EFFECTS OF SELF-ASSESSMENT ON STUDENT LEARNING IN HIGH SCHOOL CHEMISTRY

by

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STATEMENT OF PERMISSION TO USE

In presenting this professional paper in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the MSSE Program shall make it available to borrowers under rules of the program.

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ABSTRACT

Self-assessment is an important skill students need to develop to be effective learners. Students were given lists of “I can” statements about the standards for two units in a high school chemistry class. They rated how well they were meeting these standards throughout the units based on their performance on assignments and practice quizzes. They were encouraged to use these ratings to identify topics they needed to study before taking the written summative assessment. The data collection tools for this study were unit reflections and unit surveys completed by the students, the students’ summative assessments and a journal kept by the teacher. While more than half of the students found the “I can” statements helpful, using self-assessment had little impact on students’ summative assessment scores.

INTRODUCTION AND BACKGROUND

Project Background

Teaching and Classroom Environment

I have taught chemistry for the past five years; the last two of these years have been at Eisenhower High School in Goddard, Kansas. Over the years, I have been frustrated by students who do poorly in the class because they did not study the topics being taught. These students were often disappointed in their scores on summative assessments and said things like, "I thought I really knew this material" after taking the test. Their inability to recognize what they did and did not know led them to spend little time studying. Other students were aware that they did not know the material, but they struggled to identify particular topics they needed to study. These students may have felt so overwhelmed that they did not know where to start studying and, thus, never studied.

I wanted to help all my students learn to accurately self-assess their knowledge so they would know what they needed to study. I gave them a series of "I can" statements for the topics being studied and asked them to rate how well they met those expectations. For example, one of the "I can" statements was "I can identify compounds as ionic, covalent or metallic based on the structures and properties they have." I encouraged them to use a variety of resources to study the topics they did not completely understand and had them reassess their ability throughout the unit. The intent was to help students develop these skills to help them become more successful in chemistry and other courses they take in the future. If the treatment was effective, other teachers may be interested in using it in their classes.

School Demographics

Eisenhower High School is a traditional ninth through twelfth grade high school with approximately 850 students. It is in a suburban school district. The student population is 88.7% Caucasian, 2.5% African American, 2.2% Asian, 2.5% American Indian, 2.1% Multiracial and 2.0% Hispanic. 98.3% of the students speak English as their first language. 16.8% of the students qualify for the free or reduced lunch program.

Focus Questions

The main focus of my action research project was to address the question: How does students' use of self-assessment impact the learning of chemistry?

In addition to this main question, I investigated the answers to the following sub-questions.

1. How does using self-assessment affect students' scores on summative assessments?
2. How does using self-assessment affect students' attitudes about learning chemistry?
3. How do students use the results of their self-assessment to improve their understanding of chemistry?
4. Does using self-assessment during a unit help students predict their performance on summative assessments?

CONCEPTUAL FRAMEWORK

Students need to be able to monitor their own learning in order to be successful in classes throughout their lives. Swanson (1990) found that students in intermediate school with higher metacognition performed better at problem solving than students who had higher aptitude but lower levels of metacognition. Everson and Tobias (1998) found that college students with grade point averages (GPAs) above the median GPA had more accurate estimates of their knowledge than students whose GPAs were below the median. One method students can use to estimate their knowledge is self-assessment, but in order to be able to self-assess accurately, students need to know what standards they are expected to reach. They also need to be aware of conditions that may cause them to think they know more than they really do about a topic. By identifying topics that they do not know well, students can use strategies to improve their understanding.

Flavell identifies four factors that are all intertwined in the process of monitoring one's thinking: metacognitive knowledge, metacognitive experiences, goals, and actions (1979). Metacognitive knowledge is information stored in one's memory about how people in general, or oneself in particular, think. It includes information about specific study strategies, judgments of the usefulness of those strategies, beliefs about one's ability to learn, and the effects external factors have had on one's learning in the past. Metacognitive experiences are the conscious thoughts and feelings that happen as one is thinking. For example, noticing that you comprehend a text better as you reread it is a metacognitive experience. Goals are the reasons one is thinking, and actions are the thoughts or behaviors one uses to reach the goals.

Students need to be able to monitor how well they understand a new topic, because they must realize when their understanding is not complete in order to decide to seek more explanation or think more about the topic (Rickey & Stacy, 2000). People develop this ability over time. A study involving first, second, and third graders found that when given incomplete instructions, only one third grader had to attempt to follow the instructions before realizing he needed more information; all but 1 of the first graders had to attempt to follow the instructions before coming to this realization (Markman, 1977). These young students, like all people throughout their lives, will have more metacognitive experiences that cause them to adjust their metacognitive knowledge to be more reliable and useful for them (Flavell, 1979). Although students may begin by using specific metacognitive skills only in the subject in which the skills were taught, they begin to use their metacognitive knowledge more flexibly as their metacognitive regulation improves (Schraw, 1998). Metacognition is an important type of quality control. It provides a prompt to go back and review a topic by making a person aware that he has not completely comprehended it (Markman, 1977).

Self-assessment is one metacognitive process that is used to monitor and control thinking (Dory, Degryse, Roex & Vanpee, 2010; Schraw, 1998). Students can use self-assessment before an assessment for goal-setting purposes; during or after the assessment, self-assessment provides information they can use in their future self-regulation (Radhakrishnan, Arrow, & Sniezek, 1996). Their feelings of success or failure are metacognitive experiences that may cause them to alter their metacognitive knowledge about how much they should study, whether certain study strategies work for them, or whether they are capable of understanding the material. McMillan and Hearn

(2008) identify three steps necessary in the self-assessment process. These steps are self-monitoring, self-evaluation and implementing correction. In self-monitoring, a student addresses "Do I know this?" During self-evaluation, a student asks "How well do I know this compared to what is expected of me?" Finally, the student implements the correction by enacting the answer to the question "What do I do to improve and meet the expectation?" Effective learners use the answers to these questions to recognize their strengths and weaknesses and to direct their studying (Boud, 1989 as cited in Lew, Alwis & Schmidt, 2010).

In order for students to be able to self-assess accurately, it is crucial that they understand the goals they are trying to reach. As Stiggins (2005) identifies, teachers are not the only decision makers in the classroom. Students are continually making their own decisions about how they are going to participate in the class. In order to make informed decisions, students need an easily understandable version of the standards they need to meet. When students do not understand what teachers expect of them, their achievement is often low (Black & Wiliam, 1998). However, when they understand what they are supposed to learn, students are "generally honest and reliable in assessing both themselves and one another; they can even be too hard on themselves" (Black & Wiliam, 1998, p. 143). An action research project performed by Althoff, Linde, Mason, Nagel, and O'Reilly (2007) found that as a result of posting daily objectives, students remembered more of the topics they had learned about, class average grades rose, and more students saw the value of their assignments. Being made aware of what they were supposed to be learning empowered the students to meet their teachers' expectations.

If objective standards are not communicated to students, they will judge their current state of knowledge against what they knew before instruction. This causes them to have an illusion of competence, so they overestimate their future performance on an assessment (Kostons, van Dog, & Paas, 2010). Koriat and Bjork (2005) identify other factors that lead students to illusions of confidence. Students often make erroneous judgments of learning when their current learning is influenced by conditions that will not be present during an assessment, such as having the correct answer written next to a question on a study guide. When students assess their learning too soon after studying, their judgments of learning will be inaccurate because they are assessing information in their short term memories rather than in their long term memories. Students need to be trained to use strategies that will help them make more accurate judgments of their learning, so they will be able to decide whether they need to continue studying to meet their goals. Some of these strategies include: testing mastery of a topic after a delay from studying the topic; testing mastery when they are only looking at the question, not the answer; and judging how likely they are to get the correct answer instead of just answering the question (Pashler, Bain, Bottge, Graesser, Koedinger, McDaniel & Metcalfe, 2007).

In addition to being a more accurate measure of knowledge, using delayed judgments of learning which require students to access information in their long term memories may enhance their learning. Requiring students to recall information from their long term memory gives them practice in retrieving the information and helps solidify the knowledge in their memory (Paschler et al., 2007). The more difficult a successful retrieval of knowledge is, the more likely its long-term retention is (Kornell &

Bjork, 2007). Students need to be taught that there is value in persevering even when trying to remember something is difficult. There is also value in reviewing information even if it cannot be recalled; renewing the connections to the forgotten knowledge is easier than the initial learning and the subsequent rate of knowledge loss is decreased (Paschler et al., 2007).

Student attitudes toward self-assessment are mixed. A study by Maguire, Evans & Dyas found that college students were skeptical about the benefits of self-assessment tasks and viewed them as "mechanical, meaningless tasks" (2001, p. 100). Lew, Alwis, & Schmidt (2010) found that there was no statistically significant correlation between students' beliefs about the usefulness of self-assessment and the accuracy of their self-assessment. However, other studies have found that students' attitudes are positively affected by self-assessment. A study by Lopez and Kossack (2007 as cited in Lew, Alwis & Schmidt, 2010) found that students who self-assessed throughout the semester felt more responsible for their learning; their course grades were also higher. In another study by McDonald & Boud (2003), 98% of students trained in self-assessment felt it allowed them to improve their study habits; they knew how prepared they were for an assessment and had the opportunity to use this knowledge to improve their anticipated performance.

Studies about the accuracy of students' self-assessment also show mixed results. Thiede, Anderson, and Therriault (2003) discussed how multiple studies (Cavanaugh and Perlmutter, 1982; Begg, Martin, and Needham , 1992; Dunlosky & Connor, 1997; Dunlosky & Hertzog, 1997; Kelly, Scholnick, Travers, & Johnson, 1976 as cited in Thiede et al.) showed no relationship between the accuracy of a person's self-assessment

and his performance on a test: people who were more accurate in monitoring their learning did not score better on tests. However, Thiede et al. felt that the value of self-assessment may have been missed in these studies because participants were not able to use the results of their self-assessment to study the information they felt they did not know well. In the study conducted by Thiede et al., participants took a test over several texts they read, had the opportunity to restudy the texts, and then took a second test over the texts. Those who more accurately monitored their comprehension significantly improved their performance on the second test because they were more accurately able to identify which texts they needed to study. A study by Gibbs (as cited in Lew, Alwis & Schmidt, 2010) found that students entering college do not self-assess as accurately as students in later years of college. This suggests that being able to make accurate judgments of knowledge is a metacognitive skill that people develop over time or may be an adaptive strategy based on the different learning environments and expectations in high school and college.

Self-assessment is most useful when it is an accurate assessment of knowledge because it provides information used to regulate the amount of studying a person does. When people study, they typically choose to study material they think they have not yet mastered; if the amount of time to study is limited, they study the material they think will be easiest to learn, not the most difficult, to maximize their potential learning (Kornell & Bjork, 2007). People monitor the amount they are learning while they study and stop studying when the material has been learned as well as they want it to be, even if the material has not been mastered (Thiede, Anderson, & Therriault, 2003). Looking at the accuracy of their self-assessments compared to their actual performance on assessments

should help learners understand their tendency to over- or underestimate their strengths and weaknesses (Taras, 2010). As Clauss and Geedey (2010) highlight, however, "a simple correlation with exam scores misses the whole goal of the surveys as a metacognitive tool for students" (p. 22). If students are using their self-assessments to decide what to study, their actual performance would hopefully be higher than a self-assessment they report the day before an assessment.

In order for students to be effective learners, they need to have metacognitive strategies to monitor their cognitive thinking processes. Students who can monitor how well they have learned a topic can use this knowledge to determine how or if they need to continue to study it. In order to make these determinations, students need to know what their goal is and be able to make accurate assessments of whether they have truly learned a fact or mastered a skill.

METHODOLOGY

Treatment

In order to study how students use self-assessment to improve their learning of chemistry, I developed a list of "I can" statements (Appendix A and Appendix B) for each unit during which the treatment was implemented. I gave these lists of standards to my students at the beginning of the unit. Each unit lasted approximately three weeks; details about each unit are provided in the Research Design section. At the end of each class, I told my students which of the statements they should rate based on what I had taught during that class. They rated themselves with a three-point scale. A "1" rating meant "Yes, I can consistently do this on my own without assistance." A "2" rating meant "I can sometimes do this on my own without assistance." A "3" rating meant "No, I cannot do this on my own without assistance yet." I told all of the students that if they gave a 2 or a 3 rating they should refer to the textbook pages listed next to the "I can" statement for more information about the topic. I also reminded them that additional resources about many of the topics had been posted on the class's Blackboard website.

A few days after the topics were first taught in class, I gave the students a practice quiz (Appendix C and Appendix D) that included questions over several of the topics. The purpose of this was to help students identify how well they knew a topic after a delay from when they studied it. They were not allowed to use their notes, assignments or ask for help as they took the practice quiz. This was to make sure they were assessing their knowledge under conditions similar to those for the written summative assessment. It also meant they were retrieving the information from their memories and not just recognizing it as they might if they were studying notes they had taken. The scores on

these practice quizzes were not part of the students' overall course grade. I encouraged the students to take the practice quizzes seriously by explaining that the usefulness of the information they could obtain from the quiz was limited by the effort they put into the quiz. If they did not actually make an effort on the practice quiz, they would not know how they could do on it and would not be able to rate themselves accurately on the "I can" statements.

Immediately after the students had completed the practice quiz each student graded his or her own quiz. The students then re-rated themselves on each of the "I can" statements by completing the "After a few days" column. I told them to consider how they well they performed on the practice quiz and to consider the parts of each statement that may not have been directly on the quiz as well. I also told them not to be surprised if their ratings had changed because the initial rating was made while the information was in their short term memories.

After students finished their ratings, I reminded them of the resources available to help them learn the topics they had not mastered yet. The textbook pages for each topic were listed next to the "I can" statements; they could read those pages and take notes over them. They could re-read, take notes over, and re-work their assignments. I displayed the Blackboard online class resources with my projector and pointed out the resources I had posted there. These resources included copies of the PowerPoints and notes used in class, links to helpful websites, links to YouTube videos about the content at the level appropriate to the class, and links to online practice quizzes. I reminded them that I was at school before and after school almost every day if they needed more help from me. I

also reminded them that they should start studying right away and not wait until the day before the test.

In class the day before the test, the students rated themselves again on each of the statements by completing the "At the end of the unit" column. I told them to consider evidence from how they had done on the assignments throughout the unit, especially the textbook question review assignment they had just graded. I reminded them that they should consider how much help they had needed on the textbook assignment. If they had asked me for help, looked information up in their notes or book, or worked together with other students, they might not be able to meet the expectations without assistance. I reminded the students once again that they should study before the test and that there were many resources available to them.

Research Design

The study was conducted in a year-long, high school chemistry course. Data were gathered from 52 chemistry students in three different classes. Some of the students did not complete all of the portions of the study, so the number of participants in each portion varies from 48 to 52. Almost all of these students planned to go to college after high school. Some of them only took chemistry because it was necessary to meet the Qualified Admissions criteria to go to one of the four-year universities governed by the Kansas Board of Regents. Table 1 provides demographic information about the students who participated; demographic information about the entire school can be found in the Introduction and Background section.

Table 1
Demographic Information

Total Students	**52**
Male	24
Female	28
Sophomores	4
Juniors	37
Seniors	11
Caucasian	50
American Indian	3
Hispanic	2
Gifted	1

The study was conducted during four instructional units which lasted about three weeks each. The first non-treatment unit was the fourth instructional unit in the year-long chemistry course; it focused on the organization of the period table and the different properties of elements that can be determined based on their location on the periodic table due to periodic trends. The first treatment unit was the fifth instructional unit. This unit focused on the different types of bonding in chemical compounds and the properties that result from these types of bonds. It also included drawing Lewis dot structures of molecules and predicting the shapes and polarity of molecules. The second non-treatment unit was the sixth instructional unit. In this unit, students learned to write the chemical formulas of compounds and how to correctly name chemical compounds. The second treatment unit was the seventh instructional unit. It focused on the mathematical calculations that can be done using chemical formulas such as molar conversions, percentage composition, and empirical and molecular formula determinations.

Several different data collection tools were used. These tools and the research questions addressed by the data they collected are summarized in Table 2. More information about each tool follows the table.

Table 2
Research Questions and Data Collection Tools

Research Questions	**Unit Reflections**	**Non-Treatment Unit Surveys**	**Treatment Unit Surveys**	**Summative Assessment**	**Teacher Journal**
1. How does students' use of self-assessment impact the learning of chemistry?	X	X	X	X	X
2. How does using self-assessment affect students' scores on summative assessments?	X		X	X	
3. How does using self-assessment affect students' attitudes about learning chemistry?		X	X		X
4. How do students use the results of their self-assessment to improve their understanding of chemistry?	X	X	X		X
5. Does using self-assessment during a unit help students predict their performance on summative assessments?	X		X	X	

The Unit Reflections (Appendix E) were brief written surveys that the students completed in class at the end of the instructional unit on the day before the written summative assessment. The students were asked what they had learned really well, what they were still struggling with, what grade they thought they would earn on the test, and why they thought they would get that grade. The information from these reflections was used to determine whether students were able to more specifically identify the topics that were their strengths and weaknesses when they used self-assessment. It was also used to see if students were able to more accurately predict their grades when they used self-assessment.

The Non-Treatment Unit Survey (Appendix F) and the Treatment Unit Survey (Appendix G and Appendix H) were longer surveys given after the appropriate unit. The students completed these surveys in class the day after the written summative assessment for the unit. The surveys included identical questions about students' attitudes about learning chemistry, their expectations for their achievement, the amount of time they spent outside of class studying chemistry, and what techniques they used when they studied. The Treatment Unit Survey included additional questions about whether students thought the self-assessment treatment was helpful and how their study habits changed as a result of the treatment. The information from these surveys was used to determine how the use of self-assessment affected students' attitudes about learning chemistry and how they used the results of self-assessment to improve their understanding of chemistry.

The summative assessment was an exam I wrote that the students took at the end of each unit. In the first non-treatment and treatment units, the questions were mostly multiple choice with a few short answer questions. For the second non-treatment and treatment units, the questions were mostly short answer with a few multiple choice questions. These exams have been used for several years with minor modifications to improve the validity of the exams by rephrasing or replacing questions that past students missed despite having a thorough understanding of the topics. The information from this tool was used to determine how using self-assessment affected students' learning of chemistry, their scores on summative assessment, and the accuracy of their predictions about their grades on the assessments.

The teacher journal was a written record of my thoughts and observations throughout the action research process. The information from this tool was used to identify the impact of the action research on my teaching. It was also used to triangulate the other aspects of the research.

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 (Appendix I).

DATA AND ANALYSIS

The data from the various research tools were compiled and analyzed to determine how using self-assessment affected students' scores on summative assessments and their attitudes about learning chemistry. The evidence was examined to see how students used the results of their self-assessment to improve their understanding of chemistry, and to determine if using self-assessment helped students predict their performance on summative assessments.

Students' performance on summative assessments was analyzed by calculating the mean scores for each summative assessment individually and for the non-treatment and treatment units combined (Table 3).

Table 3
Mean Scores for Summative Assessments

Unit	**Mean Score on Exam**
Non-Treatment Unit 1 (N = 52)	77.0%
Treatment Unit 1 (N = 51)	78.8%
Non-Treatment Unit 2 (N = 50)	85.2%
Treatment Unit 2 (N = 49)	82.7%
Combined Non-Treatment Units (N = 102)	81.1%
Combined Treatment Units (N = 100)	80.8%

Calculating the mean scores showed that the mean score was lowest on the first non-treatment unit then increased for the first treatment unit. The second non-treatment

unit was even higher, but the mean score decreased for the second treatment unit. The difference between the mean scores when both non-treatment units and treatment units are combined was 0.3%. Based on this data, the treatment had very little effect. The treatment appeared to be helpful when compared to one of the non-treatment units but harmful when compared to the other non-treatment unit. This may be due to the varying difficulty of the content included in the different units. In an attempt to determine the effect this may have had on the results, students were asked to rank the units from easiest to hardest (Figure 1).

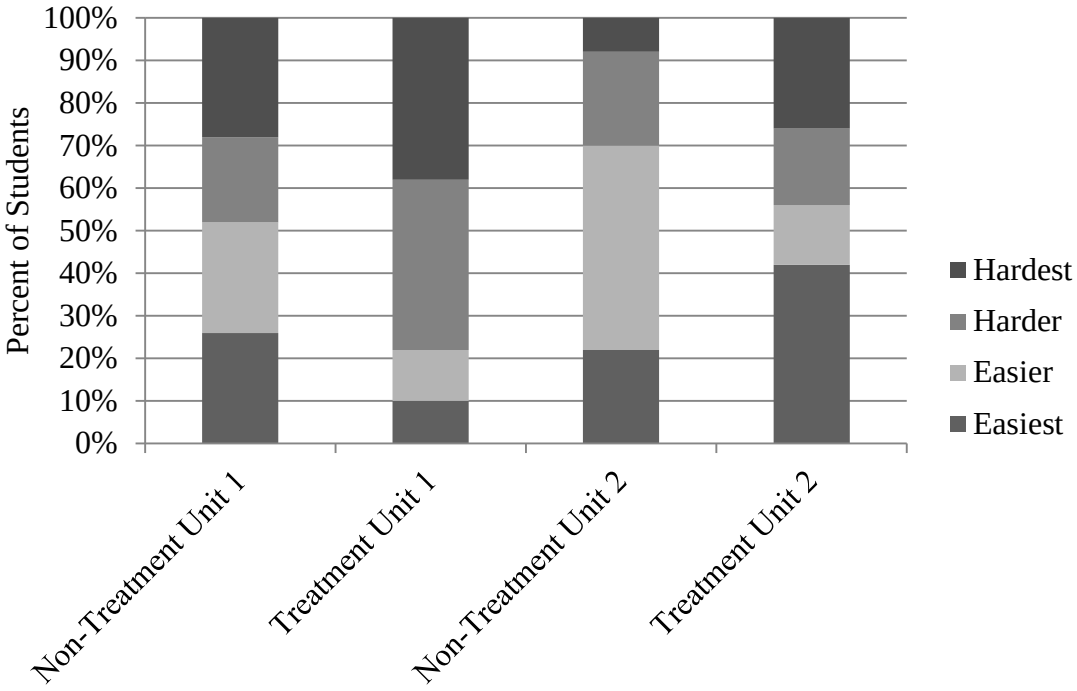

Figure 1: Students' ratings of unit difficulty, (N = 50).

Slightly more than 50% of the students found the first non-treatment unit to be the easiest or easier unit. Only about 20% of the students considered the first treatment unit to be the easiest or easier unit. The mean score for the summative assessment for the treatment unit was higher than it was for the non-treatment unit even though the students

considered it the harder unit. This shows that using self-assessment helped students learn more during what they considered to be a more difficult unit. About 55% of students found the second treatment unit to be the easiest or easier unit. This made its perceived difficulty about the same as that of the first non-treatment unit. The mean score for the second treatment unit was higher than that of the first non-treatment unit. This shows that using self-assessment helped students learn more during units of similar perceived difficulty. About 70% of students considered the second non-treatment unit to be the easiest or easier unit. The mean score on this unit's assessment was the highest even though students did not use the self-assessment treatment during this unit. It may be that students' scores were higher on the second non-treatment unit than on the treatment units because that unit was easier than the others, not because the treatment was detrimental to students' performance on the summative assessments.

To identify individual students who were most affected by the treatment, the summative assessment data were analyzed by comparing individual students' letter grades on the non-treatment summative assessments to their letter grades on the treatment summative assessments (Figure 2). If a student received a B and a C on the non-treatment assessments and then earned a C on one treatment assessment and a B on the other, the student was classified as "No Change" because his or her letter grades on the assessments were the same with and without the treatment. If, instead, that student received a B on one treatment assessment and an A on the other, the student was counted as "Increase More than 1" because his or her letter grades on the treatment assessments were more than one letter grade higher than on the non-treatment assessments.

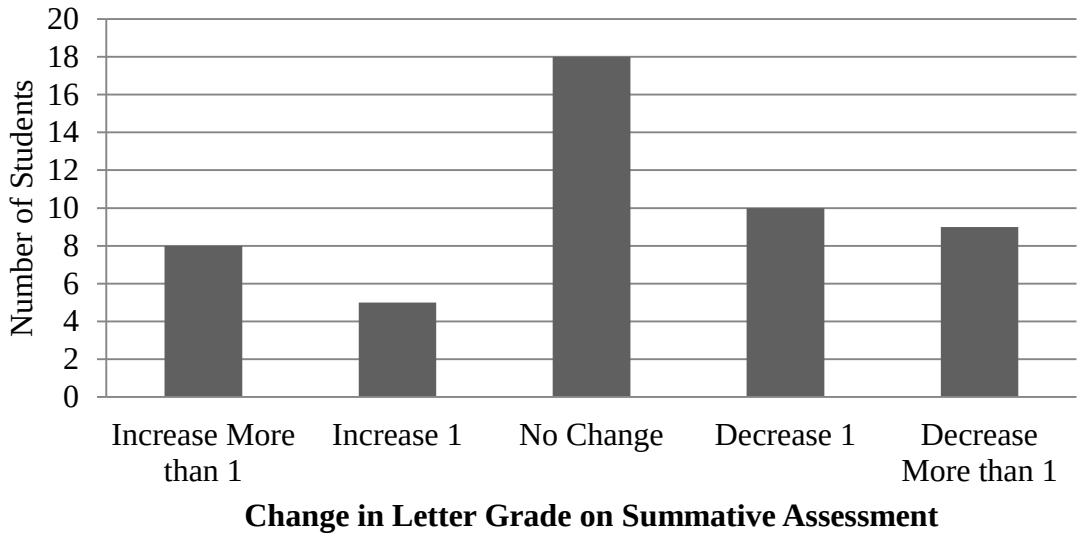

Figure 2: Effect of treatment on individual students' grades, (*N = 50).*

When comparing the students' letter grades on the assessments for the treatment and the non-treatment units, there was no difference or only a modest impact on 66% of students' grades on the summative assessments. These students were the ones whose grades increased or decreased by one letter grade and those whose letter grades did not change. Because there was no dramatic change for most students, the changes in the mean scores on the exams must have been the result of many students having small changes in their scores which may not have been large enough to affect their overall letter grades on the assessments. However, 34% of students' grades on the summative assessments changed by more than one letter grade. For these students, the use of the treatment may have had a more meaningful impact as discussed below.

For eight of the students, their letter grades on the treatment assessments were more than one letter grade better than the non-treatment assessments. Of these students, three students felt self-assessment was helpful both times, three students felt it was helpful in one unit but not the other, and two students felt it was not helpful both times.

Several of these students felt the study guides and practice tests they were given in other units served a similar purpose or were better than the "I can" statements. Based on this information, it does not seem that providing the students with lists of standards at the beginning of the unit was responsible for the improvement in all of these students' grades, but may have been responsible for some.

Of the nine students whose grades on the assessments decreased more than one letter grade, five students said the self-assessment was not helpful and did not change their study habits because "I don't study." Two students said the self-assessment was helpful for both units because "I focused more on what I had trouble with" and reported studying more but still did worse on the assessments. One student said the treatment was useful for one unit but not the other and reported doing similar amounts of studying. One student said the self-assessment was not useful for either unit because "although this showed me where I might be struggling it didn't help me as much as a study guide always does." Based on this information, it was not beneficial for these students' grades to give them the standards for the unit at the beginning of the unit. However, this may vary with the student and the content of the unit.

Although I verbally encouraged all students to change their study habits based on how they rated themselves on the standards for the unit, only about 30% reported changing their study habits as a result of using self-assessment. When these students' performance on the first treatment unit assessment was compared to their performance on the first non-treatment unit assessment, 64.3% had a higher score, 7.1% had no change and 28.6% had a lower score (N = 14). When comparing the second treatment unit scores of the students who reported changing their study habits for the second treatment unit

with their scores on the second non-treatment unit assessment, 43.8% had higher scores but 56.2% had lower scores (N = 16). As discussed earlier, most students considered the second treatment unit to be more difficult than the second non-treatment unit, so the lower scores may be the result of the more difficult topics being studied rather than the treatment itself. It does seem that providing the students with the standards for the unit did positively impact students' scores on summative assessments when the students changed their study habits as a result of the self-assessment.

There were eight students who improved their grades on the summative assessments by more than one letter grade when comparing the non-treatment and treatment units. Among these students, five had reported being unsatisfied with their grades in chemistry class after the first non-treatment unit. After the second treatment unit, four of these students reported that they were satisfied with their grades. All of them reported that the use of self-assessment was helpful for at least one of the treatment units. This may mean that the use of self-assessment has the most significant impact when the individual student has a desire to improve their performance. These students, who were not satisfied with how they were doing, when offered a new tool for learning, took it, used it and improved their performance to a level that satisfied them. They were struggling in the class, but the self-assessment helped them improve. As one of these students said, "It helped me visualize what I was and wasn't understanding and made it easier to study."

By using Likert statements, I examined how the treatment affected different aspects of students' attitudes. Students responded to statements relating to how much

control they had over their grades, their attitudes toward learning chemistry, and whether they felt effort or natural ability was more important for learning chemistry (Figure 3).

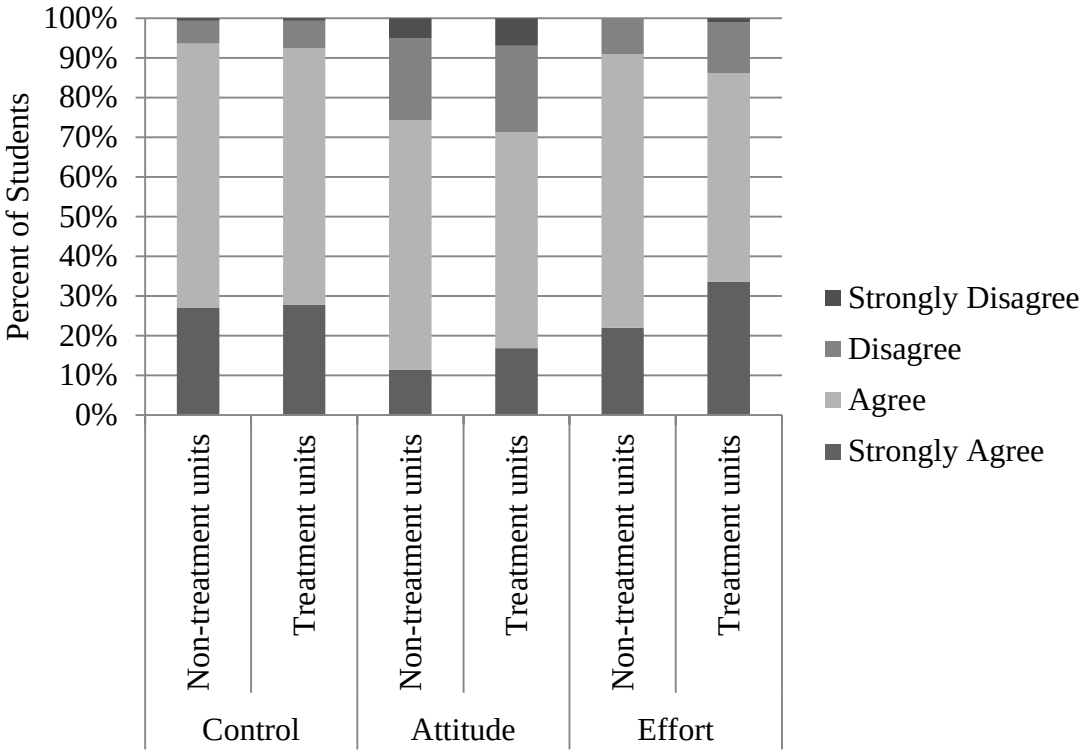

Figure 3: Students' responses to Likert statements, (*N = 51).*

I hypothesized that students would find that the use of "I can" statements made it easier for them to impact the grade they earned in chemistry class. Several of the statements they were asked to rate using a Likert scale on the post-unit surveys were related to this idea. These included "I am the person who is most responsible for how much I learn. I am able to determine what topics I need to study before a chemistry test. I can earn the grade I want to have in chemistry class." There was very little difference between students' ratings of these statements during the non-treatment and treatment units. The students were asked to elaborate about the statement "I am able to determine what topics I need to study before a chemistry test." During the treatment units, students

did often refer to the “I can” statements as a reason they were able to determine what to study. During the non-treatment units, the students often referred to the test topics pages or study guides I gave them a few days prior to a test. The “I can” statements and the list of test topics seemed interchangeable to the students; the fact that they get one early in the unit and one later in the unit did not seem to have much impact on them.

I hypothesized the use of “I can” statements would improve students’ attitudes toward learning chemistry. Several of the statements they were asked to rate using a Likert scale on the post-unit surveys were related to this idea. These included “I enjoy learning chemistry. I am willing to work hard to learn chemistry. I think learning chemistry is important.” Slightly more students strongly agreed with these statements after the treatment units, but slightly more students disagreed with these statements as well. The use of the “I can” statements may have made students who were successful in chemistry more confident, but those who struggled may have felt more hopeless when the “I can” statements did not help them.

By having students continually rate how much they had learned throughout the unit, I had hypothesized that they would see that the amount of effort they put into learning a topic is related to how well they do in class. The Likert statement that students rated related to this idea was “Effort is more important than natural ability for doing well in chemistry class.” More students strongly agreed with this statement after a treatment unit, but slightly more students also disagreed and strongly disagreed with the statement as well. Students who saw positive results when they used the “I can” statements would be more likely to see the benefits of relying on effort rather than natural ability. Students who did not earn higher grades as a result of the additional effort they put into using self-

assessment may have been discouraged and come to feel that natural ability was more important than effort.

Overall, the use of self-assessment had little impact on students' attitudes about learning chemistry. However, the agreement with positive statements was so high without the use of the treatment that there was little room for improvement when the treatment was implemented. The most substantial change was in the percentage of students who strongly agreed with the statements for the effort category. There was about a 10% increase after the treatment. With regards to effort versus natural ability, this may mean that the use of self-assessment helped students see that the effort they put into the course in by using self-assessment to identify the areas in which they were weak had an impact on their overall performance.

To learn how students used the results of their self-assessment to improve their understanding of chemistry, I asked several questions on the post-treatment unit surveys. During the treatment units, 57 students found self-assessment helpful while 42 did not think it was helpful. Twenty-eight students reported changing their study habits while 71 did not. The students' responses and the grades they earned are summarized in Table 4. The reasons students gave for whether or not they considered self-assessment helpful and whether or not they changed their study habits are discussed after the table.

Table 4
Distribution of Grades by Students' Survey Responses

Students considered self-assessment helpful	**Students changed study habits**	**Number of Students Earning Grade**					**Total number of students**
		A	B	C	D	F	
Yes	Yes	8	5	6	4	5	28
Yes	No	13	8	4	1	3	29
No	Yes	0	0	0	0	0	0
No	No	15	10	7	4	6	42

When students said that self-assessment was helpful, 29 responses said it was because it meant they knew what to study. Eight said it meant they knew what to work on, and ten said it helped them know what they knew and what they didn't know. Three students said it helped them remember what they had done early in the unit that would be on the test. One student said it was helpful because the "I can" statements gave him page numbers to look at the information if he didn't understand it. Another student said it made him think about what he had learned. One student said "It made me realize what I needed to do to get the grade I wanted." Four students gave other miscellaneous responses. From this information, it appeared that the treatment did have the anticipated impact of helping the students identify the topics that they did not understand or know well enough before the summative assessment. Even if students' overall exam scores were not affected in the different units, the students may have better understood particular topics in the unit than they would have understood them if the treatment had not been used at all.

Some students who considered self-assessment helpful changed their study habits. They reported a variety of ways their habits changed. Six students studied more; these students earned two A's, one B, two C's, and one D. One of the students who studied more said, "I made more time to study and look at things instead of just skimming." One student studied less and earned an A. Fourteen students knew what topics they needed to study and studied those topics more; these students earned 3 A's, 3 B's, 3 C's, 1 D, and 4 F's. One student went over everything listed on the "I can" statements; this student earned a B. One student found that the use of self-assessment caused her to look over things from early in the chapter; this student earned an A. Five students gave

miscellaneous other ways their studying changed; these students earned an A, a C, two D's, and an F. Although only 28% of students changed their study habits as a result of self-assessment, most of those who did made changes that would positively impact how much they learned. If more students had changed their study habits, a more substantial positive impact on the mean of students' summative assessment scores may have been observed.

When students changed their study habits, they gave a variety of reasons for why they changed their habits. Fourteen students' responses indicated it was because they knew what they did and did not need to study; these students earned six A's, three B's, three C's and two F's. Two said that having the page numbers listed on the "I can" statements meant that they knew where to find the information they needed to study; these students earned a C and an F. Three students said that they wanted to increase their understanding; they earned a C, a D, and an F. One student said the "I can" statements were better than the list of test topics they were given for other units and earned a B. One student said it helped her track what we did in class and earned an F. Other students provided miscellaneous reasons for why they changed their study habits; these students earned two A's, a B, a C, and three D's. Providing "I can" statements increased students' ability to recognize and access the level of understanding expected of them to meet the standards for the course.

Some students found self-assessment helpful, but did not change their study habits. Eighteen of these students continued studying the way they always had; on the assessments, nine of these students earned an A, four earned a B, four earned a C and one earned a D. One student said he does not study for tests and earned a B. Four said they

did not have time to study; one of these students earned an A, one a B and the other two F's. Three students did not rely on the self-assessment, but went over everything to see what they did not know and studied those topics; two of these students earned an A, and one earned a B. One student said, "The self-assessment showed what I needed to study not how," this student earned an A. One student reported focusing more on what she didn't know the best; she earned a B. One student reported paying more attention in class but not studying outside of class; this student earned an F. Thus, most of these students do earn acceptable grades without changing their study habits. As one of these students said, "I had no real cause to change them." Two of the students who failed the tests, which should cause them to change their study habits, indicated that the reason they did not do so was a lack of time. This was a limitation that self-assessment cannot address.

Students who did not consider the self-assessment helpful gave a variety of reasons for why it was not helpful. Fourteen students said they already knew what they needed to study without using self-assessment; as one student said, "I already knew what I needed to work on, writing it down didn't make me study any more. [sic]" These students earned nine A's, three C's and two F's. Eleven students said it was not helpful because they did not use it; one admitted, "I never really looked at it after you [the teacher] said to check it." Two of these students earned A's, four earned B's, two earned C's, one earned a D, and two earned F's. Four students just said it was not helpful or useful; these students' grades were an A, a B, a C, and an F. Four students said it was not helpful because they forgot to complete it or rushed to complete it. The students' grades were an A, a B, a C, and a D. One student preferred the test topic lists or study guides they were given in other units rather than the "I can" statements; this student earned a B.

Eight students, who earned a two A's, three B's, two D's and an F gave miscellaneous responses for why they did not consider the self-assessment helpful.

Students who did not find self-assessment helpful did not change their study habits. They gave a variety of responses for why they did not change. Six students said it was because their study habits did not need to change; these students were correct because five of the students earned an A, and one earned a B. As one student said, "I think it was a little time consuming for someone who understands chemistry quickly." Eight students said it was because they do not study; for these students, the grades were two A's, one B, one C, one D and three F's. Five students indicated that they studied everything anyway; these students earned two A's, two C's and a D. Five students said they did not use self-assessment; two of these students earned A's, two earned B's, and one earned an F. Three students said they already knew what to study without using self assessment; for these students, the grades earned were an A, a C and an F. Two students said it was because the topics were simple; the grades these students earned were A's. Many other students gave miscellaneous responses about why they did not change their study habits. Of these students, one earned an A, six earned B's, three earned C's, two earned D's, and one earned an F. Overall, most students who did not change their study habits did have some room for improvement in their grades, but only some could have been influenced by using self-assessment.

To determine what aspect of the self-assessment treatment students found most useful, I identified four key components of the treatment. They were the list of "I can" statements, the textbook pages listed on the statements, the practice quizzes, and the

ratings students gave themselves after taking the practice quizzes. On the post unit surveys the students rated how helpful they found these aspects (Figure 4).

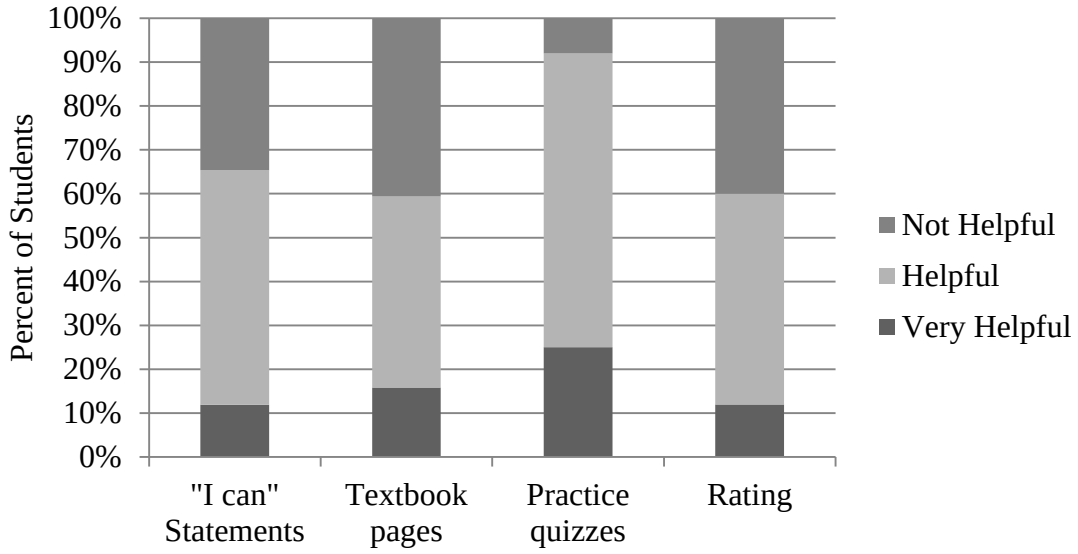

Figure 4: Students' ratings of helpfulness of various self-assessment aspects, (*N = 51).*

About 10% of students found the statements about what they needed to be able to do, the textbook pages listed for those statements, and rating those statements to be very helpful. About 50% of students considered those same things to be helpful; while about 40% found they were not helpful. The students found the practice quizzes to be the most helpful aspect of the self-assessment treatment. About 25% considered them to be very helpful, and 65% considered them helpful; while only 10% did not find them helpful.

The practice quizzes may have been the most helpful because they were the portion of the self-assessment that most closely modeled how the students would be assessed on the summative assessment. They were also the most engaging portion of the self-assessment for students because the students were actively thinking and using what they had learned to try to answer the questions. From my observations, almost all of the students took the practice quizzes seriously by focusing on the questions and actively

trying to determine the answers. One student commented that "More practice quizzes would be nice."

The students did not treat their ratings with the same level of seriousness which may be why there were not as helpful. I observed some students taking their time and seriously considering the ratings they gave themselves while others rushed through the ratings and others did not complete them at all. I did observe that during the second treatment unit I was not as focused on reminding the students to rate themselves on the "I can" statements. One student commented on this as well, "We always forget to fill it out." This did not appear to have negatively impacted how helpful the ratings were because only 37% (N = 49) of students considered the rating "not helpful" for that unit while 43% (N = 51) of the students found it "not helpful" during the first treatment unit.

The statements themselves and textbook page numbers were not items that the students had to actively use. They were information for the students to refer to as needed. Some students found them very helpful. One student commented "I wanted to have gotten more one-on-one help … but the "I can" statements and textbook pages really helped." Other student comments included, "It's easy for me to find out what I need to study and where it's at," "It told me I know a lot of the things we did in class," and "It is a good way to keep the information of the chapter manageable."

Students were asked to report the frequency and length of their studying for the non-treatment and treatment units (Figure 5 and Figure 6).

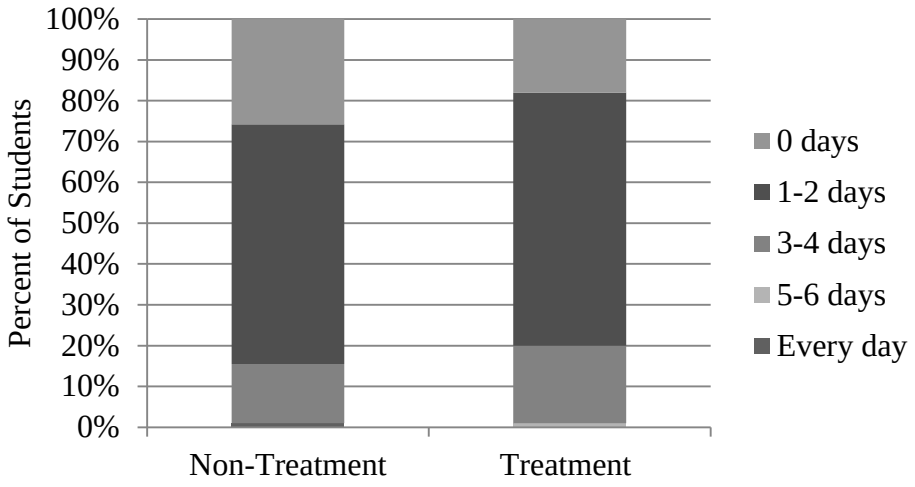

Figure 5: Number of days students reported studying outside of class, (*N = 51).*

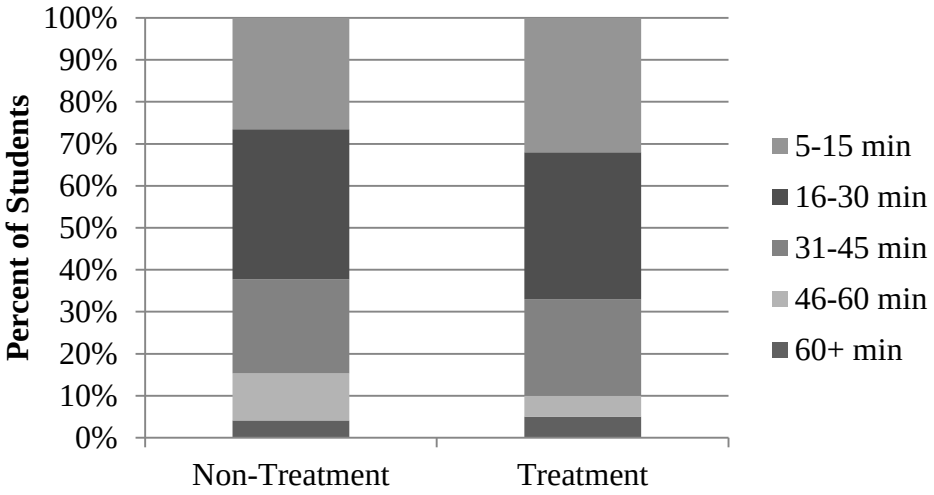

Figure 6: Average amount of time students reported studying, (*N = 51).*

The percentage of students reporting more frequent studying increased slightly during the treatment units. The percentage of students reporting shorter amounts of time spent studying on a day they studied also increased slightly. This suggested that students were studying for shorter periods of time but studying more often during the treatment units. Being able to identify topics they were struggling with throughout the unit may have caused these students to spread their studying throughout the unit rather than waiting until the end of the unit to spend large amounts of time studying. This may have

helped students do better on the summative assessments because spaced learning is more effective than massed learning (Pashler et al., 2007).

Students were asked to predict their grades on the summative assessment the day before the assessment. Their predictions were compared to their actual grades on the assessment (Figure 7). Students who earned a higher grade than they predicted "under predicted" their grades; students who earned the grade they predicted were "correct." Students who earned a lower grade than they predicted "over predicted" their grades.

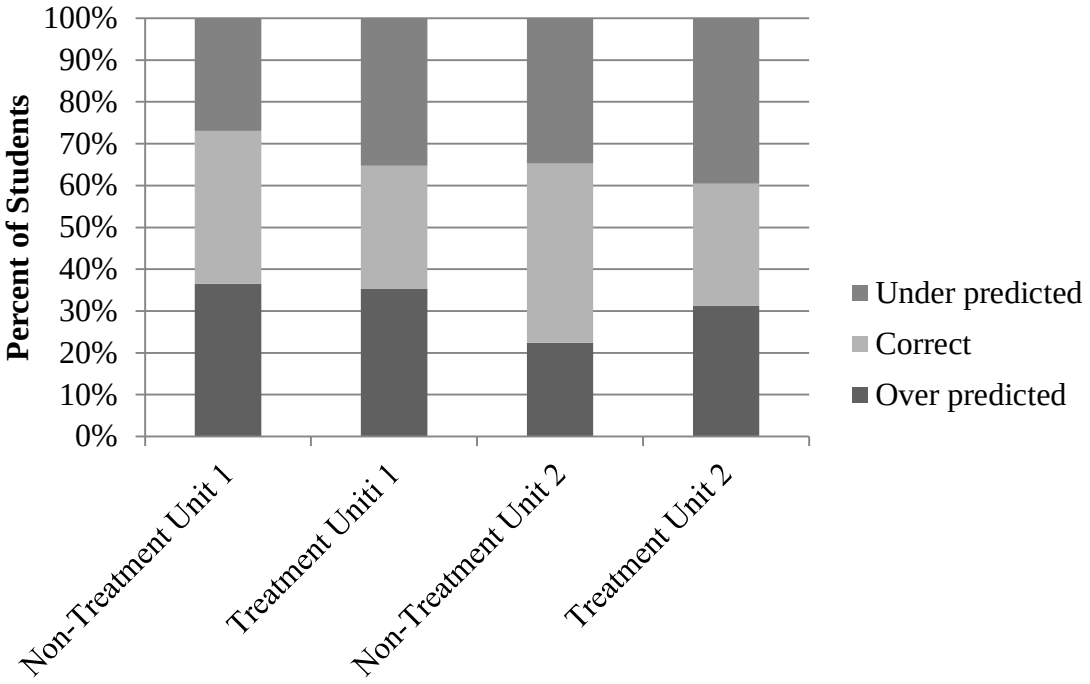

Figure 7: Accuracy of students' predictions of grades on summative assessments, (*N* = 51).

Students were more likely to correctly predict their grade on the summative assessment when they were not using self-assessment. They were slightly more likely to under predict the grade they would earn during a treatment unit. This may be because they were more aware of what they did not know, but they were also able to focus more

on those particular topics when they studied which meant they did better on the test than they expected to do before they had finished studying. However, students were also slightly more likely to over predict their grade during a treatment unit. This may be because they did not go back and study topics they had rated themselves as understanding early in the unit. They may not have realized that they did not remember that information very well. Being able to see their initial rating for a topic on the "I can" statements while rating themselves subsequent times may have biased their ratings.

INTERPRETATION AND CONCLUSION

The study was designed to examine how students' use of self-assessment impacted the learning of chemistry. It investigated how self-assessment affected students' scores on self-assessment, how it affected their attitudes about learning chemistry, how students use its results to improve their learning, and whether it helps students predict their performance on formative assessments.

In response to my action research sub-question on the impact of self-assessment on summative assessment scores, the use of self-assessment slightly improved students' scores on summative assessments when comparing units of similar perceived difficulties. The mean scores on the summative assessments for the two treatment units, 78.8% and 82.7%, were slightly higher than those on the first non-treatment unit, 77.0%. This non-treatment unit was judged by students to be easier than the first treatment unit and approximately the same difficulty as the second treatment unit. The improvement in students' scores was modest: while the mean score was higher, only eight students saw an improvement of more than one letter grade. Four of these students had been unsatisfied

with their grades prior to the treatment; they found the self-assessment treatment helpful and reported that they were satisfied with the grades they earned as a result.

In response to my action research sub-question on the impact of self-assessment on students' attitudes, the use of self-assessment had little impact on students' attitudes about learning chemistry. The students' attitudes about their control over their grades, their attitudes toward learning chemistry, and their attitudes about the importance of effort and natural ability for learning chemistry were very positive before the treatment was implemented. There was little room for improvement as a result of using self-assessment.

In response to my action research sub-question about how students used the results of self-assessment, some students used the results of self-assessment to improve their understanding of chemistry. About 58% of students found self-assessment helpful for a variety of reasons. About 30% of students responded that they found self-assessment helpful because using self-assessment meant they knew what they needed to study. While some students changed their study habits to spend more time studying, some students did not change their study habits because they had already developed good study habits. Other students already had a strong understanding of chemistry and felt that they had no reason to change. A few students who did have room to improve their understanding chose not to change their study habits. More than 90% of the students considered the practice quizzes used as part of the treatment to be helpful. These quizzes gave the students the opportunity to judge their level of understanding under conditions similar to those they would experience during the summative assessment. From data gathered about the frequency and length of students' studying, students studied slightly

more frequently for shorter periods of time when the self-assessment treatment was being implemented.

In response to my action research sub-question on the impact of self-assessment on students' ability to predict their grades, self-assessment had little impact on students' ability to predict their performance on summative assessments. Similar percentages of students over predicted their grades on the assessments whether self-assessment was used or not. Students were slightly more likely to under predict their grades when they were using self-assessment.

Overall, the use of the "I can" statements as a tool for self-assessment had a small positive impact on students' grades on summative assessments on units of similar perceived difficulty. It had little impact on their attitudes about learning chemistry. Some students used the self-assessment results to improve their understanding of chemistry by changing their study habits and studying more frequently. The students felt the practice quizzes were the most helpful part of the self-assessment. Self-assessment did not have much impact on the students' ability to predict the grades they would earn on the summative assessments.

VALUE

The action research process caused me to think critically about why students do not perform as well on summative assessments as they think they will prior to taking these assessments. The information I learned while developing my conceptual framework was very interesting, and it has given me much to consider for further changes I may make in my classroom. For example, knowing that difficult, but successful, retrieval of knowledge increases long-term retention (Kornell & Bjork, 2007) means that

when I notice students struggling to remember something I will not step in as quickly to supply them with the information. They should benefit by persevering in trying to remember on their own. Creating the lists of "I can" statements helped me to clarify for myself what topics were most important for students to learn in a particular unit, and it allowed me to communicate those expectations to my students. As I drafted the statements based on the questions on the summative assessments, this action research helped me align the assessments more closely with my expectations. For example, one of the assessment questions asked students to identify a very technical definition of a chemical bond; I am more interested if students can define a chemical bond using words they understand, so I altered the assessment question. This action research improved the quality of my teaching and assessments.

I have given some consideration to how I will continue to use self-assessment in my classroom based on the results of this study. About 65% of students considered the lists of "I can" statements to be helpful so I plan to create "I can" statement lists for all of the units in my chemistry course. Because about 60% of students found the textbook page numbers on the lists of statements helpful, I will continue to do this as it does not require much time to add these to the lists. I do plan to incorporate more practice quizzes into my classes since more than 90% of students considered them to be helpful. On a typical day, I begin class by having students answer a few questions about the previous day's topics; they can use their notes, assignments, and each other as resources as they answer these questions. It will be easy to adjust this routine every few days to incorporate practice quizzes for the students to take using just what they can individually remember.

Other parts of the self-assessment treatment I do not plan to continue using with all of my students. Due to the amount of time it took in class for students to rate themselves, I do not plan to require all students to rate themselves throughout the units. About 60% of students found this helpful, but I do not feel that it provided a high enough return for the amount of time it required. For the first few units in the school year, I will tell my students about how to make accurate assessments of their knowledge and encourage them to rate themselves. I will share with them the results I found with this research that students who were not satisfied with their grades used this technique to successfully increase their knowledge and test scores. When I find that specific students are struggling to learn, I will encourage those students to more actively use the "I can" statements to rate themselves and study based on their results. I may check in with these students at the end of class to help them identify what they can do to remediate those areas, and I could then check in with them again the next day to see if they followed through with those plans.

There are several ways in which this research could be improved or expanded. To attempt to control for the varying levels of difficulty of different instructional units, it may be possible to compare the performance of students in previous school years on the different summative assessments. By looking at the mean scores earned by students who did not use any part of the treatment, it may be possible to select treatment and non-treatment units that are more equal in difficulty. It would be interesting to explore the ways technology could be used to incorporate the "I can" statements into classroom activities. Using different technology devices, students could report their level of confidence on each of the statements to me; I could then focus a review day on the topics

that most students identified as weaknesses. In the interest of helping students develop more accurate self-assessment skills, it may be beneficial to have students analyze the questions they answered incorrectly on the summative assessments to see whether they were able to accurately assess their knowledge of those specific standards on the day before the exam. It would also be interesting to examine whether or not having the students reflect on the accuracy of their predictions would result in more accurate predictions of summative assessment grades. Students who consistently over predicted their grades may notice this overly optimistic tendency and adjust their study habits as a result of their reflections.

Overall, implementing self-assessment in the form of “I can” statements required a small amount of work on the part of the teacher but helped many students identify what topics they needed to study to better understand chemistry.

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APPENDICES

APPENDIX A

“I CAN” STATEMENTS FOR UNIT 5

Name:_____ Hour: _____ Date: _____

"I Can" Statements for Unit 5

Use the following categories to rate yourself on how well you can do the things given below.

1 = Yes, I can consistently do this on my own without assistance.
2 = I can sometimes do this on my own without assistance.
3 = No, I cannot do this on my own without assistance yet.

If you identify topics that you cannot consistently do yet, study your assignments and notes. You may also find it helpful to read the textbook pages, check Blackboard for additional assistance or see your teacher before or after school for extra help.

Topic	Textbook Pages for Topic	Right away	After a few days	At the end of the unit
I can define the terms chemical bond, molecule, lustrous, malleable, and ductile.	175, 178, 196			
I can describe where the electrons are in ionic, metallic, polar covalent and nonpolar covalent bonds.	175-176, 195			
I can identify ionic, polar covalent and nonpolar covalent bonds when given images or when given a chemical formula.	175-177			
I can identify compounds as ionic, covalent or metallic based on the structures and properties they have.	175-176, 178, 190-193, 195-196			
I can define the term dipole.	204			
I can determine the number of valence electrons in a compound.	160, 185-186			
I can draw a Lewis dot structure for a molecule.	184-189			
I can identify elements that don't need to have an octet of 8 electrons in a Lewis dot structure.	183			
I can define the terms polyatomic ion and resonance.	189 & 194			
I can draw a Lewis dot structure for a polyatomic ion.	194			
I can draw resonance structures for molecules that need them.	189			

I can define the terms lone pair electrons and VSEPR.	197			
I can explain the ideas behind VSEPR theory.	197-200			
I can use VSEPR theory to predict the shapes of molecules.	197-200			
I can determine the molecule type from Lewis dot structures.	198-200			
I can determine whether a molecule is polar or nonpolar.	204-205			
I can define the terms bond energy and bond length.	181			
I can describe the properties of single, double and triple bonds.	186-187			
I can interpret a bond energy graph.	179			
I can describe the relationship between bond length and bond energy.	186-187			
I can define the terms intermolecular force and intramolecular force.	203 & notes			
I can identify and describe the four types of intermolecular forces and their causes.	203-207			
I can rank intermolecular forces and bonds according to how strong they are.	203-207			
I can identify the three elements that can form hydrogen bonds.	206			
I can explain how intermolecular forces affect the properties of compounds.	203-207			
I can describe the special properties water has because of its hydrogen bonding.	Reading handout			
I can use polarity to determine if two substances will dissolve in each other.	Notes			

APPENDIX B

“I CAN” STATEMENTS FOR UNIT 7

Name:_____ Hour: _____ Date: _____

"I Can" Statements for Unit 7

Use the following categories to rate yourself on how well you can do the things given below.

1 = Yes, I can consistently do this on my own without assistance.
2 = I can sometimes do this on my own without assistance.
3 = No, I cannot do this on my own without assistance yet.

If you identify topics that you cannot consistently do yet, study your assignments and notes. You may also find it helpful to read the textbook pages, check Blackboard for additional assistance or see your teacher before or after school for extra help.

Topic	Textbook Pages for Topic	Right away	After a few days	At the end of the unit
I can determine the molar mass of a compound.	237-239			
I can write the formula of a hydrate when given its name and vice versa.	Notes			
I can convert from grams of a compound to moles of the compound and vice versa.	240-242			
I can convert from grams of a compound to number of molecules or formula units of the compound and vice versa.	240-242			
I can calculate the percentage composition of a compound.	242-243, 256			
I can calculate the mass percentage of water in a hydrate from the compound's formula.	243-244			
I can use percentage composition calculations to determine the amount of an element that could be obtained from a sample.	Notes			
I can determine the empirical formula of a compound when given a molecular formula.	245, notes			
I can determine the empirical formula of a compound when given data about the amounts of the elements in the compound.	245-247			
I can determine the empirical formula from experimental data.	Lab			

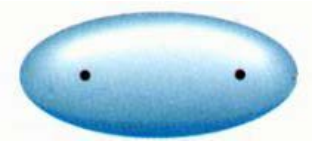
I can determine the molecular formula of a compound when given its empirical formula and its molar mass.	248-249			
I can determine the molecular formula of a compound when given data about the amounts of the elements in the compound and its molar mass.	248-249			
I can determine the mass percentage of water in a hydrate from experimental data.	Lab			

APPENDIX C

PRACTICE QUIZZES FOR UNIT 5

Practice Quiz 1 for Unit 5

1. In a polar covalent bond, electrons are _____ between two atoms.
2. What is a molecule?
3. Draw a Lewis Dot structure for PH_3?
4. How many valence electrons does boron need to have around it in a completed Lewis Dot structure?
5. The Ag-Au bond is _____. (ionic, polar covalent, nonpolar covalent, metallic)
6. How many valence electrons are in a molecule of CH_2F_2?
7. A compound conducts electricity when it is in solution. What kind of compound is it? (ionic, metallic or covalent)
8. The image of the electron cloud shown represents a _____ bond. (ionic, polar covalent, nonpolar covalent, metallic)



Practice Quiz 2 for Unit 5

1. What is the molecule shape that has a central atom with a lone pair of electrons and three atoms bonded to it?
2. What two molecule types have bent shapes?
3. Give an example of a linear molecule that is nonpolar.
4. Give an example of a linear molecule that is polar.

Draw a Lewis Dot Structure for PCl_2F. Then use it to answer the following questions.

5. How many pairs of lone pair electrons are on the P?
6. What is the molecule type for this compound?
7. What is the molecule shape for this compound?
8. Is the molecule polar or nonpolar?

APPENDIX D

PRACTICE QUIZZES FOR UNIT 7

Practice Quiz 1 for Unit 7

1. What is the formula of copper (II) chloride dihydrate?
2. How many molecules are there in 32 grams of carbon tetrachloride?
3. What is the percentage composition of lithium carbonite?

Practice Quiz 2 for Unit 7

1. Determine the empirical formula for a compound that is 77.3% silver, 7.40% phosphorous and 15.3% oxygen.

Practice Quiz 3 for Unit 7

1. A compound with a molar mass of 116.07 g/mol is 41.39% C, 3.47% H and 55.14% O. What is its molecular formula?

APPENDIX E

UNIT REFLECTION

Name:_____ Hour: _____ Date: _____

Unit Reflection for Unit #_____

Participation in this research is voluntary and participation or nonparticipation will not affect a student's grade or class standing in any way.

Directions: Take a few moments to think about what you have learned in this unit in chemistry. Then answer the questions that follow.

1. What have you learned really well? Please be as specific as you can.

2. What are you still struggling with? Please be as specific as you can.

3. What grade do you think you will get on the test? Please circle ONE.

   A B C D F

4. Why do you think you will get this grade?

APPENDIX F

NON-TREATMENT UNIT SURVEY

Name:_____ Hour: _____ Date: _____

Post-Unit Survey for Unit #4

Participation in this research is voluntary and participation or nonparticipation will not affect a student's grade or class standing in any way.

1. Please draw a circle around the response that most closely reflects how much you agree with each statement below: strongly agree, agree, disagree, or strongly disagree.

   a. I enjoy learning chemistry.
   Strongly Agree Agree Disagree Strongly Disagree

   b. I am willing to work hard to learn chemistry.
   Strongly Agree Agree Disagree Strongly Disagree

   c. I am satisfied with my grade in chemistry class.
   Strongly Agree Agree Disagree Strongly Disagree

   d. Effort is more important than natural ability for doing well in chemistry class.
   Strongly Agree Agree Disagree Strongly Disagree

   e.
   Strongly Agree Agree Disagree Strongly Disagree

   Why did you answer this statement the way you did?

   f. I am the person who is most responsible for how much I learn.
   Strongly Agree Agree Disagree Strongly Disagree

   Why did you answer this statement the way you did?

   g. I am able to determine what topics I need to study before a chemistry test.
   Strongly Agree Agree Disagree Strongly Disagree

   Why did you answer this statement the way you did?

   h. I can earn the grade I want to have in chemistry class.
   Strongly Agree Agree Disagree Strongly Disagree

   Why did you answer this statement the way you did?

2. Please check the response that most closely reflects how you would complete the statement.

a. The number of days a week that I spend time outside of class studying for chemistry is:

__ Every Day __ 5-6 Days __ 3-4 Days __ 1-2 Days ___ 0 Days

b. On a day when I study for chemistry, the average amount of time I spend studying is about:

__ 5-15 min. __16-30 min. __31-45 min. __46-60 min. __ 60+ min.

3. Please check **ALL** of the following which describe how you studied for chemistry in the last unit.

_____I reread my assignments.

_____I took notes over my assignments

_____I covered the answers to assignments and reworked the problems.

_____I read pages in the textbook.

_____I took notes over the pages in the textbook.

_____I did extra practice problems from the textbook.

_____I came in and asked my teacher for help before or after school.

_____I made flashcards.

_____I quizzed myself.

_____I asked someone else to quiz me.

_____I examined the questions I missed on the textbook assignment to determine why I missed them.

_____I talked about chemistry topics outside of class with other chemistry students.

_____I searched the internet for information about topics I was studying.

_____I watched on-line videos about the topics I was studying.

_____I looked at resources posted on Blackboard.

_____I played the rest of the review game we played in class.

_____I wrote about the topics I was studying.

_____I drew sketches about the topics I was studying.

_____Other, please specify:_____

_____Other, please specify:_____

APPENDIX G

TREATMENT UNIT SURVEY FOR UNIT 5

Name:_____ Hour: _____ Date: _____

Post-Unit Survey for Unit #5

Participation in this research is voluntary and participation or nonparticipation will not affect a student's grade or class standing in any way.

1. Did you think using self-assessment was helpful? _____ Yes _____ No
    a. Why or why not?

2. Did your study habits for chemistry change when using self-assessment? ___ Yes ____No
    a. If yes, how?

    b. If yes, why?

    c. If no, why not?

3. Please draw a circle around the response that most closely reflects how helpful you found each of the following for studying chemistry.
    b. List of "I can" statements

        Very helpful Helpful Not helpful

    c. Textbook pages listed on "I can" statements

        Very helpful Helpful Not helpful

    d. Practice quizzes

        Very helpful Helpful Not helpful

    e. Rating how well you could do something several times during the unit

        Very helpful Helpful Not helpful

4. What other thoughts or information would you like to share about using self-assessment?

5. Please draw a circle around the response that most closely reflects how much you agree with each statement below: strongly agree (SA), agree (A), disagree (D), or strongly disagree (SD).

   a. I enjoy learning chemistry.
      SA A D SD

   b. I am willing to work hard to learn chemistry.
      SA A D SD

   c. I am satisfied with my grade in chemistry class.
      SA A D SD

   d. Effort is more important than natural ability for doing well in chemistry class.
      SA A D SD

   e. I think learning chemistry is important.
      SA A D SD

      Why did you answer this statement the way you did?

   f. I am the person who is most responsible for how much I learn.
      SA A D SD

      Why did you answer this statement the way you did?

   g. I am able to determine what topics I need to study before a chemistry test.
      SA A D SD

      Why did you answer this statement the way you did?

   h. I can earn the grade I want to have in chemistry class.
      SA A D SD

      Why did you answer this statement the way you did?

6. Please check the response that most closely reflects how you would complete the statement.

a. The number of days a week that I spend time outside of class studying for chemistry is:

__ Every Day __ 5-6 Days __ 3-4 Days __ 1-2 Days ___ 0 Days

b. On a day when I study for chemistry, the average amount of time I spend studying is about:

__ 5-15 min. __16-30 min. __31-45 min. __46-60 min. __ 60+ min.

7. Please check **ALL** of the following which describe how you studied for chemistry in the last unit.

_____I reread my assignments.

_____I took notes over my assignments

_____I covered the answers to assignments and reworked the problems.

_____I read pages in the textbook.

_____I took notes over the pages in the textbook.

_____I did extra practice problems from the textbook.

_____I came in and asked my teacher for help before or after school.

_____I made flashcards.

_____I quizzed myself.

_____I asked someone else to quiz me.

_____I examined the questions I missed on the textbook assignment to determine why I missed them.

_____I talked about chemistry topics outside of class with other chemistry students.

_____I searched the internet for information about topics I was studying.

_____I watched on-line videos about the topics I was studying.

_____I looked at resources posted on Blackboard.

_____I played the rest of the review game we played in class.

_____I wrote about the topics I was studying.

_____I drew sketches about the topics I was studying.

_____Other, please specify:_____

_____Other, please specify:_____

APPENDIX H

TREATMENT UNIT SURVEY FOR UNIT 7

Name:_____ Hour: _____ Date: _____

Post-Unit Survey for Unit #7

Participation in this research is voluntary and participation or nonparticipation will not affect a student's grade or class standing in any way.

1. Did you think using self-assessment was helpful? _____ Yes _____ No
    a. Why or why not?

2. Did your study habits for chemistry change when using self-assessment? ___ Yes ____No
    d. If yes, how?

    e. If yes, why?

    f. If no, why not?

3. Please draw a circle around the response that most closely reflects how helpful you found each of the following for studying chemistry.
    f. List of "I can" statements

        Very helpful Helpful Not helpful

    g. Textbook pages listed on "I can" statements

        Very helpful Helpful Not helpful

    h. Practice quizzes

        Very helpful Helpful Not helpful

    i. Rating how well you could do something several times during the unit

        Very helpful Helpful Not helpful

4. What other thoughts or information would you like to share about using self-assessment?

5. Rate the last four units from easiest (1) to hardest (4).

   _____ Unit 4: History of the Periodic Table and Periodic Trends

   _____ Unit 5: Types of Bonding, Molecular Shapes and Intermolecular Forces

   _____ Unit 6: Nomenclature and Formulas

   _____ Unit 7: Math of Formulas

6. Please draw a circle around the response that most closely reflects how much you agree with each statement below: strongly agree (SA), agree (A), disagree (D), or strongly disagree (SD).

   a. I enjoy learning chemistry.
      SA A D SD

   b. I am willing to work hard to learn chemistry.
      SA A D SD

   c. I am satisfied with my grade in chemistry class.
      SA A D SD

   d. Effort is more important than natural ability for doing well in chemistry class.
      SA A D SD

   e. I think learning chemistry is important.
      SA A D SD

      Why did you answer this statement the way you did?

   f. I am the person who is most responsible for how much I learn.
      SA A D SD

      Why did you answer this statement the way you did?

   g. I am able to determine what topics I need to study before a chemistry test.
      SA A D SD

      Why did you answer this statement the way you did?

h. I can earn the grade I want to have in chemistry class.
SA A D SD

Why did you answer this statement the way you did?

6. Please check the response that most closely reflects how you would complete the statement.

a. The number of days a week that I spend time outside of class studying for chemistry is:

__ Every Day __ 5-6 Days __ 3-4 Days __ 1-2 Days ___ 0 Days

b. On a day when I study for chemistry, the average amount of time I spend studying is about:

__ 5-15 min. __16-30 min. __31-45 min. __46-60 min. __ 60+ min.

7. Please check **ALL** of the following which describe how you studied for chemistry in the last unit.

_____I reread my assignments.

_____I took notes over my assignments

_____I covered the answers to assignments and reworked the problems.

_____I read pages in the textbook.

_____I took notes over the pages in the textbook.

_____I did extra practice problems from the textbook.

_____I came in and asked my teacher for help before or after school.

_____I made flashcards.

_____I quizzed myself.

_____I asked someone else to quiz me.

_____I examined the questions I missed on the textbook assignment to determine why I missed them.

_____I talked about chemistry topics outside of class with other chemistry students.

_____I searched the internet for information about topics I was studying.

_____I watched on-line videos about the topics I was studying.

_____I looked at resources posted on Blackboard.

_____I played the rest of the review game we played in class.

_____I wrote about the topics I was studying.

_____I drew sketches about the topics I was studying.

_____Other, please specify:_____

_____Other, please specify:_____

APPENDIX I

INSTITUTIONAL REVIEW BOARD EXEMPTION

INSTITUTIONAL REVIEW BOARD

For the Protection of Human Subjects
FWA 00000165

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MEMORANDUM

TO: Laura Feldkamp and Walter Woolbaugh

FROM: Mark Quinn, Chair Mark Quinn CMJ

DATE: October 15, 2012

RE: *"Effects of Self-Assessment on Student Learning in High School Chemistry" [LF101512-EX]*

The above research, described in your submission of October 15, 2012, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

X (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

X (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

____ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

___ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

____ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

_____ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.