THE EFFECT OF A CONTEXTUAL APPROACH TO CHEMISTRY INSTRUCTION ON STUDENTS' ATTITUDES, CONFIDENCE, AND ACHIEVEMENT IN SCIENCE

by

Angela Hutchison Brist

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Angela Hutchison Brist

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To Brad, for all your love, patience, and encouragement throughout this process. You never doubted for a moment that I would make it this far.

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ABSTRACT

The goal of this project was to determine if students' attitudes about chemistry, confidence in chemistry, and performance in chemistry increased as a result of being taught with a contextual approach to the subject. A contextual approach to teaching means that a political, environmental, or social issue is presented to the students first and, any science content needed to better understand the issue is taught on a need-to-know basis. During this investigation, 36 students were presented with a chemistry unit taught from a contextual point of view, from which the content to understand the context was drawn.

The results of this study indicated that, for the most part, student attitudes, confidence, and performance in chemistry slightly decreased, with the exception of students' attitudes about the relevancy of chemistry in their lives, which increased. Several reasons may be the cause of the decline, including not linking content activities to the context often enough, exhaustion from the unit being twice as long as other units, and overall student performance decline across subject areas during the time of the treatment period. When teaching with a contextual approach in the future, I will shorten the units and create more student-centered learning opportunities that directly link back to the context.

INTRODUCTION AND BACKGROUND

Justifying what science content is taught in the classroom is getting more difficult for schools as students are bombarded with isolated facts and formulas that seemingly have nothing to do with their lives. Furthermore, these isolated facts tend to get memorized for a test and are forgotten soon after because they have no importance to students. As an educator, I have always felt that teaching with a conventional textbook approach disengages students, and since I place a high value on science and science education, disengaging students is the last thing I want to do. After taking an online course that utilized the American Chemical Society's *Chemistry in Context* textbook, I had an answer to my struggle with curricular reform.

For the past three years I have been teaching at North Tama High School in Traer, Iowa. It is a small, rural town that sits 20 miles south of Waterloo and 45 miles northeast of Cedar Rapids. Many of the students' families live or work at local farms. The entire North Tama school district holds 537 students in a two-building complex which houses the elementary, middle, and high schools. This year the high school has 188 enrolled students in grades 9-12. Diversity in the district is minimal with over 90% of the students identifying as Caucasian. A little less than one-third of the enrolled students are part of the free and reduced lunch program. Of the 39 full time teachers in the district, 25 live within the district, many with their own children attending the North Tama schools. The overall attitude of the teachers is positive because most students are willing to work hard in and out of school. Parents, students, and teachers are actively involved in school sports and extracurricular activities. Last school year the football team won the state championship in its class, and the boys' basketball team made it into the state playoffs. This year the girls' basketball team made it to the state playoffs. The district has also had success with academics, often scoring well on the Iowa Test of Educational Development (S. Early, personal communication, February 24, 2012).

My research was conducted with my 2 chemistry classes, a total of 36 students. Most of the students were juniors with one being a senior. The majority of the group was Caucasian, but one student was Filipino-American and another was Native American. The students came from a variety of socioeconomic backgrounds and ranged from high achievers to average achievers. As the school requires three years of science for graduation, most students will take chemistry their junior year if they have the algebra prerequisite. Thus, student attitudes towards taking chemistry were varied. Some of them were there because they love science and wanted to be there while others were simply there because they needed a third year of science.

The primary focus of this study was to determine if using a context-based chemistry curriculum increased students' positive attitudes, confidence, and overall performance in chemistry.

CONCEPTUAL FRAMEWORK

Many of the traditional methods of teaching chemistry originated from scientific practices of the late nineteenth and early twentieth centuries. During this time, chemistry at the professional level dealt with analyzing and classifying substances as well as understanding their properties and structures. In modern times, the work chemists do is more diverse and applied. They apply their knowledge in the field to develop new products and technologies and to monitor and understand the world around them (Bulte, Westbroek, de Jong, & Pilot, 2006). One of the major goals in teaching chemistry with a contextual approach is that students will develop the ability to understand and make decisions about issues they may face in their everyday lives outside of the classroom (King, 2007; King, Bellocchi, & Ritchie, 2006). Teachers can better prepare students for the modern world by teaching with a modern approach.

Traditional science courses at the high school and college levels present content in a linear matter, where one concept builds off of another. Such an approach can be viewed as a “ladder” approach in which one concept is a rung of a ladder and successive rungs can only be reached by first stepping on the lower rungs (Figure 1). This ladder approach works for some students, many of whom tend to have scientifically-oriented minds and can easily make the connections between the rungs of the ladder. However, many other students cannot easily make these connections and find themselves wobbling while attempting to climb the ladder. By drawing on teaching approaches in the humanities and social sciences, where a central problem serves as the basis for new information, high school science classes can reach out to these struggling students. Such an approach to teaching is known as a context-based approach (Schwartz, 2006).

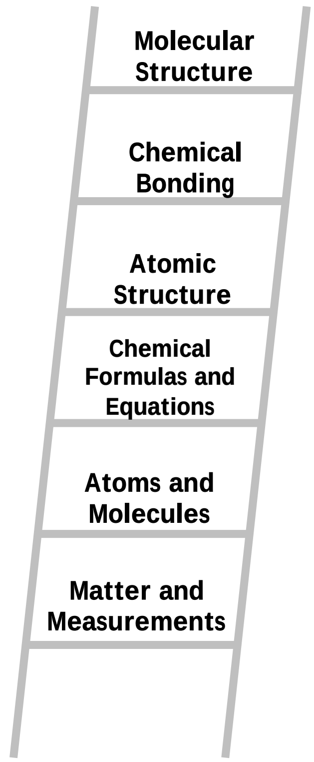

Figure 1. The ladder metaphor for learning chemistry. Each successive rung of the ladder builds in knowledge from the previous rung (Adapted from Schwartz, 2006).

This central-idea or context-based approach to teaching can be seen as a web rather than a ladder (Figure 2). Teaching a science like chemistry with a context-based approach places a social, environmental, ethical, and/or political context at the center of the web and introduces only those science concepts needed to fully understand the context (Stanitski, Eubanks, Middlecamp, & Pienta, 2003). This need-to-know basis of content ensures that the science concepts taught arise from the context rather than being presented as disconnected fragments of knowledge (King, 2009). The concepts are a natural result of understanding the context in depth, which makes learning more meaningful to a greater range of students (Bulte, et al., 2006; King, 2009). Although concepts spread outwards from the web's central context, there are still linear segments where one concept builds off of another concept. Students that prefer the ladder approach will find the web approach still to their liking (Schwartz, 2006).

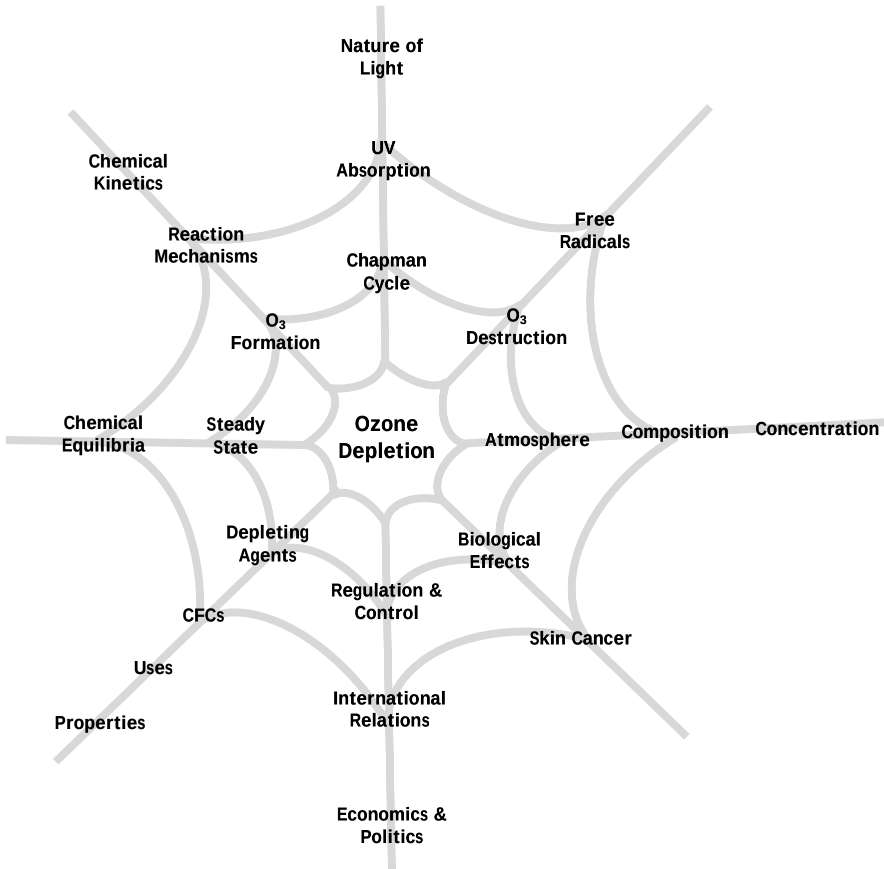

Figure 2. The web metaphor for learning chemistry. Specific concepts radiate linearly from a central context (Adapted from Schwartz, 2006).

In designing a context-based chemistry course, the chosen central issue for each unit is one that reaches beyond the classroom. Context topics are contemporary, interdisciplinary real-world issues that allow not only for the incorporation of chemistry concepts but also the societal significance of chemistry (King, et al., 2008; Middlecamp, 2008; Schwartz, 2006). Through a context-based approach, students can develop their analytical skills, critical judgment skills, and risk-benefit assessment skills, all of which are important to develop in order to become informed participating members of society (Schwartz, 2006).

Teaching chemistry with a contextual approach has an advantage over traditional approaches for several reasons. The context-based approach allows students to be more closely engaged with complex problems. Such an approach is actually more representative of how professional chemists conduct research. Science is not simply a collection of facts and data, but an inquiry process to understand nature (Schwartz, 2006). With a context-based approach, students are presented with the "inquiring, experimental, and often tentative nature of science" (Schwartz, 2006, p. 983). As a result they gain an understanding of the ambiguity of the natural world, something the traditional approach rarely covers (Schwartz, 2006).

Context-based chemistry brings relevancy to the subject which encourages scientific literacy for all students (King, 2009; King et al., 2008). Students of all abilities will be able to see clearly the links between the chemistry they are studying and their everyday lives (King, 2009). In fact, some of the major goals of the Chemistry in Context curriculum designed by the American Chemical Society are to broaden science literacy and help students deal with the challenges of modern society by teaching them how to make scientifically informed decisions (Middlecamp, 2008; Stanitski et al., 2003). Traditional chemistry classes tend to focus on the repetition of mathematical problems, the following of cook-book style lab work, and the memorization of chemistry facts and tables (King, 2007). Students find this work uninspiring, abstract, and irrelevant to their lives (Bulte et al., 2006; King, 2007). In contrast, teaching with a context-based approach to chemistry lends itself to topics and tasks that are “interesting, relevant, and effective for conceptual learning” (King et al., 2008, p. 379).

As a result of the lack of relevancy to students’ lives, students receiving the traditional approach to chemistry become disengaged in class (Bulte et al., 2006; King, 2007). By centering on a real-world concept, students become more interested and attentive in class, thereby reaching higher levels of achievement. This can also lead to higher levels of motivation in and positive attitudes towards science (King, 2009; King et al., 2008; Middlecamp, 2008). Since the availability of context-based chemistry courses, the number of high school students enrolled in a chemistry course rose from 32% in 1982 to 62% in 2002. Additionally, there may be concern that student achievement and understanding will be hindered by not covering all the topics of a traditional chemistry course. However, studies have shown that students enrolled in context-based courses learn chemistry as effectively as students enrolled in traditional courses (King, 2009; King et al., 2008; Schwartz, 2006).

Teaching chemistry with a contextual approach has its concerns as well. First and foremost, there is no consensus amongst teachers on exactly how to teach context-based chemistry (King, 2007; King, 2009; King et al., 2008). Differences in opinion center around the balance of context and content, especially in respect to how much need-to-know content should be taught. Such disparities will continue as long as there is no state-wide or national standards set for the course.

In certain studies teachers voiced a concern that students may still experience difficulty in transferring knowledge and concepts to new situations, despite the context-based approach (King, 2009, King et al., 2008). Another study found that the context may take a greater precedence over the content and obscure or interfere with the transfer of concepts to other contexts (Schwartz, 2006). One reason for this may be in the design and delivery of planned units. Activities and assessments should be designed to allow students to demonstrate their conceptual understanding when the concepts are tied to a new context.

A final concern with implementing a context-based curriculum is the amount of time a teacher will need to design the course. Teachers will need to completely change the way they approach lesson planning and instruction in order to focus on a central context (King, 2007). They will need to rethink their instructional and learning outcomes as well as adjust their practices to meet these outcomes. Furthermore, some teachers will have to spend a good deal of time to research and learn about unfamiliar central concepts and how to incorporate the science content into the context (Middlecamp, 2008). The context-based approach can also lead to the repetition of some content and the omission of other content, which some teachers may find uncomfortable (Schwartz, 2006). Despite the many questions of how the course should be designed and implemented, a context-based approach still makes chemistry more relevant and accessible to students than traditional courses and increases student achievement in science (King, 2007).

METHODOLOGY

The purpose of this study was to determine if using a contextual approach to teaching chemistry would improve student confidence, attitudes, and achievement in science. The test group included 36 students from 2 general chemistry classes. Males accounted for 54% of the group, and females accounted for 46% of the group. 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.

During the nine-week treatment period, I presented one unit to the students with the overarching environmental and political concept of water quality. The unit was designed based on the American Chemical Society's *Chemistry in Context (6th ed.)* and *Chemistry in the Community (5th ed.)* books. The concept was introduced at the start of the unit, and the chemistry needed to better understand the concept was presented afterward. Only the chemistry needed to understand the concept was included and presented with greater depth. These topics included water properties, intermolecular and intramolecular bonding, molecular polarity, solubility and concentration, federal water regulation, and water treatment. Assignments, experiments, and assessments focused on both the environmental concepts and the chemistry behind the concepts.

In order to gauge students' confidence in learning and understanding of chemistry, they all were given the Confidence in Chemistry Survey (CCS) (Appendix A). This survey was administered before the treatment period and after the treatment period had concluded. The questions on the survey were modified from the Fennema-Sherman Mathematics Attitudes Scales developed in 1976 (Mulhern & Rae, 1998). It was emphasized that each categorical scale for the FSMAS functions independently, so specific questions were only taken from the Confidence in Learning Mathematics scale and the Mathematics Anxiety scale. The FSMAS has been tested for validity with positive results. Students' responses were analyzed using a Likert scale, with the choices of *agree (5), tend to agree (4), neutral (3), tend to disagree (2),* and *disagree (1).* The distributions of pre- and post-treatment responses, as well as pre- and post-treatment averages, were analyzed for changes.

All students were administered the Student Attitudes of Chemistry Survey (SATCS) before and after the treatment period (Appendix B). Questions on the survey were modified from the Attitude Toward Chemistry Lessons Scale and the Changes in Attitude about the Relevance of Science questionnaire (Cheung, 2009; Siegel & Ranney, 2003). Both scales were tested to be reliable data collection tools. Like the CCS, student responses to the SATCS were analyzed using an identical Likert scale. The distributions of pre- and post-treatment responses and average scores were analyzed for changes.

Before and after the treatment period, 27% of the students were randomly selected to be interviewed with the Interview Questions in order to gain a deeper understanding of their confidence and attitudes about chemistry (Appendix C). Responses were coded and analyzed for trends. Unit averages, test score average, and quiz score averages from the previous units were compared to those from the treatment period unit. Activities, tests, and quizzes during the treatment period were similar in difficulty and content as those during other units. During the treatment period, I reflected weekly in a personal journal on students' attitude and behaviors during lessons. The data collection methods are summarized in Table 1.

Table 1
Triangulation of data collection methods

Research Questions	Data Source 1	Data Source 2	Data Source 3
Do student attitudes towards science improve?	Questionnaire	Student interviews	Personal reflective journaling
Does student confidence in chemistry improve?	Questionnaire	Student interviews	Personal reflective journaling
Does student performance in chemistry improve?	Pre- and post-treatment period test scores	Pre- and post-treatment student averages	

DATA AND ANALYSIS

Confidence in Chemistry Survey

Students were administered the CCS before and after the treatment period. The 24 statements of the survey were divided into four categories: class work, general confidence, test anxiety, and class anxiety. Each category had a mixture of positive-response statements and negative-response statements. A selection of five on the positive-response statements indicated higher confidence in chemistry whereas a selection of one on the negative-response statements indicated higher confidence in chemistry.

General Confidence

Statements categorized as *General Confidence* were designed to uncover students' confidence in learning chemistry as a subject. There were three positive-response statements and three negative-response statements in this category. There was a downshift in responses to the positive-response statements, and an upshift in the negative-response statements (Table 2). Average responses pre- and post-treatment agree with this decrease in confidence about chemistry class (Figure 3).

Table 2
Differences in percent of responses to statements related to general confidence in chemistry class (N=36)

		Response				
Survey Statement	Type	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Generally confident about chemistry	Pos	2.9%	2.9%	0.0%	0.0%	-5.9%
No good at chemistry	Neg	-2.0%	-5.0%	3.5%	-2.5%	6.0%
Can learn chemistry	Pos	-2.9%	3.2%	10.1%	4.4%	-14.9%
Not the type to do well	Neg	-12.4%	-0.9%	-3.6%	8.4%	8.5%
Knack for messing up chemistry	Neg	-8.2%	7.0%	0.5%	-2.4%	3.0%
Lot of self-confidence	Pos	2.9%	2.9%	17.1%	-17.1%	-5.7%

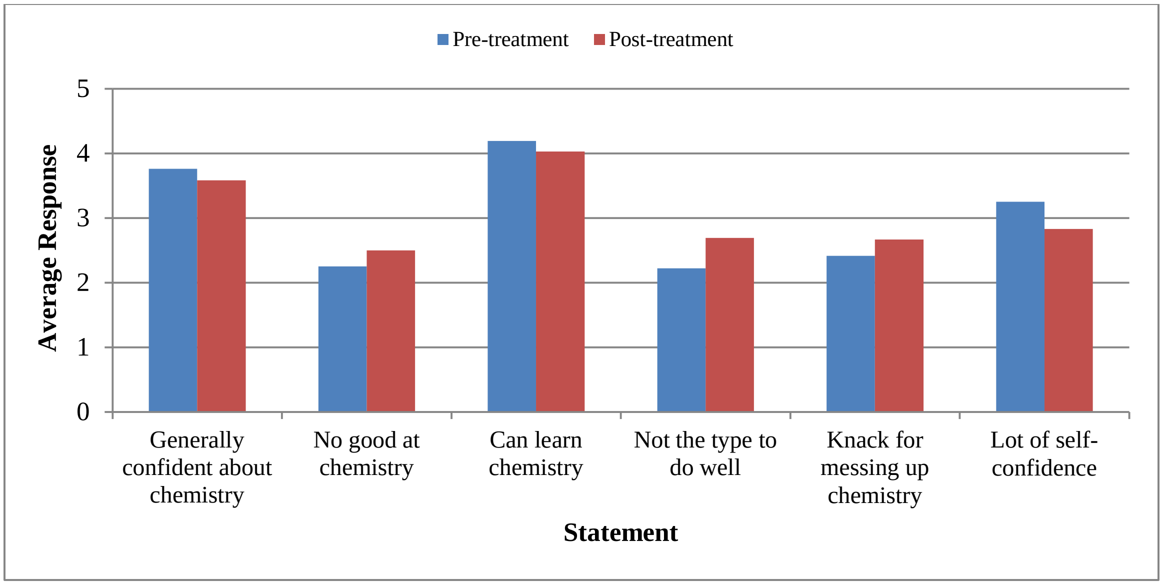

Figure 3. Students' average responses to general confidence in chemistry statements pre- and post-treatment, (*N*=36).

Class Work

Statements categorized as *Class Work* were designed to uncover students' confidence in chemistry assignments and activities. There were four positive-response statements and three negative-response statements in this category. There was a downshift in responses to the positive-response statements, most significantly with statements about handling difficult chemistry and getting good grades in chemistry (Table 3). There was an upshift in the negative-response statements, particularly with statements about chemistry being difficult and their worst subject. Average responses pre- and post-treatment agree with this decrease in confidence about chemistry class work (Figure 4).

Table 3
Differences in percent of responses to statements related to confidence in class work in chemistry class (N=36)

		Response				
Survey Statement	Type	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Can do advanced work	Pos	2.4%	-0.3%	4.8%	-6.5%	-0.3%
Can't do advanced work	Neg	-15.7%	14.3%	-12.7%	20.5%	-6.5%
Can handle more difficult work	Pos	8.3%	5.4%	-9.7%	-0.7%	-3.3%
Get good grades in class	Pos	2.9%	2.9%	-5.2%	15.7%	-16.4%
Seems unusually hard	Neg	-21.4%	16.8%	-6.9%	5.5%	5.9%
Worst subject	Neg	-15.8%	0.9%	0.3%	6.0%	8.7%
Would take more courses	Pos	2.9%	0.0%	5.9%	-11.8%	2.9%

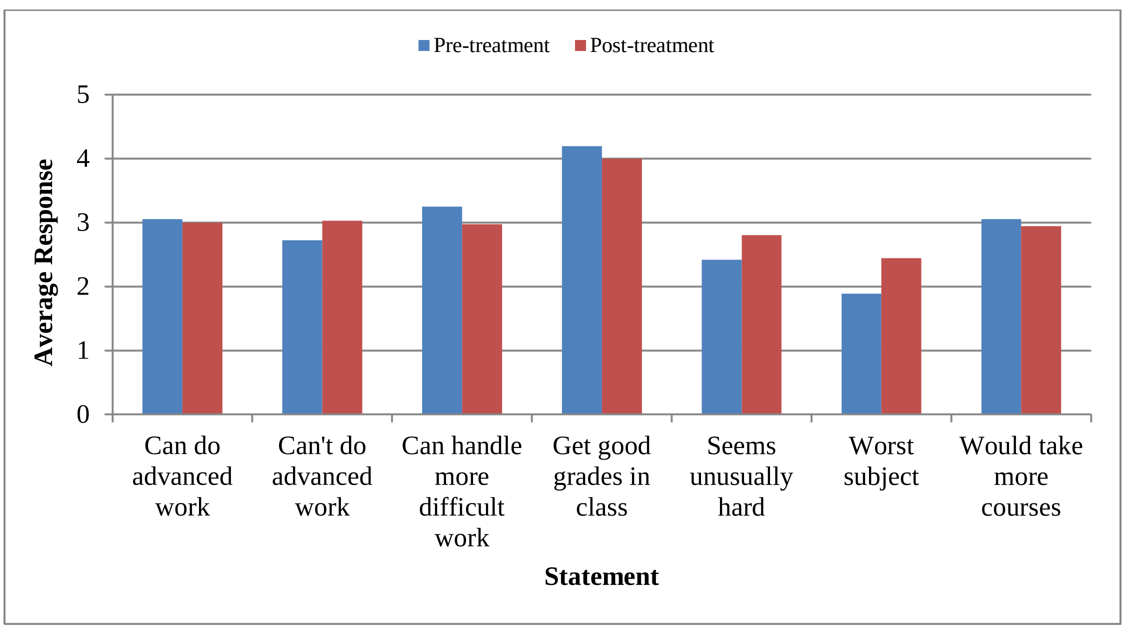

Figure 4. Students' average responses to confidence in class work statements pre- and post-treatment, (*N*=36).

Text Anxiety

Statements categorized as *Test Anxiety* were designed to uncover students' confidence in taking chemistry tests. There were two positive-response statements and one negative-response statements in this category. Like the previous categories, there was a downshift in responses to the positive-response statements, an upshift in the negative-response statement (Table 4). Average responses pre- and post-treatment agree with this decrease in confidence about taking chemistry tests (Figure 5).

Table 4
Differences in percent of responses to statements related to text anxiety in chemistry class (N=36)

		Response				
Survey Statement	Type	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Almost never get nervous during tests	Pos	14.7%	0.0%	-17.6%	8.8%	-5.9%
At ease during tests	Pos	11.4%	-2.9%	-5.7%	0.0%	-2.9%
A test would scare me	Neg	-4.3%	-24.5%	16.2%	9.4%	3.2%

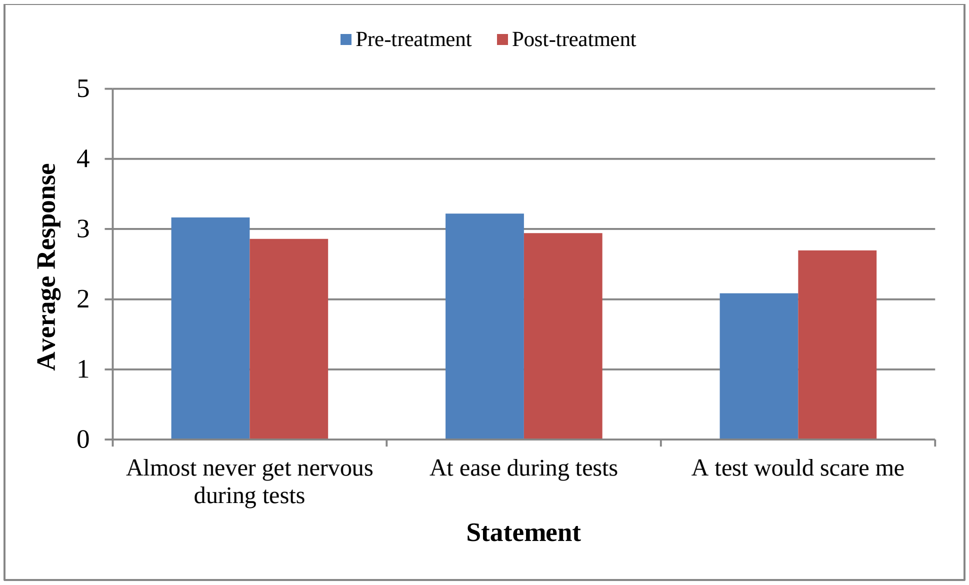

Figure 5. Students' average responses to test anxiety in chemistry statements pre- and post-treatment, (*N*=36).

Class Anxiety

Statements categorized as *Class Anxiety* were designed to uncover students' anxiety levels in chemistry class. There were three positive-response statements and five negative-response statements in this category. There was a general downshift in responses to the positive-response statements, mostly significantly with the statement about being at ease during chemistry class (Table 5). There was an upshift in all the negative-response statements. Average responses pre- and post-treatment agree with this increase in students' anxiety levels in chemistry class (Figure 6).

Table 5
Differences in percent of responses to statements related to anxiety in chemistry class (N=36)

		Response				
Survey Statement	Type	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Doesn't scare me	Pos	6.2%	-2.0%	16.0%	-29.9%	9.6%
Makes me uncomfortable/nervous	Neg	-24.0%	7.9%	13.6%	-3.2%	5.7%
Makes me irritable/impatient	Neg	-19.2%	6.4%	3.3%	3.6%	6.0%
Haven't worried about solving problems	Pos	-2.6%	-2.2%	0.7%	6.7%	-2.5%
Worry about solving problems	Neg	-13.6%	9.8%	0.6%	0.3%	2.9%
Can't think clearly	Neg	-11.0%	6.8%	-10.8%	12.1%	2.9%
Been at ease during class	Pos	2.9%	3.2%	0.8%	1.2%	-8.1%
Makes me uneasy/confused	Neg	-10.8%	-1.8%	6.3%	0.3%	6.0%

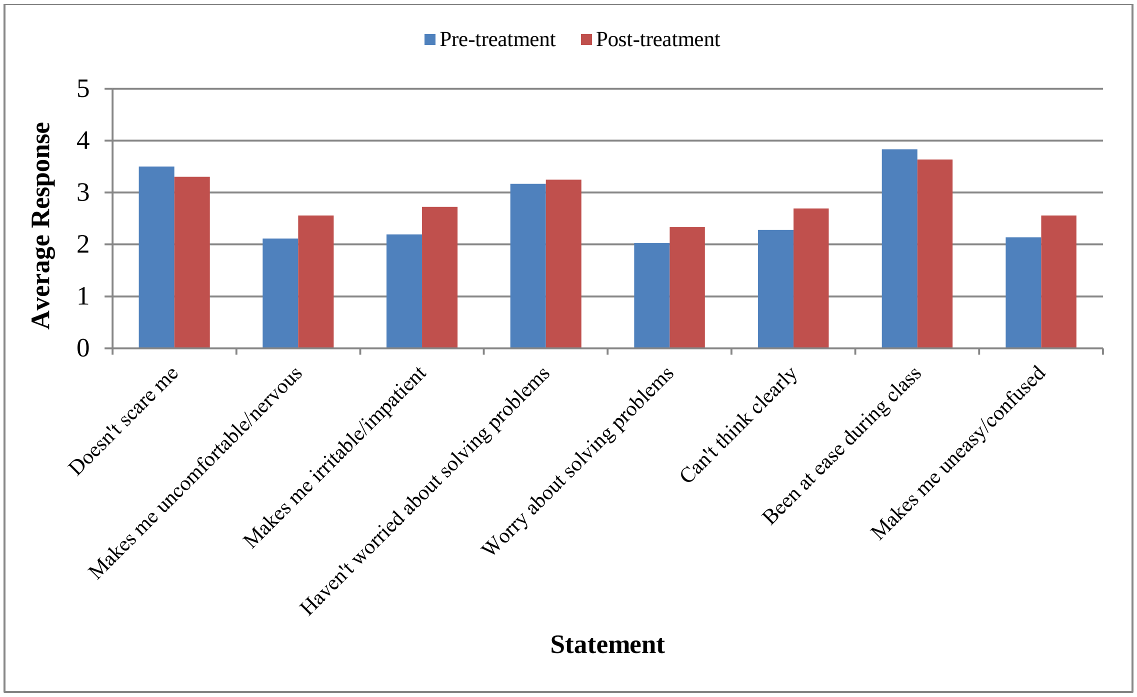

Figure 6. Students' average responses to chemistry class anxiety statements pre- and post-treatment, (*N*=36).

Topics of Confidence

Students stated the most recent studied topics as the ones they were most confident about, such as stoichiometry and the water unit. Either they couldn't remember early topics or stated certain parts, such as math or memorization, as topics they were less confident in. There was no indication that students were more confident in the water unit than they were in other units.

Student Attitudes about Chemistry Survey

Students were administered the SATCS before the treatment period and after the treatment period. The 28 statements of the survey were divided into 5 categories: interest in chemistry as a subject, interest in chemistry lab work, using chemistry for problem solving and decision making, relevancy to life, and behavioral tendencies to learn chemistry. Each category had a mixture of positive-response statements and negative-response statements. A selection of five on the positive-response statements indicated a favorable attitude about chemistry whereas a selection of one on the negative-response statements indicated a favorable attitude about chemistry.

Chemistry as a Subject

Statements categorized as *Chemistry as a Subject* sought out students' attitudes about chemistry compared to other subjects in school. There were three positive-response statements and one negative-response statement in this category. There was a small downshift in responses to the positive-response statements and a slight upshift in the negative-response statements (Table 6). Average responses pre- and post-treatment also indicated a very small decrease in attitude about chemistry as a subject (Figure 7).

Table 6
Differences in percent of responses to statements related to chemistry as a subject (N=36)

		Response				
Survey Statement	Type	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Like over other subjects	Pos	14.7%	- 14.7%	11.8%	-8.8%	-2.9%
Lessons interesting	Pos	-2.9%	11.8%	5.9%	-8.8%	-5.9%
Not favorite subject	Neg	2.4%	-3.7%	-2.0%	1.5%	1.8%
Important subject to study	Pos	5.9%	-14.7%	8.8%	0.0%	0.0%

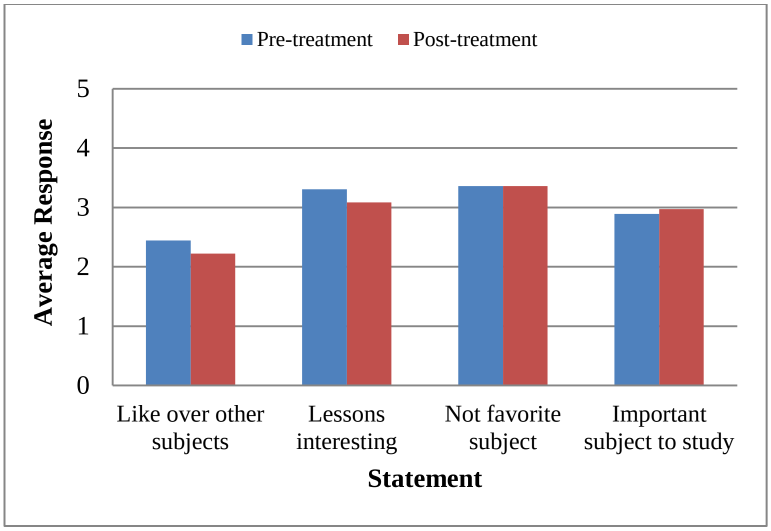

Figure 7. Students' average responses to Chemistry as a Subject statements pre- and post-treatment, (*N*=36).

Chemistry Lab Work

Statements categorized as *Chemistry Lab Work* sought out students' attitudes about labs and experiments done in chemistry class. There were two positive-response statements and one negative-response statement in this category. Like the previous category, there was a downshift in responses to the positive-response statements and a small upshift in the negative-response statements (Table 7). Average responses pre- and post-treatment agree with this decrease in attitude about chemistry lab work (Figure 8).

Table 7
Differences in percent of responses to statements related to chemistry lab work (N=36)

		Response				
Survey Statement	Type	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Do not like experiments	Neg	-4.2%	-0.8%	2.4%	-3.0%	5.7%
Doing something important	Pos	5.9%	5.9%	11.8%	-14.7%	-8.8%
Doing experiments is fun	Pos	0.1%	3.0%	3.5%	-1.9%	-4.7%

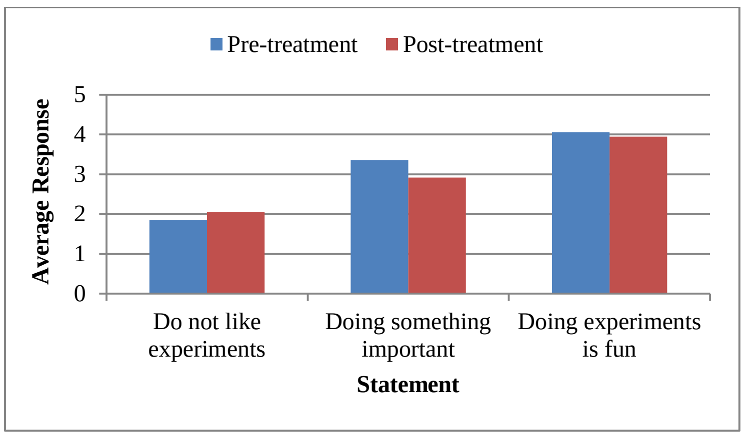

Figure 8. Students' average responses to Chemistry Lab Work statements pre- and post-treatment, (*N*=36).

Problem Solving and Decision Making Skills

Statements categorized as *using chemistry for problem solving and decision making* sought out students' attitudes about how useful chemistry is in solving everyday problems. There were four positive-response statements and one negative-response statement in this category. The majority of these statements showed an overall upshift in responses to the positive-response statements and a downshift in the negative response statements (Table 8). Average responses pre- and post-treatment agree with this increase in attitude about the usefulness of chemistry in solving problems and making decisions (Figure 9).

Table 8
Differences in percent of responses to statements related to problem solving and decision making skills in chemistry (N=36)

		Response				
Survey Statement	Type	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Useful for everyday problems	Pos	-6.6%	2.0%	-8.0%	4.0%	8.6%
Effect on voting in elections	Pos	-3.6%	-7.2%	13.2%	-2.3%	0.0%
Does not help judge other points of view	Neg	2.9%	2.9%	8.8%	-5.9%	-8.8%
Making good decisions scientific process	Pos	5.6%	-0.3%	-12.7%	10.7%	-3.3%
Help decide what to buy	Pos	-3.3%	-3.4%	1.9%	-0.8%	5.6%

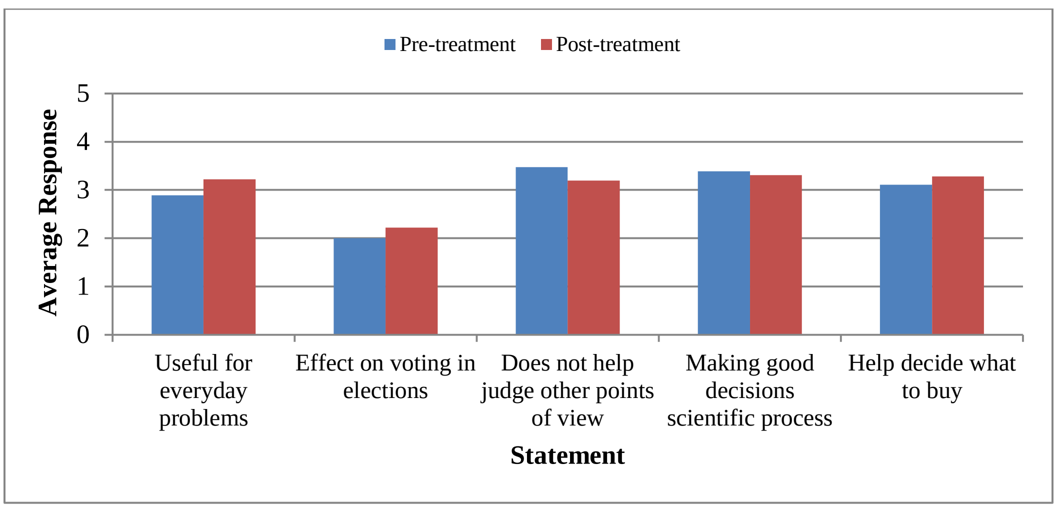

Figure 9. Students' average responses to Problem Solving and Decision Making Skills statements pre- and post-treatment, (*N*=36).

<u>Relevancy to Life</u>

Statements categorized as *relevancy to life* sought out students' attitudes about how relevant chemistry is to their everyday lives. Though similar to *using chemistry for problem solving and decision making*, these statements did not focus specifically on problems solving and decision making. There were four positive-response statements and six negative-response statements in this category. Whereas half of the positive-response statements showed an obvious upshift in responses, the other two positive-response statements showed a small downshift in response (Table 9). The two statements that displayed an upshift in responses dealt specifically with usefulness of chemistry in everyday life, similar to the previous category of statements, and how chemistry helps them learn about the environment, which was the focus of the unit. The statements that showed downshifts concerned chemistry experiments, similar to the lab work category, and career choices in the sciences.

The majority of the negative-response statements showed a slight downshift in responses, indicating a slight increase in students' attitudes about the relevancy of chemistry to their lives. However, the two questions that focused on their personal use of chemistry in the future showed a small upshift in response. Average responses pre- and post-treatment agree with the mixed changes in attitude about the relevancy of chemistry in their lives (Figure 10).

Table 9
Differences in percent of responses to statements related to chemistry's relevancy to life (N=36)

		Response				
Survey Statement	Type	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Does not affect lives	Neg	1.5%	-5.2%	10.3%	-0.7%	-5.9%
Useful in my everyday life	Pos	-2.7%	6.6%	-19.5%	9.4%	6.1%
Helps to understand environment	Pos	-2.7%	-2.7%	-2.4%	10.0%	-2.3%
Does not help to understand world problems	Neg	10.0%	3.8%	-12.9%	2.3%	-3.1%
Has nothing to do with my life	Neg	6.7%	-4.6%	-3.8%	2.3%	-0.7%
Has nothing to do with local issues	Neg	9.8%	4.8%	-11.7%	-2.9%	0.0%
Experiments help to understand world	Pos	0.0%	0.0%	2.9%	-2.9%	0.0%
Not important for future success	Neg	-2.8%	-5.6%	8.3%	-5.6%	5.6%
Will not use science after school	Neg	1.9%	-3.3%	5.1%	-6.1%	2.4%
Interested in science career	Pos	2.9%	-2.9%	2.9%	5.7%	-8.6%

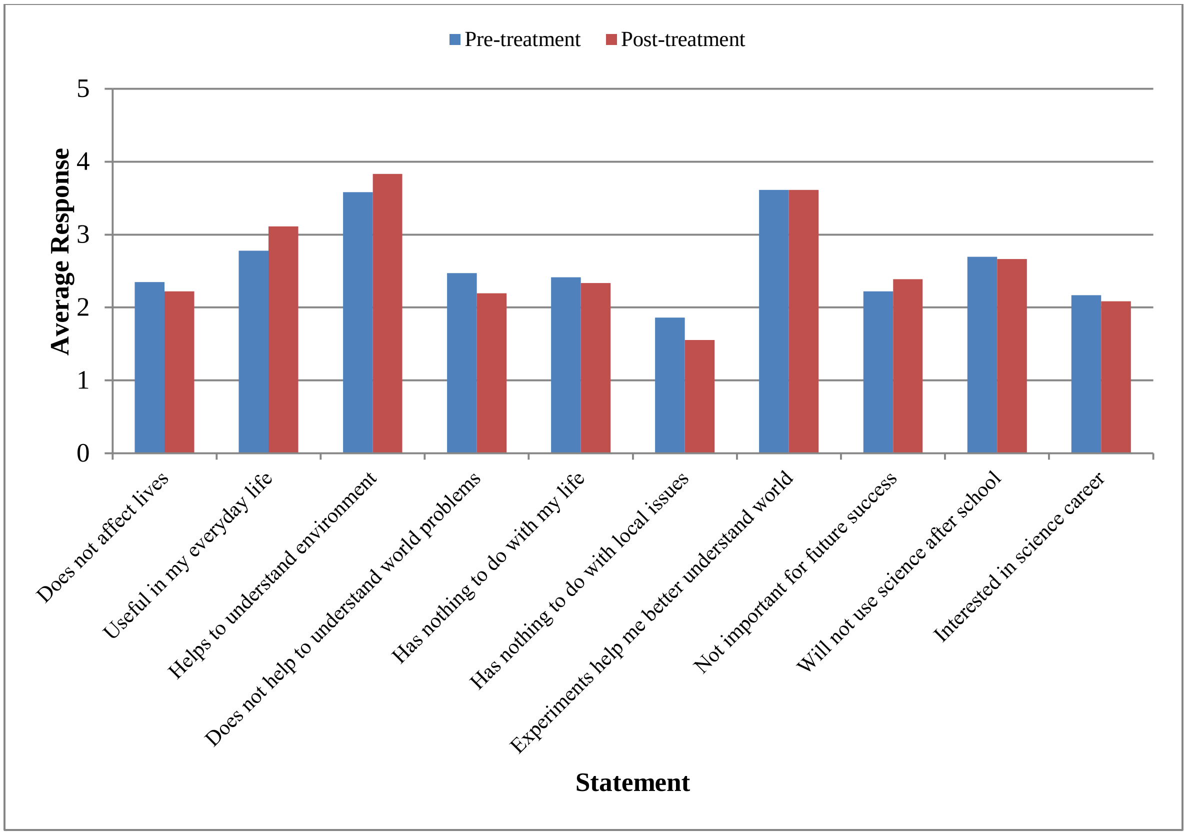

Figure 10. Students' average responses to Relevancy to Life statements pre- and post-treatment, (*N*=36).

Behavioral Tendencies to Learn Chemistry

Statements categorized as *behavioral tendencies to learn chemistry* sought out students' attitudes about how willing they are to learn the subject of chemistry. There were four positive-response statements and two negative-response statements in this category. The shifts in positive-response statement responses were mixed though there seemed to be an overall significant downshift in responses, indicating a large drop in attitude (Table 10). The statement regarding spending more time reading chemistry books was the only statement to show a bit of an upshift in responses. The negative-response statements showed a slight upshift in responses, agreeing with the downshift of positive-response statement responses. Average responses pre- and post-treatment agree with the decreased changes in attitude about their behavioral tendencies to learn chemistry (Figure 11). I also noticed students complained less than usual during the treatment period through my weekly journaling.

Table 10
Differences in percent of responses to statements related to behavioral tendencies to learn chemistry (N=36)

		Response				
Survey Statement	Type	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Willing to spend time reading	Pos	-26.8%	-4.4%	10.1%	12.3%	8.8%
Like solving new problems	Pos	35.6%	6.5%	-5.0%	-28.5%	-8.6%
Would do a project	Pos	-5.0%	15.2%	9.5%	-22.7%	3.0%
Taking more science classes	Pos	12.3%	3.3%	-5.5%	12.3%	-22.4%
Only taking because required	Neg	-10.0%	8.4%	-0.4%	-0.4%	2.3%
Should not be required	Neg	-7.1%	-3.4%	8.0%	-0.1%	2.6%

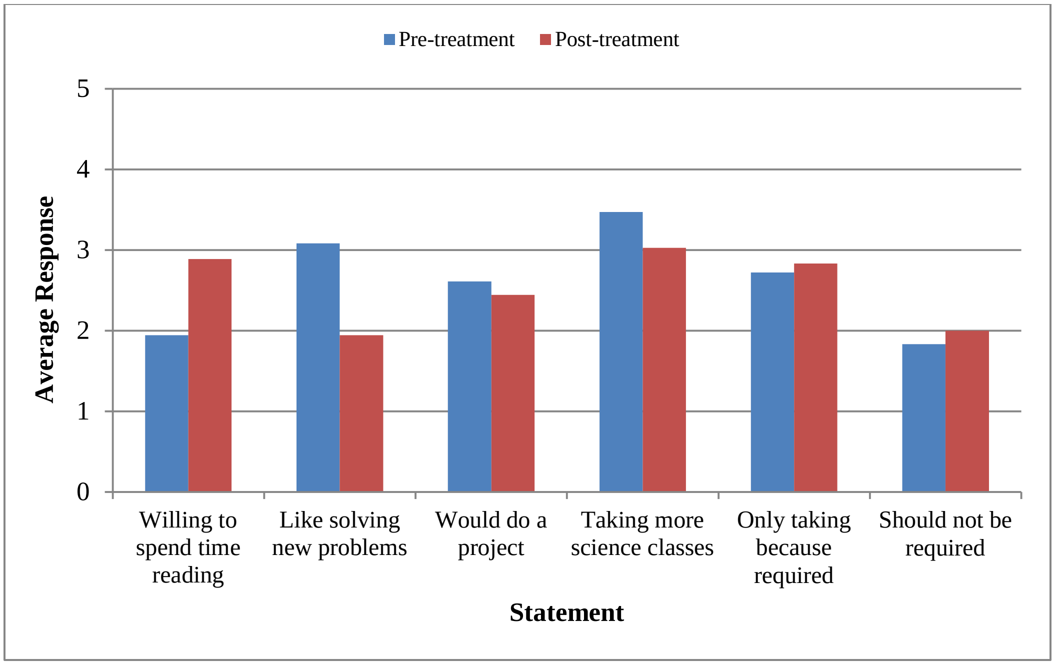

Figure 11. Students' average responses to behavioral tendencies to learn chemistry statements pre- and post-treatment, (*N*=36).

<u>Student Work Effort</u>

Before and after the treatment period, students were polled on how much effort they put into their science work. They had a choice among: *I don't try at all, I do just enough to get by, I give an average amount of effort, I try pretty hard, but not as hard as I could*, and *I work as hard as I can*. After the treatment period, there was a downshift in the amount of effort that students put into their chemistry work (Figure 12).

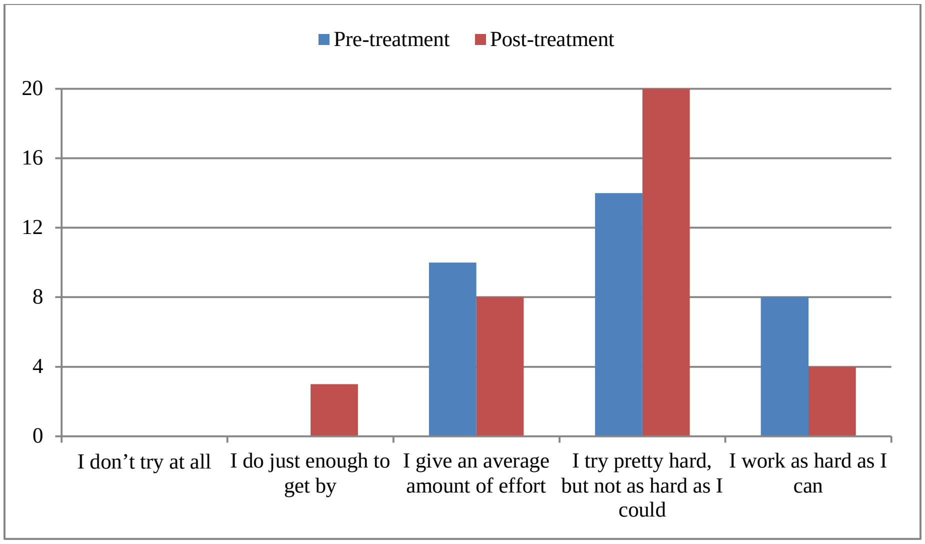

Figure 12. Distribution of students’ effort put into their science work pre- and post-treatment, (*N*=36).

<u>Why Students are Taking Chemistry</u>

Students were polled on why they were taking chemistry class. For both pre-treatment and post-treatment polls, the greatest number of responses, 44% and 50% respectively, was that chemistry was required for graduation from high school. Other responses included needing chemistry to get into college, because they were interested in the subject, needing chemistry for a future career, being a better option to take than Earth Science, needing it outside of school, and knowing they could do it (Table 11). After the treatment period, there was a drop in student responses of needing chemistry for college, chemistry being a better option than other sciences, and being able to do chemistry. However, there was also a nine percent increase in the number of students responding they were interested in chemistry.

Table 11
Reasons why students are taking chemistry (N=36)

Reason	Pre-treatment %	Post-treatment %
Future Career	14%	14%
Required	44%	50%
For College	25%	17%
Better option than other sciences	14%	8%
Interested in it	19%	28%
Can do it	6%	0%
No Response	8%	0%
Need it outside of school	0%	3%

Grades

Average percentages from pre-treatment units were compared to average percentages from the treatment period unit (Figure 13). The average percentage from the water unit from the treatment period, 75.1%, was lower than the average percentage from the pre-treatment period units. This is confirmed when considering which unit was the students' worst unit in terms of grades. The water unit was the lowest average for 37% of the students (n=35) and the highest average for no students (Figure 14).

In my weekly journal I made several notes about students struggling with some of the material, confirming the results of their grades. Students seemed to enjoy the labs and experiments we did in class, especially those in which they were able to test water samples from the school or from their own homes. Students did not enjoy assignments that involved a significant amount of reading and/or calculations.

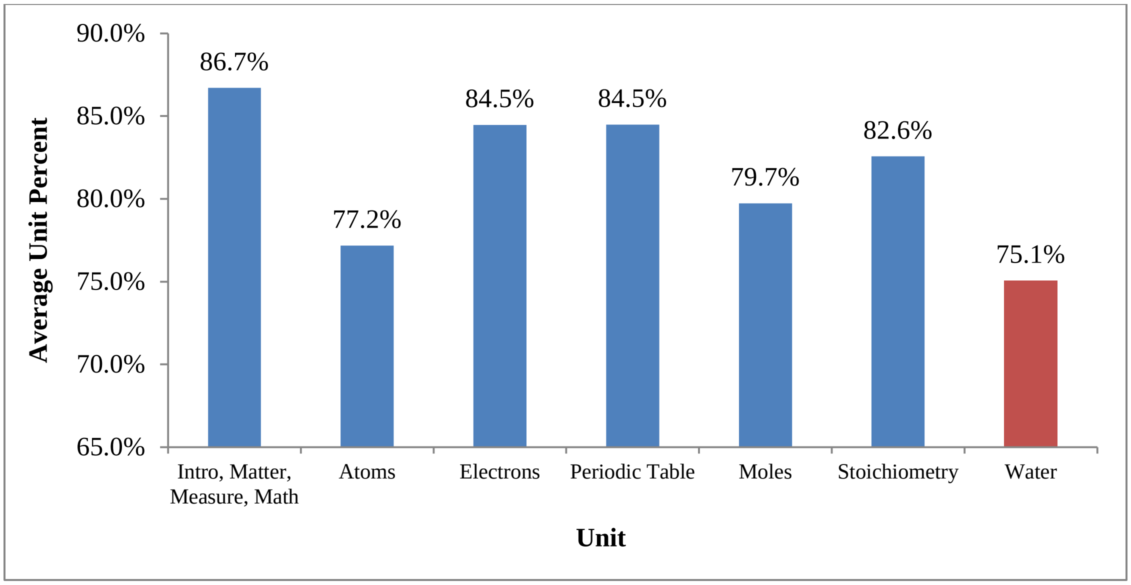

Figure 13. Students' combined work and test average percentages of chemistry units, (*N*=35). Blue = pre-treatment units, red = treatment units.

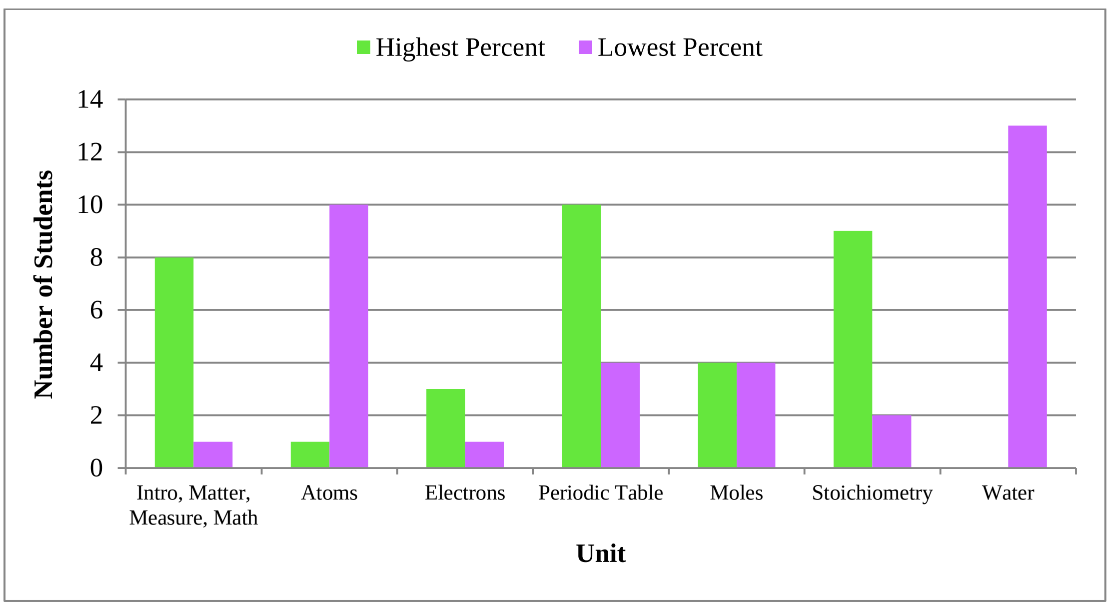

Figure 14. Students' highest-scoring and lowest-scoring units, (*N*=35).

<u>Interviews</u>

Of the ten students interviewed, 70% provided the same confidence ranking after treatment as before treatment, with 20% showing an increase in confidence, and 10%

showing a slight decrease in confidence (Figure 15). Also, 50% of the students mentioned the water unit as a topic they were very confident in compared to no students saying it was a unit they were less confident in.

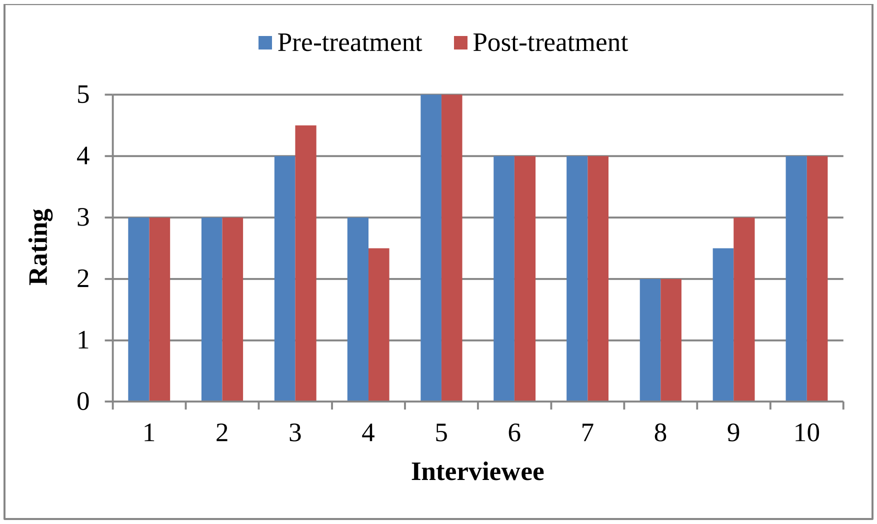

Figure 15. Students' rating of their confidence in chemistry class pre- and post-treatment, (*n*=10). Note: 5 is considered high confidence and 1 is considered low confidence.

Ten percent of the students demonstrated a changed attitude about chemistry as evidenced by their comments about the water unit and when they would use chemistry outside of school. However 80% of the interviewed students already had an understanding of how chemistry can be used outside of the classroom before the treatment period based on their responses. One student expressed a common sentiment when she stated in regard to using chemistry outside the classroom, "You're not necessarily going to want to know all of the formulas and little tiny details." Of the 80% who mentioned this understanding before the treatment period, 37.5% added water safety or environmental concerns to their examples of when they would use chemistry outside of the classroom.

In terms of using chemistry to make decisions in everyday life, 10% retained their position of not using it, 10% retained their position of maybe using it depending on the situation, and 40% retained their position of using it. The remaining 30% of the students changed their original position from no or maybe to yes. One student commented, "Now I know how to do that titration thing, to know how good my water is. …And I can figure things out like that fish kill we studied this semester." A recurring comment by 40% of the students was using chemistry to make decisions regarding water quality or the environment. Another student stated that the water unit had a positive impact on her. She commented,

> I think you use it every day with everything that happens. Every time you take a drink of water you don't know if there's been pills flushed down your toilet that's in your water. It's just something to think about. A lot of people don't know about it, but if everybody knew about it, it would have a big effect on how people treated their water and all that stuff.

INTERPRETATION AND CONCLUSION

The results of this action research project, which sought to determine if using a contextual-based approach to teaching chemistry would increase students' attitudes, confidence, and performance in class, indicated that although students expressed a greater understanding of the relevance of chemistry in their lives outside of the classroom, for the most part, attitudes, confidence, and performance slightly declined after the change. These results are generally inconsistent with results found in the literature.

I can think of many reasons the results of this project were not what I had hoped for. First and foremost, there is no explicit method for teaching with a contextual approach. The literature provided no clear suggestions apart from starting the unit with a contextual scenario from which to draw the content. As such, I depended heavily on the structure presented in the American Chemical Society's *Chemistry in the Community* and *Chemistry in Context* books. During several sections of their chapters devoted to water quality, content is presented as mostly pure content with little connection to the context. In order to ensure students grasped the content, some assignments were given that really did not relate back to the content and may have felt disjointed from the scenario. King (2009) suggested keeping the context central during all classroom activities, which is an important factor to consider in future unit designs. Another context-related problem could be in the chosen context itself. If the chosen context is not meaningful to the students directly, they may not feel very connected to it and miss its importance in learning chemistry through a contextual approach (Corrigan & Rodrigues, 2002).

Furthermore, the types of activities done in class could influence students' attitudes, confidence, and performance in chemistry. Although some of the activities done in class were directly related to the context of the unit, many units were not obviously connected. Additionally, several activities were also not considered student-centered. Altering activities to be more student-centered and obviously context-based may change the results of this project. One such activity could be what King, Bellocchi, & Ritchie (2008) call an *extended experimental investigation*, in which students design and carry out an investigation to solve a real-life problem related to the context being studied. Other ideas may be role-playing activities, class debates, and community-related activities.

The water unit itself could have been too long, as well, since it lasted as long as two of the other units. Some contexts, like the water quality unit, lend themselves to covering perhaps too much content. Students may have just become overwhelmed with amount of information and lost sight of the greater picture. There were also fewer checks for understanding than I should have probably utilized to ensure students were grasping the information.

Finally, the students themselves may have lost interest in school in general during the treatment period. Based on conversations with other teachers during the treatment period, student assignment completion and work effort dropped off across subject areas. The months of March and April seem to be months in which students tend to give up a little as the see the end of the school year approaching. During the treatment period students also scheduled their classes for the following school year, which may have skewed their responses to survey questions regarding taking more science courses, since they knew exactly what they were going to be taking the following year. Lastly, also based on conversations with other staff members, this particular junior class tended to be less motivated and lazier than past junior classes. The dynamics of their personalities may have affected the results of this project as well. I cannot rule out that the chemistry subject matter itself is difficult for many students, although some topics, like covalent and ionic bonds, were covered with these students when they were freshmen.

VALUE

In some ways, I am grateful that the results were far different than what I expected. I know where the problems occurred, and I can work to change the results in future classes. The negative results can only help me grow as an instructor.

After completing the unit, I had students fill out the Informal Water Unit Feedback Form, which asked them what they liked, what they didn't like, and what they would suggest for the future (Appendix D). They all seemed to enjoy the labs we did in class, many stating that they were hands-on learners. They also appreciated the real world applications of the unit. So although the unit may not have increased their confidence and performance, I can rest well knowing they at least have a greater understanding of the importance of chemistry as it applies to the world around them. As I work to restructure this unit, I plan on ensuring the context is present in nearly all, if not all, of the activities the students do in class. Furthermore, I plan on breaking up the unit to focus on less content but perhaps in more depth. I may still use one context or scenario as the overarching theme, or perhaps I will create smaller contexts that lend themselves to focus on less content. Either way, I still see the value of presenting a context first and drawing content from it. I also think it would be of value to research issues specific to Iowa and the rural community so that the contextual scenario is directly related to the students.

One of the major complaints that the students had was that there was too much reading with few opportunities to comprehend what they had read. There were definitely more reading assignments during this unit that in other units simply because in many cases it was the best way to integrate and elicit discussions about the contextual scenario. To make students more comfortable with reading assignments, however, I will use them more frequently during other units with more scaffolding opportunities to guide them to be better critical readers. I also found that discussions tended to turn more into chat sessions rather than constructive dialogues about the material. In order to change this in the future, students will need to have clear-set discussion rules and practice with these rules throughout the year.

The failure of this project to increase students' attitudes, confidence, and performance in chemistry is by no means the end of the road in teaching with a contextual approach. Not only will I continue to teach the water unit, albeit modified, I plan on developing and teaching additional context-based lessons. I now know how to evaluate the success or failure of lessons based on student feedback. I also realize that although some contexts lend themselves to seemingly endless amounts of content, less is more. Sometimes I forget to put myself in the students' shoes and try to incorporate as much as I can into a unit. I need to remember that this is mostly new material to the students, and they need time to process it and incorporate it into their schemas. I can only learn from the flaws, make improvements to the process, and in the end, grow to become a better educator.

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APPENDICES

APPENDIX A

CONFIDENCE IN CHEMISTRY SURVEY (CCS)

Directions: The statements in this survey have to do with your confidence in chemistry class. Please read each statement carefully, and circle the number that best expresses **your own** feelings.

Participation in this survey is voluntary. Your grade will not be affected by your responses to this survey. This is not a test, and there are no "right" or "wrong" answers. Please respond to every item.

Statement	Agree	Tend to Agree	Tend to Disagree	Disagree
Generally I have felt confident about attempting chemistry	4	3	2	1
I am sure I could do advanced work in chemistry	4	3	2	1
I'm no good at chemistry	4	3	2	1
I am sure that I can learn chemistry	4	3	2	1
I don't think I could do advanced chemistry	4	3	2	1
I'm not the type to do well in chemistry	4	3	2	1
I think I could handle more difficult chemistry	4	3	2	1
I can get good grades in chemistry	4	3	2	1
For some reason even though I study, chemistry seems unusually hard for me	4	3	2	1
Most subjects I can handle okay, but I have a knack for messing up chemistry	4	3	2	1
I have a lot of self-confidence when it comes to chemistry	4	3	2	1
Chemistry has been my worst subject	4	3	2	1
Chemistry doesn't scare me at all	4	3	2	1
It wouldn't bother me to take more chemistry (science?) courses	4	3	2	1
Chemistry usually makes me uncomfortable and nervous	4	3	2	1

Chemistry makes me feel uncomfortable, restless, irritable, and impatient	4	3	2	1
I haven’t usually worried about being able to solve chemistry problems	4	3	2	1
I get a sinking feeling when I think of trying chemistry problems	4	3	2	1
I almost never have gotten nervous during a chemistry test	4	3	2	1
I usually have been at ease during chemistry tests	4	3	2	1
My mind goes blank and I am unable to think clearly when working chemistry	4	3	2	1
A chemistry test would scare me	4	3	2	1
I usually have been at ease during chemistry class	4	3	2	1
Chemistry makes me uneasy and confused	4	3	2	1

What aspects of chemistry are you most confident about?

What aspects of chemistry are you least confident about?

APPENDIX B

STUDENT ATTITUDES TOWARD CHEMISTRY SURVEY (SATCS)

Directions: The statements in this survey have to do with your attitudes about chemistry and science. Please read each statement carefully, and circle the number that best expresses **your own** feelings.

Participation in this survey is voluntary. Your grade will not be affected by your responses to this survey. This is not a test, and there are no "right" or "wrong" answers. Please respond to every item.

Statement	Agree	Tend to Agree	Tend to Disagree	Disagree
I like chemistry more than any other school subjects.	4	3	2	1
Chemistry lessons are interesting.	4	3	2	1
Chemistry is useful for solving everyday problems.	4	3	2	1
Chemistry is not one of my favorite subjects.	4	3	2	1
I am willing to spend more time reading chemistry books.	4	3	2	1
I do not like to do chemistry experiments.	4	3	2	1
When I am working in the chemistry lab, I feel I am doing something important.	4	3	2	1
People do not need to understand chemistry because it does not affect their lives.	4	3	2	1
I like trying to solve new problems in chemistry.	4	3	2	1
Doing chemistry experiments in school is fun.	4	3	2	1
Chemistry is one of the most important subjects for people to study.	4	3	2	1
If I had a chance, I would do a project in chemistry.	4	3	2	1
Much of what I learn in science is useful in my everyday life today.	4	3	2	1
Learning science will have an effect on the way I vote in elections.	4	3	2	1
I plan to take more science classes in high school.	4	3	2	1
Learning chemistry helps me understand about the environment.	4	3	2	1

Chemistry class helps me to judge other people's points of view.	4	3	2	1
Chemistry will not help me understand more about world-wide problems.	4	3	2	1
Chemistry has nothing to do with my life outside of school.	4	3	2	1
Making a good decision is a scientific process.	4	3	2	1
Chemistry has nothing to do with local issues, such as waste from nearby factories.	4	3	2	1
Chemistry can help me make better decisions about what I buy.	4	3	2	1
Chemistry experiments can help me to better understand the world.	4	3	2	1
Learning chemistry is not important for my future success.	4	3	2	1
I only take science because it is a required course.	4	3	2	1
Science should not be required in school.	4	3	2	1
I do not expect to use science much when I get out of school.	4	3	2	1
I am interested in a career as a scientist or engineer.	4	3	2	1

1. How much effort do you usually put into your science work? (*Circle One*)
   a. I don't try at all
   b. I do just enough to get by
   c. I give an average amount of effort
   d. I try pretty hard, but not as hard as I could
   e. I work as hard as I can

2. The reason I am taking chemistry is because…

3. How far do you expect your will go in school? (*Circle one*)
   a. Will not finish high school
   b. High school diploma
   c. Trade or vocational school
   d. Some college, but no degree
   e. 2-year (associate's) degree
   f. 4-year (bachelor's) degree
   g. Master's degree
   h. Ph.D. degree
   i. Other advanced degree
   j. Don't know

4. What is your gender? Male Female

APPENDIX C

INTERVIEW QUESTIONS

Directions: The questions in this interview have to do with your attitudes and confidence about chemistry.

Participation in this interview is voluntary. Your grade will not be affected by your responses to this interview. This is not a test, and there are no “right” or “wrong” answers. Please respond to each question truthfully.

1. Do I have your permission to record this interview? The recording will only be used by me to double check your responses to the questions.

2. On a scale of 1 to 5, with 5 being most confident and 1 being least confident, how would you rate your confidence in chemistry class? Explain your answer.

3. What aspects or areas of chemistry are you most confident about? Why?

4. What aspects or areas of chemistry are you least confident about? Why?

5. Do you feel it’s important to study chemistry? Explain your answer.

6. Do you feel that chemistry is important to know in order to make decisions about things in everyday life? Explain your answer.

7. Do you expect to use chemistry and chemistry skills when you are done with the class? If so, how? If not, why not?

APPENDIX D

INFORMAL WATER UNIT FEEDBACK FORM

Water Unit Feedback

Please answer all questions honestly, using constructive criticism when appropriate (i.e. when you have something negative to say).

1. What were the parts or activities of the water unit you liked the most? Be specific.

2. What did you like about them? Be specific.

3. What were the parts or activities of the water unit you liked the least? Be specific.

4. What didn't you like about them? Be specific.

5. What could Mrs. Brist do next year to improve the parts you liked the least, besides get rid of them? Be specific.