center had long gone by.

Fifteen hours later, with third-degree burns over her entire body, Sara Hulpher could no longer keep up the fight, her organs shut down, and she quietly became the 20th victim of Yellowstone's thermal pools.

Doctors painted a grave picture for the critically injured Lance Buchi and Tyler Montague. Lance was suffering from third-degree burns over 97% of his body. Tyler was suffering from third degree burns over 90% of his body. Their physicians gave them less than a 10% chance of surviving the next 48 hours.

Since August 21st the hours have turned into days. At the Lower Geyser Basin in Yellowstone National Park the scene of the accident is blocked off with yellow tape. People continue to walk through the same area where the tragedy happened. Back in Salt Lake City Buchi and Montague continue the fight of their lives. With the initial risk of organ failure now in check, doctors paint a slightly more optimistic picture with their survival odds at 30% to

40%. However, at least three months of hospitalization, possibly 15 to 20 surgical procedures, and two years of physical therapy lay ahead of the badly burned pair.

Meanwhile at the Old Faithful Lodge things continue as normal. Thousands of guests pass through the Amfac cafeteria ordering meals and buying large souvenir sports bottles filled with soft drinks. Orders are taken for dinner, and the tables are cleared made ready for the next wave of hungry tourists. Beds are made, floors are cleaned and things are being prepared for summers last fading days in Yellowstone.

People sit at the tables that Sara was taking orders at and Lance was clearing just a short week ago. People are sleeping in rooms that Tyler had cleaned. Their friends who witnessed a nightmare are probably back to work, and coping the best they can with the swirl of emotions inside. Their roommates in the dorms they lived in continue their routines around three empty beds. Even Old Faithful continues to erupt every 40 to 70 minutes in a display of scalding hot steam and water and college will start this fall. Yet despite the continuing routine something doesn't seem quite right. The afternoon wasn't supposed to end that way.

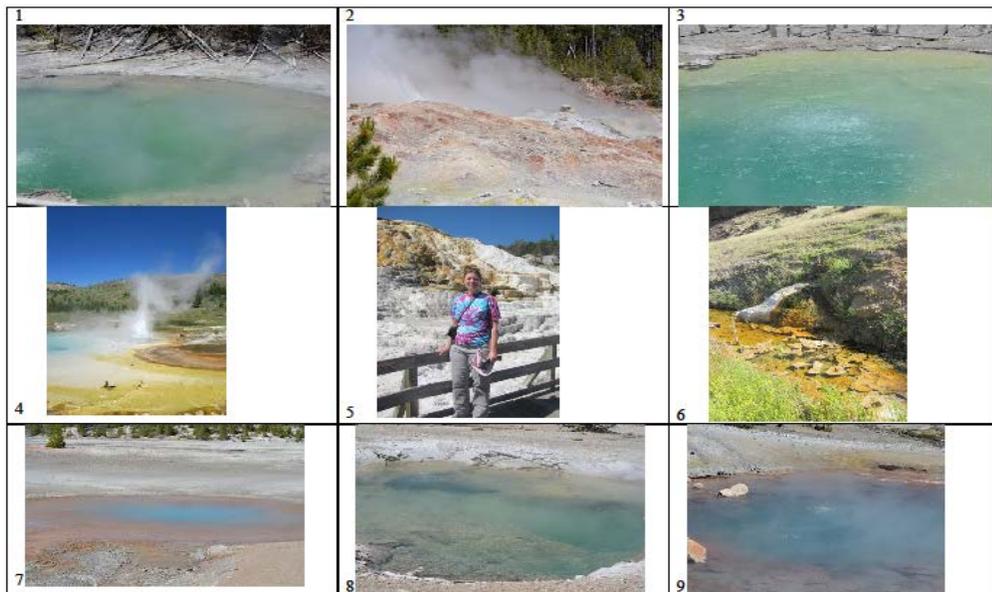
Question Set 4

1. Give a brief summary of what happened to Sara, Tyler and Lance.
2. Make a connection between the microbes that live in the thermal features and the elements present.

Thermal Features of Yellowstone

Thermal Feature	Location of feature	pH	Temperature degrees Celsius	Elements present
1. Emerald Spring	Norris Geyser Basin	4	82	Yellow= Sulfur Blue = Silicon dioxide
2. Steamboat Geyser	Norris Geyser Basin	2-3	71	White= Silicon dioxide Red = Iron Orange = Arsenic Yellow= sulfur
3. Cistern Spring	Norris Geyser Basin	4.5	64	*Figure this one out from the picture
4. Imperial Geyser	Midway Geyser Basin	7	>70	*
5. Opal Terrace	Mammoth Hot Springs	7	68	Calcium carbonate
6. LaDuke Hot Springs	North of Yellowstone NP	7	60	*
7. Whirligig Geyser	Norris Geyser Basin	3.4	68.3	Orange/red = iron oxide
8. Crater Spring	Norris Geyser Basin	4.2	85	*
9. Echinus Geyser	Norris Geyser Basin	3-5	60	Sulfur Iron Arsenic Silicon dioxide

Thermal Features of Yellowstone



APPENDIX B

SHOULD BILL BUY "SAMMY"? CASE STUDY

Below is the case study used in the Bonding Unit by Klein, J.W. (1999). The additional questions are a combination of my own questions and those from the teacher notes page of the case study.

Should Bill Buy "Sammy"?

A Case Study Introducing Basic Chemistry Concepts



by
Jessie W. Klein
 Science Department
 Middlesex Community College, Bedford, MA

Bill Brown walked through the mall looking for the GNC store. He had been feeling depressed lately and was not looking forward to starting the semester in this mood. The previous day, while eating dinner, he had spoken to his mother about his feelings.

"You know, Mom, I just don't feel like doing anything these days. I'm feeling depressed, don't like hanging out with my friends or going to the gym. I even called in sick to work today. I'm not sure I really want to go back to school this semester. Maybe I should take some time off."

Mrs. Brown was concerned. This did not sound like Bill. He was usually an upbeat guy, liked his job at the software company, and always looked forward to the start of the school year, especially since he was hoping to graduate in the spring.

"Perhaps you should visit my doctor, and he can give you something to make you feel better," she told him. She herself was under a doctor's care and was taking a prescription drug to help control her depression.

"You know how I feel about taking a lot of meds," he said. "Those anti-depressants are so unnatural and can have side effects like sleeplessness, agitation, and headaches. I saw a news report last week about a new dietary supplement for depression. Maybe I should go to the natural food store and check it out." Bill headed out the door and toward the mall.

As Bill browsed the aisles of the GNC store, a sales clerk approached him.

"May I help you find something?" the clerk asked.

"I'm looking for something that might help with depression," replied Bill. "I saw a news report about a supplement that is now being imported from Europe."

The clerk led Bill to the next aisle and handed him a flyer on SAME (pronounced Sammy).

"This is a new product that we have just started carrying. It has been used in Europe for years. Why don't you take a few minutes to look over the pamphlet? I'd be happy to answer any other questions."

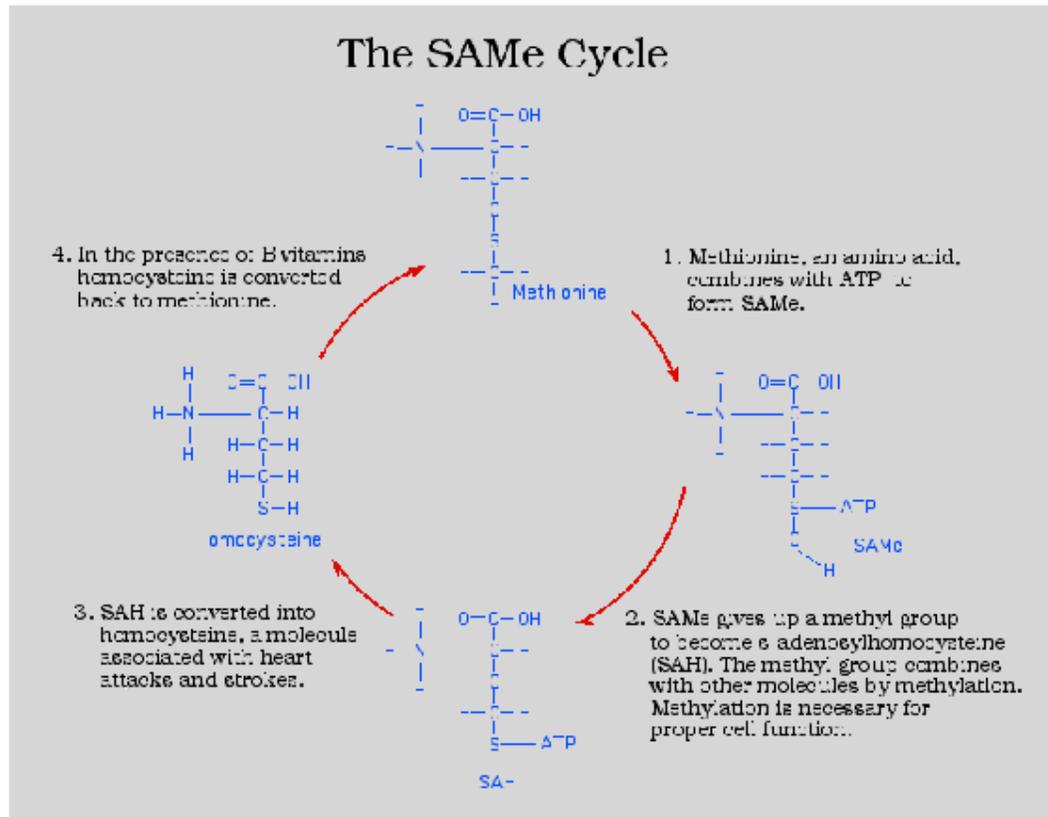
Bill took the flyer, quickly browsed through it and found the following information about SAME:

SAMe (which stands for s-adenosyl methionine) has been used in Europe for over twenty years to treat arthritis and depression. SAMe is a compound found in our bodies and protein rich food. It is formed from an amino acid methionine and is involved in many biochemical reactions that occur in the body. People who suffer from depression tend to have lower levels of SAMe. Experiments performed in Italy have found that 70% of depressed patients responded to SAMe. This is similar to the results found with prescription drug treatments. Dr. Richard Brown of Columbia University has

found SAME to work just as well as prescription anti-depressants with minimal side effects.

The pamphlet now became more technical and described how SAME works in the body:

Our bodies make SAME by combining methionine with ATP, the energy molecule (see diagram). SAME then passes its methyl group to other molecules (methylation) and is eventually converted into homocysteine. SAME is important for our cells because it is responsible for a major portion of the methylation that occurs in our cells. Methylation is the process by which one molecule donates a methyl group to another molecule. Methylation is necessary for proper gene function, preservation of cell membranes and regulation of neurotransmitters.



High levels of homocysteine have been implicated in heart disease and strokes, but in the presence of B vitamins or folic acid our body converts homocysteine either back into SAME or glutathione, a powerful anti-oxidant.

It is believed that SAME helps to fight depression because methylation is necessary to produce the neurotransmitters dopamine and serotonin that help prevent depression. SAME may also play a role in maintaining the structure of the brain cell membranes and receptors.

Bill finished reading the flyer. He did not understand all the technical information, but he decided to try one

bottle of SAME to see if it helped him. He knew his mother would not be pleased with his decision, but he would deal with that later.

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ADDITIONAL SOURCES OF ONLINE INFORMATION

- "Can One Substance Treat Both Osteoarthritis and Depression? Checking out the claims for SAME" Tufts University Health & Nutrition Letter. November 1999. (Temporarily available online at <http://www.healthletter.tufts.edu>).
- Information on SAME from the GNC website is available at <http://www.GNC.com>; following the path to "Vitamins and Minerals" or type "SAME" in the search box on the top page of the site.
- Information from the Naturemade website is available at <http://www.naturemade.com>; type "SAME" in the search box on the top page of the site.

Questions for "Should Bill Buy "Sammy"?"

1. Why is Bill considering buying SAME?
2. After reading the pamphlet, what questions do you have about SAME?

3. If you were considering this supplement, what additional information would you want to have?
4. In the diagram of S_AM_e, what do the symbols and lines represent?
5. What is methionine?
6. What is ATP?
7. What is methylation?
8. Why is methylation important?
9. Where does methylation occur?
10. Do you agree with Bill's decision to buy S_AM_e? Why or why not?

APPENDIX C

ONLINE STUDENT SURVEY

This is the survey my students took before and after the treatment.

Conceptual Science PoR Student Survey

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way. Please take a few moments to respond to the following questions thoughtfully and honestly. Thank you for your time.

Please respond to the following questions by indicating whether you agree or disagree and to what extent. *

	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
Much of what I learn in science classes is useful in my everyday life today.	<input type="radio"/>				
Science helps me to make sensible decisions.	<input type="radio"/>				
The things I do in science have nothing to do with the real world.	<input type="radio"/>				
Science helps me to make decisions that could affect my body.	<input type="radio"/>				
Making decisions can be difficult without reliable	<input type="radio"/>				

Strongly disagree Somewhat disagree Neutral Somewhat agree Strongly agree

evidence.

I do not expect to use science much when I get out of school.



Science can help me to make better choices about various things in my life. (e.g., food to eat, car to buy, etc.)



Learning science enables me to explain my thoughts better to others



Collecting evidence is an important part of making a decision.



Science experiments can help me to better understand the world.



Science has nothing to do with local issues, such as waste from agricultural



	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
run-off.					
Science teaches me to think less clearly than I already do.	●	●	●	●	●
Science class will help me prepare for college.	●	●	●	●	●
Science helps me to work with others to find answers.	●	●	●	●	●
Science class helps me to evaluate my own work.	●	●	●	●	●
Science has nothing to do with my life outside of school.	●	●	●	●	●
Making a good decision is a scientific process.	●	●	●	●	●
Learning science is not important for my future success.	●	●	●	●	●

Strongly disagree Somewhat disagree Neutral Somewhat agree Strongly agree

Learning science
will have an
effect on the way
I vote in
elections.



Choose one of the statements above and explain your choice. *

Submit

APPENDIX D

PRE- AND POST- ASSESSMENT ATOMIC STRUCTURE UNIT

Atomic Structure Pre- & Post- AssessmentName _____
Block _____

- The smallest unit of matter that maintains the properties of that element.
 - electron
 - proton
 - neutron
 - atom
- Match the subatomic particle to its charge by drawing a line to connect them

a. Neutron	1. positive
b. Electron	2. neutral
c. Proton	3. Negative
- The atomic number is equal to the

a. number of neutrons	c. atomic mass
b. number of protons	d. number of electrons
- An atom of gold with 79 protons, 79 electrons, and 118 neutrons would have a mass number of

a. 79	b. 158	c. 197	d. none of these
-------	--------	--------	------------------
- Fill in the chart below using a periodic table to help you.

Element	# of protons	# of electrons	#of neutrons	Atomic number	Atomic mass
Carbon-14				6	
	17		18		

- Isotopes exist because atoms of the same element can have different numbers of

a. protons	b. neutrons	c. electrons	d. nuclei
------------	-------------	--------------	-----------
- How many dots should be in an electron dot structure for Calcium

a. one	b. two	c. three	d. four
--------	--------	----------	---------
- Yellowstone hot springs get their different colors from

a. the elements present in them	c. the microbes that live in them
b. both a and b	d. neither a nor b

APPENDIX E

PRE- AND POST- ASSESSMENT OF BONDING UNIT

Chemical Bonding Pre- and Post- Assessment

Name _____

Block _____

- An ion is formed when
 - an atom gains electrons
 - an atom shares electrons
 - an atom loses electrons
 - both a & c
- When electrons are shared a(n) _____ bond is formed
 - covalent
 - ionic
 - chemical
 - both a & c
- What charge does a sodium ion have?
 - 1
 - 2
 - +1
 - +2
- How many electrons are needed in the outer energy levels of most atoms for the atom to be chemically stable?
 - 8
 - 2
 - 6
 - 4
- In methionine, $\text{CH}_3\text{SC}_3\text{H}_5\text{NH}_3\text{COOH}$, determine the number of each type of atom.
 Carbon _____ Hydrogen _____ Sulfur _____
 Nitrogen _____ Oxygen _____
- What type of bonds exist in methionine? _____
 How do you know? _____
- Which group on the periodic table contains elements that do not normally form chemical bonds?
 - Group 2
 - Group 18
 - Group 6
 - Group 8
- What determines whether an atom will form bonds?
 - Number of electrons
 - Number of protons
 - number of valence electrons
 - number of neutrons
- A (n) _____ tells what elements a compound contains and the exact number of each type of element.
 - chemical bond
 - chemical formula
 - ion
 - oxidation number
- The force that holds atoms together in a compound is a _____.
 - valence
 - chemical formula
 - chemical bond
 - ionic bond

APPENDIX F
INTERVIEW QUESTIONS

Interview Questions

Questions were taken from these options.

1. Do you like science?
2. Do you like this science class?
3. Do you prefer learning on your own, listening to class lectures, or working in a group?
4. Are there certain times when science seems more relevant/connected to the rest of your life? What are those times?
5. Do you think using stories like Yellowstone or SAMe help you understand science more? Why or why not?
6. Do you like using the stories to relate science to real-life issues?
7. Did using the stories increase your curiosity about the topic we were studying?
8. Did using the case studies (stories) make science seem more or less relevant? Tell me why you think this.