INTEGRATING LABORATORY EXPERIENCE WITH LECTURE CONTENT
THROUGH THE USE OF COGNITIVE AND COOPERATIVE LEARNING
STRATEGIES IN A COMMUNITY COLLEGE INTRODUCTION
TO CHEMISTRY COURSE

by

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of

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DEDICATION

This is dedicated to my son whose existence in my life has motivated me to seek this level of professionalism for the expression of my love for science. I also dedicate this paper to Dr. John Green who has opened up his classroom and has been available throughout this process, and whose endless love of chemistry is inspiring. Jen Best also has a share of this dedication without whose help I would never have gotten this far in my education.
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ABSTRACT

This study investigated the effects of cooperative learning groups in conjunction with cognitive learning strategies for the understanding of chemistry concepts for 23 Introduction to General Chemistry students at the community college level. Students trained in cooperative learning groups. These groups served as the traditional lab group in the laboratory and small discussion groups in the lecture. Various data collection instruments, including a survey, interviews, observations, student self-reflections, formative assessments, and summative assessments were used to determine the effect of the treatment on student understanding of chemistry concepts, motivation and attitude, and metacognitive abilities.
INTRODUCTION AND BACKGROUND

Chemistry can be overwhelming for the introductory student at any age. The traditional model of teaching chemistry consists of lecture and a related laboratory experiment for each concept. In the lecture, chemistry concepts are illustrated by specific examples and in the laboratory specific examples are created, observed, and measured. To the introductory student, concepts are often confusing and the specific examples accumulate as separate items rather than examples and illustrations that articulate a unified concept. In various Classroom Assessment Techniques (CAT) given in an introductory chemistry class at the Scott Community College last year, students were asked about chemistry concepts. Their responses included examples or procedures, but concepts were absent. Often, students were able to explain an example, but could not make appropriate connections to other examples given in class or to the chemical principle the example was demonstrating. This problem mirrors my past experiences as a chemistry student, including when I was a student in Dr. Green’s chemistry class. I assume that this is the way that my former elementary science students perceived chemistry topics. As a science instructor, the burning question that has bothered me for years is “why do examples and hands-on experiences seem to overwhelm students rather than clarify chemistry concepts? “

When Dr. Green agreed to sponsor my capstone project in his community college classroom, we began to discuss the frustrations that we each experienced as science instructors in our respective level of teaching: Dr. Green in postsecondary education and me in primary education. We agreed that, students had the impression they experienced
significant learning from the hands-on portion of the class, but this was not necessarily
demonstrated in students’ formal assessments. Why were students unable to apply and
integrate their laboratory observations and experiences with the concepts and examples
taught in lecture to promote understanding? We both remembered students saying, “I
have understood everything in the past labs, but don’t know how to answer the question.”
We both agreed that lecture and laboratory experiments were essential, yet these
traditional teaching components were not working together in a way that supports
students’ understanding of beginning chemistry concepts.

The treatments developed in this project come from our pursuit to improve the
effectiveness of the traditional chemistry class in ways that create a solid comprehension
of important chemistry concepts students will need throughout their professional training,
in their future professions, and in their lives as scientifically literate citizens.

We hypothesized that by combining and applying the two educational practices of
cognitive learning strategies and cooperative learning strategies, we might be able to
support synthesis and integration of material presented in lecture with experiences in the
laboratory to help students understand chemistry concepts. We recognized that
synthesizing and integration are higher order thinking skills that would require an
instructors’ scaffolding to assist students’ understanding.

Cognitive strategies are strategies used to break down a complex learning task.
They involve more than the skill for doing the task. For example, decoding is a natural
and obligatory skill for reading, but it is not a cognitive strategy. However, asking
questions while reading to monitor for comprehension is a cognitive strategy (Pressley,
Harris, & Marks, 1992). A cognitive strategy helps to insure that a skill or process is being used or applied in the way necessary to yield intended outcomes. Cognitive learning strategies that involve monitoring are very similar to the way that metacognition has come to include self-regulation. The developmental psychologist, John Flavell first used the word metacognition in the 1970s to refer to, “one’s knowledge concerning one’s own cognitive process or anything related to them,” (1976). Since this time, awareness has developed into active strategies. In a paper called, “Studying in higher education: students’ approaches to learning, self-regulation, and cognitive strategies” authors Heikkila and Lonka (2006) define self–regulated learning as, “A students who is regulating his or her leaning is able to set task-related, reasonable goals, take responsibility for his or her learning, and maintain motivation.”

As we looked closely at what was working well and not working well in Dr. Green’s traditional chemistry class, we noticed that students gathered in groups that stayed the same within the classroom and in the laboratory. Students seemed to cling to their groups with a quality of desperation and urgency especially when it came to obtaining a right answer from the group. Dr. Green and I recognized the importance of peer support and the social aspect of community college. We saw that by using cooperative learning groups, we could transform something that already existed into a more productive, deliberate, and positive educational practice.

The second aspect of this treatment was to develop a system for the use of cooperative groups. Subtle distinctions are often made between cooperative learning and collaborative learning. For the purpose of this paper, I will only use the term cooperative
learning to refer to the instructional strategy of learning in small groups to maximize the understanding of all involved and for the purpose of working on a structured learning task (Kyndt, Raes, Lismont, Timmers, Casscallar, & Dochy, F, 2013; Johnson, Roger, & Smith, 1991). Although there is much dispute about the nature of a cooperative group, two main criteria are accepted: the interdependence of all group members for the purpose of accomplishing a goal, and individual accountability to the group (Walters, 2000). This treatment sought to extend the cooperative learning groups organized for lab work to serve as a small discussion group in the lecture portion of the class. In these group contexts, focused questions and activities that would meet the requirement of the common goal of the group. In addition, the cooperative groups in this research had a third component, deemed necessary by the Johnson model of cooperative learning. This component is a system of evaluation for the cooperative group. Dr. Green and I further hypothesized that through participation in this research his students would gain an awareness of their own learning, and perhaps gain new skills to become better learners.

The focus question of this project was: what are the effects of using cognitive learning strategies and cooperative learning groups on students’ understanding of community college chemistry concepts? The subquestions were: what are the effects of using cognitive learning strategies and cooperative learning groups on students’ attitudes toward learning chemistry; and, what are the effects of using cognitive learning strategies and cooperative learning strategies on students’ understanding of their own learning of chemistry concepts?
The members of my Masters of Science education (MSSE) cohort offered valuable information and feedback throughout the development of this project. Eric Brunsell, Ed. D. and Jewel Reuter, Ph.D. were my Montana State University Master of Science Education instructors and advisors. Joseph Bradshaw was my science reader.

CONCEPTUAL FRAMEWORK

The traditional chemistry classroom includes a laboratory portion in which traditional laboratory exercises are performed by small groups. This small group work corresponds to the more recent use of cooperative learning groups as both a cognitive learning strategy and as pedagogical technique. By extending the traditional laboratory group into the classroom lecture, students had a consistent cooperative learning group for support while learning chemistry concepts.

There is an overwhelming amount of research to support the advantages of education in cooperative learning groups. In fact, Robert Slavin(1996) states, "Research on cooperative learning is one of the greatest success stories in the history of educational research."( p.43). When reviewing the separate research that supports the use of cognitive learning strategies and cooperative learning strategies to aid complex tasks and processing concepts, I found that there is research that has combined cognitive and cooperative learning strategies for the purpose of seeing their combined effects on student motivation, attitude, and metacognition.

The concept of cognitive strategies was born out of constructivist theory, which states that knowledge and understanding are constructed bit by bit by the learner. The original constructivist thoughts came from the work of Cultural Historical Theory of Lev
Vygotsky (1896 – 1934). Vygotsky observed that there was a gap between the level of cognitive activity students were capable of performing independently and the level of cognitive activities students were able to perform with the assistance of a more experienced learner. This gap is described as the zone of proximal development (ZPD). After repetition of a challenging task with support, the student is able to move through the ZPD in order to establish a new zone of independent capable functioning. A new ZPD is established again between the assisted zone and the independent zone (Bodrova, Leong, & Akhutina, 2011). In social constructivist thinking the student is influenced by the environment and people that make up the assisting zone while the student internalizes and constructs cognitive tools to address the challenges of the intermediate zone (2011).

After Vygotsky, Jerome Bruner (1961), further developed the concept of scaffolding to describe how external support could assist the learner to move through one ZPD to the next. The learner is scaffolded through the ZPD with a cognitive strategy that is directly taught or modeled. By using cognitive strategies together with cooperative learning strategies both aspects of constructivist theory are employed: Cognitive strategies provide the scaffolding, and cooperative learning provides the external assistance to move from the assisted zone to the independent zone.

The use of cognitive strategies is related to students’ motivation and attitude. The term cognitive strategies are also referred to as active learning strategies because the student is actively engaged in his or her own learning. As a result, there is a strong relationship between the use of cognitive strategies and student motivation. When discussing a study with students at the University of Helsinki, Heikkila and Lonka (2006)
write, “Our main findings indicate that approaches to learning, self-regulation of learning and cognitive strategies, measured with self-report inventories, are intertwined” (p.111).

Although it is almost universally acknowledged that cognitive strategies increase student achievement and understanding, there is much debate about the best method in which to teach students these techniques. There is some evidence that explicit instruction is most effective. In addition, cognitive strategies must be selected and specifically applied in order to be successful. A study by O’Sullivan and Pressley (1984) compared groups of fourth-grade students learning vocabulary. It was found that the groups that used cognitive strategies had higher achievement. These students were often unaware that it was the cognitive strategy that made the difference in their success. The students who were aware of this fact were more likely use the strategy in other learning tasks. This research supports that use of cognitive strategies should be deliberate, explicitly taught, part of active learning, acknowledged as effective, and used to promote metacognitive thinking.

Although, the research supports the teaching of cognitive strategies, there remain questions about whom and when should the strategies be taught. Research from Peterson and Swing (1983) illuminated the problems raised when teachers are expected to teach cognitive strategies. One of the solutions to these issues is to use peer scaffolding in the cooperative learning group (Manion & Alexander, 1997).

Vygotsky’s theories gave rise to ZPD, then scaffolding, and the cognitive strategies. However, Vygotsky also emphasized the importance of the social context in which student may invent cognitive tools (Bordrova et al., 2011). Cooperative learning
as a cognitive strategy is represented by ideas and techniques, such as peer-assisted learning strategies and reciprocal teaching.

Cooperative learning groups have been cited as the way in which students can model cognitive learning strategies to each other. In a very interesting study, Manion and Alexander (1997), studied fourth-graders with varying levels of metacognitive abilities as they performed a recall task. Then they compared individual performance to group performance, finding that the group’s recall rate exceeded that of the individual’s. In addition to this advantage of cooperative work, the students with the lowest level of metacognitive proficiency increased in their individual ability to use this cognitive strategy. Increases in recall after the use of cooperative groups is explained by the authors as being due to the additional time on task spent in discussion. The discussion also gave rise to increased metacognitive interactions and, therefore, the opportunity for the least proficient learners to practice this skill.

In another study, Olivera and Straus (2004) found that research showing the group’s effect on the individual was lacking and specifically created a study in which individuals worked on puzzles individually, then in a group, and then individually again for a third trial. They found that, “individuals who either worked in or observed groups showed significantly greater improvement in performance than did individuals who worked by themselves.” (Olivera & Straus, 2004, p. 455) In addition, they recommend that for the best long-term effects, “group work should be structured in a way that promotes exposure to problem-solving strategies.” (Olivera & Strays, 2004, p. 457)
In another study titled, “Enhancement of Metacognition Use and Awareness by Means of a Collaborative Intervention”(Sandi-Urena, Cooper,& Stevens, 2010) it was demonstrated that metacognition can be developed by individuals in a group in the same way that cognitive learning strategies can be transferred from group to members in the previous mentioned study. In this study groups of students were given a non-chemistry problem that caused cognitive imbalance followed by a chemistry problem. Students were asked to reflect collectively on the problems, then they were given an individual problem and an individual reflection to that problem. Finally, students were given feedback and another reflection. Students who participated in all aspects of this treatment showed significant increased ability to solve this kind of problem and problems of higher difficulty (Sandi-Urena et al, 2010). The authors further conclude, “it [the study], presents evidence for the claim that metacognitive skills developed during collaboration are transferable to the individual solution of an unrelated and independent task. (Sandi-Urena et al., 2010, p.337)”

These studies are in agreement with Vygotsky’s idea that skills and knowledge are transferable from the group to the individual. This information supports that with the use of cognitive strategies in the context of cooperative learning groups, students will be better able to understand how examples in the lecture and the lab can be integrated in an understanding of chemistry concepts.

METHODOLOGY

For this project, I observed one section of the Introduction to Chemistry at Scott Community College in Bettendorf, Iowa. This project consisted of one nontreatment
period of time and one treatment period of time. The topics taught during the
nontreatment period were chemical measurements, introducing the metric, International
System of units (SI units), atomic structure, and periodic table. The content for the
nontreatment unit was taught through lecture and lab with reading assignments, and two
homework assignments. Formal assessments for this period included two quizzes, one
open book and the other not, and an open book test. When presenting new material, Dr.
Green wrote subject topics and subtopics on the white board followed by examples.
Students were expected to take notes that could later be used for quizzes and tests.

In the nontreatment unit, students were encouraged to print the lab material from
the Internet postings before class. They were asked to read the material prior to class.
Students formed lab groups of three and four students who were familiar with each other
from previous classes. If clarification was needed about either the procedure or content
of the lab and its integration into the overall content of the chemistry class, students either
asked each other, the professor, looked on line, or read in the book.

At the start of the lab periods, Dr. Green also supported students by “walking”
through the lab step-by-step. Dr. Green describes this class as a traditional chemistry
class. In other words, he has taught this class the same way his chemistry class was
taught to him more than 50 years ago. During this pretreatment period, students were
given a pretreatment survey as seen in Appendix A. Two students from each
achievement level (low, middle, and high) were interviewed at the beginning of the
semester to determine how they felt about learning chemistry (Appendix B). Students’
behavior in lecture and in laboratory was also observed.
Table 1

Units and Activities in Introduction to General Chemistry

<table>
<thead>
<tr>
<th>Unit</th>
<th>Topic</th>
<th>Activities and assignments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nontreatment</td>
<td>Units of Measurement SI units</td>
<td>Lab 1: Chemical Measurement</td>
</tr>
<tr>
<td></td>
<td>Atomic Structure</td>
<td>Lab 2: Density/Specific Gravity</td>
</tr>
<tr>
<td></td>
<td>Periodic Table</td>
<td>Assignment 1: measurement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Assignment 2: Compounds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quiz 1: Measurement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quiz 2: Elements and Symbols</td>
</tr>
<tr>
<td></td>
<td></td>
<td>First interim test</td>
</tr>
<tr>
<td>Treatment</td>
<td>Chemical Compounds</td>
<td>Lab 3: Stoichiometry 1 (MgO)</td>
</tr>
<tr>
<td></td>
<td>Ionic and Covalent Bonds</td>
<td>Lab 4: Stoichiometry 2 [Cu(NH₃)₄] x H₂O</td>
</tr>
<tr>
<td></td>
<td>Polar and non-polar molecules</td>
<td>Cooperative group exercises</td>
</tr>
<tr>
<td></td>
<td>Chemical quantities and reaction</td>
<td>Lab 5: Chemical Compounds</td>
</tr>
<tr>
<td></td>
<td>equations</td>
<td>Lab 6: Hydrated Salts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Assignment 3: Stoichiometry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Assignment 4: Chemical Equations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quiz 3: Ionic Compounds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quiz 4: Molecular Compounds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Second interim test</td>
</tr>
</tbody>
</table>

**Intervention**

The treatment took place during the second grading period that covered the subject matter chemical compounds, ionic and covalent bonds, polar and non-polar molecules, chemical quantities, and reaction equations. The treatment units included the same traditional lecture and laboratory class periods as the nontreatment unit, although three separate practices were on-going throughout the treatment period. First, the self-selected lab groups were transformed into cooperative learning groups through two exercises at the beginning of the treatment. Students were asked to create a visual Likert scale to be used by all members of their lab group. They were given directions on how to choose images to represent different levels of understanding and contentment with the lab and lab group (Appendix C). It was explained that this scale would be used by the
individuals of the group to rate their cooperative group experience and individually reflect on their chemistry understanding at the end of each lab period. The six different lab groups choose widely different images for their group’s visual Likert scale, as seen in Appendix D. This exercise proved to be a powerful and creative way for the group to get to know one another and brand their group collectively. For the second pre-treatment cooperative training, students were asked to discuss and choose different lab responsibilities they would perform for the whole group. The roles were designed to promote interdependence necessary for cooperative groups. These roles are described in Appendix E.

The second feature of the treatment was also present in the lab portion of the class. After all their lab work was completed, students were asked respond to a check out paper. The check out consisted of a set of two questions. The first corresponded to the lower order thinking strategy of identifying an example. The second part of the question was specifically scaffolded to require students to integrate examples answering the first question which could have come from either the lab or the lecture and then using these various examples to explain a concept taught in the lecture. This two-step process explicitly supports students to practice the inductive reasoning necessary for scientific thinking. Students were encouraged to discuss with their lab group how the examples demonstrated the concept asked about in the second question before individually answering the question.

After the lab check out question students completed their specialized group Likert scale to evaluate their lab experience. Below the Likert scale was space titled “in your
own words” for any reflection students wanted to write. Overall, five lab check outs were given during the treatment period. On the fifth and final lab check out instead of “In your own words” students were asked “How were these lab check out papers helpful to you and your lab group?” Examples of the lab check out papers can be found in Appendix F, G, H, I, and J.

The third part of this treatment took place after the lecture on the days with no lab period. These check out papers included a question or task specifically related to the lecture that day. There were two of these lecture check out papers. An example is provided in Appendix I. The same two-step process was used consisting of finding an example and using it to articulate a concept with the help of group discussion followed by individual response.

After collecting the lab check out papers, I quickly reviewed the papers with Dr. Green for any outstanding misconceptions. We discussed the various ways we would address student misconceptions. Sometimes he addressed the problems in his class introduction and other times I wrote a letter or returned student papers with comments. Overall, this treatment consisted of the creation of cooperative groups that were intended to be a support for students throughout both lab and lecture periods, five lab check out papers, two lecture check out papers, and student self-evaluation of each of their lab experiences during the treatment, applied throughout a period of eight class periods (four weeks) for the purpose of giving students the opportunity to integrate examples from lecture and lab into an understanding of chemistry concepts.
Participants

The sample class was a four-credit community college chemistry class called Introduction to General Chemistry. There were 22 students in this class: 17 female and five male students. The average age of the students was 24 with a range from 17 and to 39. All students needed to take this class to meet a requirement for their degrees. Eleven students were at the beginning of a degree in health-related professions and the other eleven were taking this course for liberal arts credits. All but three of the students had chemistry in high school, which took place between last semester and 23 years ago. The class was comprised of 18 Caucasian students, two African American students, and two Latino students. This class met on Monday and Wednesday from 2:00 p.m. to 3:30 p.m. for lecture with an additional lab period on Wednesday from 3:40 p.m. to 5:40 p.m. The demographic of this class is consistent with that of the entire college.

Data Collection Instruments

For each question posed for this project, three different kinds of data were collected. I used a pretreatment and posttreatment student surveys, interviews during the pretreatment and posttreatment, field observations, student self – evaluations of lab periods, and check out papers. In this situation, the researcher was not the teacher. The triangulation of data allowed the results from many sources to be compared. The triangulation matrix can be found in Table 2.
Table 2  
*Data Triangulation Matrix*

<table>
<thead>
<tr>
<th>Focus Question</th>
<th>Data Source 1</th>
<th>Data Source 2</th>
<th>Data Source 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Question:</strong> 1. What are the effects of using cognitive learning strategies in conjunction with cooperative learning strategies on the effectiveness of understanding chemistry concepts in a community college classroom?</td>
<td>Preunit assessment and Postunit assessment Post lecture and lab cooperative work</td>
<td>Pretreatment and posttreatment student surveys</td>
<td>Preunit and Postunit student concept interviews</td>
</tr>
<tr>
<td><strong>Secondary question:</strong> 2. What are the effects of cognitive strategies in conjunction with cooperative learning on students’ understanding of their own learning of chemistry concepts?</td>
<td>Post and Delayed Unit Assessment</td>
<td>Post and Delayed Unit student concept interviews</td>
<td>Post and Delayed Treatment Surveys</td>
</tr>
<tr>
<td>3. What are the effects of cognitive learning strategies in conjunction with cooperative learning on students’ attitude and motivation?</td>
<td>Pretreatment and posttreatment student surveys Student self-evaluations</td>
<td>Researcher field observations of engagement and nonengagement</td>
<td>Pretreatment and posttreatment student nonconcept interviews</td>
</tr>
</tbody>
</table>

During both the treatment and nontreatment units, students were observed during the lecture and the lab with regard to their level of engagement. Students were given a survey at the beginning of the class to determine their attitudes towards chemistry. This was then compared to the results of the same survey at the end of the treatment units. Six different students, two in each category representing low, middle, and high-achieving students, were interviewed during the pretreatment period, and in the posttreatment...
phases of this research. The triangulation of the qualitative and quantitative data showed the effectiveness of cognitive strategies applied in a cooperative learning group while at the same time eliminated possible misinterpretations of any one source of data.

Student data was obtained from the qualitative analysis of student lab check out papers. The lab check out papers that were a part of the treatment served as a formative assessment for student learning. Student self-evaluation responses were way to measure student attitudes and motivation. See Appendix L for timeline of the project. The nontreatment portion of this project began at the end of January with the beginning with the first unit of the new semester at the community college and continued until the first test on February twenty third. The period that made up the treatment portion of the research started on February twenty- third and continued until the second test on March twenty-fifth.

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. The Institutional Review Board documents for both institutions can be found in Appendices M and N.

DATA AND ANALYSIS

In order to determine if the treatment of check out papers, cooperative groups, and reflections were effective in raising students achievement I compared the mean of the first test taken before the intervention to the second test taken after the intervention had just finished. I then broadened the comparison to include all graded work in the pretreatment and posttreatment periods. The scores of individuals in comparison to the
mean of their lab groups revealed more about the possible impact of the intervention. The survey of students’ attitudes and opinions and answers to interview questions about how to best learn chemistry pretreatment and posttreatment were compared to determine the effects of cooperative learning groups and students’ point of view about the integration of the lab and the lecture as a way to learn chemistry concepts. The pretreatment and posttreatment survey results in relation to the interview responses were reevaluated to determine the effects of the treatment on student metacognition.

The Impact of Cognitive and Cooperative Learning Strategies to Learn Chemistry Concepts

The effect of using cognitive and cooperative learning strategies to learn chemistry concepts in an introduction to chemistry class at the community college level was inconclusive. The intervention was conducted between the first and second exam. By comparing the class mean of the tests, it can be seen that small gains were made in student understanding of chemistry concepts. The first, preintervention, exam had a mean of 77.9% and a standard deviation of 8.9%. The second exam, taken after the intervention, had a mean of 81.8% and a standard deviation of 10.8%. This gain is still within the standard deviation and does not indicate any change with respect to the intervention.

By expanding the comparison to include all the five graded assessments during each period of pretreatment and treatment, two assignments, two quizzes, and one test, the scores are also inconclusive in relation to the possible effect of the treatment. The pretreatment period class mean was 80.7% and the treatment mean of graded assessments
was 76.2%. The 4.5% decrease can be explained by the fact that all the individuals in lab group (A) did not turn in any assignments. Without lab group A, the class mean of all graded assessments of pretreatment is 75% and posttreatment is 83.8%. Showing an increase of 8.8%, this increase is still inconclusive because it cannot be shown to be a result of the treatment.

Another measure of the effect of the intervention was a comparison of the pre and post treatment survey of questions pertaining to the integration of the lab and the lecture. The intervention was designed to help students integrate the chemistry examples discussed in the lecture with the chemistry examples experienced in the lab in order to better understand chemistry concepts. Giving students this exercise created clarity for some students and confusion for others as evidenced by the consistent increased polarization in all questions on the survey that asked about the integration of the lab and the lecture as seen in Table 3 and figure 1.
Figure 1. Questions related to concepts on pre and post survey, (N=22).

When asked if they agreed or disagreed with the statement, “Knowledge in chemistry consists of many disconnected topics,” the majority of students had been neutral in the pretreatment, but shifted to 35% disagreement and 35% agreement in the posttreatment. Question 11, “I enjoy the lab, but I have no idea what it means in terms of chemistry concepts” was also a question that saw increased polarization with disagreement shifting from 45% to 58% and agreement shifting from 22% to 24%.

Question 15, “I feel like I understand chemistry concepts in lecture, but the lab confuses what I think I understand,” asked about the same issue in a different way, and also had
the same shifts in student opinion. Students who disagreed with the statement increased from 50% to 58%, and students who agreed with the statement increased from 23% to 29%. In all three questions that asked about the integration of the lab and the lecture an increased polarization can be seen. This effect shows that by deliberately and explicitly directing questioning about chemistry concepts, some students see more unity in chemistry whereas others found the questioning more confusing.

Table 3
Comparison of Survey Data Showing Shifts in Student Attitudes Pretreatment N=22 posttreatment N=17

<table>
<thead>
<tr>
<th>Survey question number and question</th>
<th>Disagreement</th>
<th>Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretreatment</td>
<td>Posttreatment</td>
<td>Pretreatment</td>
</tr>
<tr>
<td>2. Knowledge in chemistry consists of many disconnected topics</td>
<td>27%</td>
<td>35%</td>
</tr>
<tr>
<td>6. To understand chemistry I discuss it with friends and other students.</td>
<td>45%</td>
<td>17%</td>
</tr>
<tr>
<td>7. Doing experiments in the lab is the best way to learn chemistry concepts.</td>
<td>4%</td>
<td>5%</td>
</tr>
<tr>
<td>8. I feel like I understand how experiments in the lab are examples of chemistry concepts.</td>
<td>9%</td>
<td>5%</td>
</tr>
<tr>
<td>11. I enjoy the lab, but I have no idea what it means in terms of chemistry concepts.</td>
<td>45%</td>
<td>58%</td>
</tr>
<tr>
<td>14. I like it when I have other people to help solve chemistry problems.</td>
<td>23%</td>
<td>11%</td>
</tr>
<tr>
<td>15. I feel like I understand chemistry concepts in lecture, but</td>
<td>50%</td>
<td>59%</td>
</tr>
</tbody>
</table>
Cooperative Learning Aspect of Primary Research Question

The cognitive exercise on the check out paper served the purpose of the common goal. This is one way of creating positive interdependence. Johnson and Johnson (2009) write, “Knowing that one’s performance affects the success of group mates seems to create responsibility forces that increase one’s effort to achieve.” (p. 367) With this prerequisite met, the lab group was transformed to a cooperative group. The intervention process of working in cooperative groups proved to have a more significant impact than the intervention task. Evidence from the comparison of individual scores to the lab group mean, and students’ self assessments show the cooperative aspect of intervention, benefited students.

By looking at individual scores of graded material and comparing the lowest performing student to the mean for the lab group, cooperative learning groups showed a positive effect on the lowest students for four out six of the lab groups. The comparison of the percent grades for these periods is made individually and collectively by lab group on Table 3. The lowest student in lab group B improved from 83% to 86%. The lowest student in group C, improved from 46% to 76%. The lowest student in lab group D,
improved from 75% to 81%. The lowest student in lab group F, improved from 55% to 76%. The scores of the individuals in lab group E, changed in various ways, yet the lab group as a whole maintained the same mean in both periods. This pattern is further highlighted when the cumulative scores for lowest performing students in each lab group are averaged and compared pretreatment to treatment. The lowest performing students in each lab group (excluding lab group A) had a mean of 67.6% with a percent deviation of 14% before the treatment and a mean of 78.8% with a 4.2% of deviation after the treatment. This is an 11.2% increase as compared to the high performing students whose averaged mean changed from 87.8% to 91.4% thus showing only a 3.6% increase.

Table 4
A Comparison of Individual and Lab Group of Percent of Graded Assessments

<table>
<thead>
<tr>
<th>Name of lab group</th>
<th>Individual percent</th>
<th>Lab group average percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - pretreatment</td>
<td>71, 58, 86, 79</td>
<td>73</td>
</tr>
<tr>
<td>- treatment</td>
<td>51, 44, 46, 60</td>
<td>50</td>
</tr>
<tr>
<td>B - pretreatment</td>
<td>90, 88, 83, 95</td>
<td>89</td>
</tr>
<tr>
<td>- treatment</td>
<td>67, 87, 86, 97</td>
<td>85</td>
</tr>
<tr>
<td>C - pretreatment</td>
<td>46, 87, 96, 87</td>
<td>79</td>
</tr>
<tr>
<td>- treatment</td>
<td>76, 91, 102, 87</td>
<td>89</td>
</tr>
<tr>
<td>D - pretreatment</td>
<td>82, 75, 81</td>
<td>81</td>
</tr>
<tr>
<td>- treatment</td>
<td>87, 81, 83</td>
<td>84</td>
</tr>
<tr>
<td>E - pretreatment</td>
<td>80, 79, 86</td>
<td>81</td>
</tr>
<tr>
<td>- treatment</td>
<td>85, 75, 82</td>
<td>81</td>
</tr>
<tr>
<td>F - pretreatment</td>
<td>55, 71, 80, 72</td>
<td>69</td>
</tr>
<tr>
<td>- treatment</td>
<td>76, 73, 89, 82</td>
<td>80</td>
</tr>
</tbody>
</table>

Secondly, student self-assessment contributed to evidence that the cooperative aspect of the intervention was beneficial to students. Each lab check out paper had a reflection with a Likert scale and an open response section titled, “In your own words,” Of the various categories of comments expressed in this section, many included comments about how the group had helped them. One student wrote, “I’m coming along
with the help of my teammates, (smiley face).” Another student wrote, “I like the group that I am with, I can understand everything clearly. I enjoy my team’s work and help on everything.” Although not everyone explicitly stated they received help from their teammates, the number of praising comments later discussed in the motivation and attitude section show the helpful benefits of the use of cooperative strategies.

Third the comparison between the pre and post survey questions that pertain to cooperative work show a decisive shift toward favoring the benefits of cooperative work. In question 6, “To understand chemistry I discuss it with friends and other students,” disagreement changed from 45% to 17% and agreement changed from 45% to 70%. To question 12, “I like it when I have other people to help solve chemistry problems,” disagreement changed from 23% to 11% and agreement changed from 50% to 70%, as shown in figure 1. These answers show decisive preference for wanting friends and other students to talk and help with chemistry problems.
Finally, further evidence of an increase in positive attitude comes from observing students after the treatment was finished. I observed students wandering around the room sincerely looking at the experiments of the other lab groups, asking each other questions about the lab, and also asking the instructor questions about why the experiment looked so different at different lab stations. I see these larger whole group interactions as a transfer of skills from the work in the cooperative learning groups to being comfortable and motivated to discuss chemistry with the larger group during the lab period.

**Attitude and Motivation**

The effects of cognitive learning strategies in conjunction with cooperative learning on students’ attitudes and motivation can be seen by looking at the same survey questions that supported cooperative learning, and by looking at students’ comments in their student reflections. It can be seen that the intervention contributed to an improved
attitude and motivation to learn chemistry. Participation in the intervention seem to increased many student’s desire to work with other students to discuss chemistry. Wanting to work with other students showed an improved attitude towards chemistry.

An analysis of student writing also supports the claim that the intervention offered an opportunity for positive attitudes while learning chemistry. After the six-question Likert scale reflection, there was a space for students to write additional comments. Knowing that their participation was voluntary, I think it is significant that out of the 51 written comments, 20 were praise and compliments for their teammates. A few comments were simply, “My team is awesome!” or more specifically, “My team has a great communication set of skills and it is very easy to work together. We plan things out in an orderly fashion and it works great.” One person wrote poetically about their lab group, “Sarcasm is the glue that binds us together. Sarcasm is our shared electrons.”

The largest group of written comments were ones describing how the well the lab went. There were 25 comments in this category. These too were almost entirely positive and often overlapped the category of comments giving praise. For example, “I love my team! This was a fun experiment!” or “Lab was great. We always use teamwork. Our group is interested in learning and seeing what happens in the lab.” These sentiments are very different from the anxious dread five out of six students I interviewed talked about at the beginning of the class in January. There is not a direct link between the intervention and the expressions of positive attitude except to say that the intervention gave the students an opportunity to express whatever it is they wanted and positive feelings about their lab experience and lab group were chosen.
Effects on Metacognition

The effect of cognitive strategies in conjunction with cooperative learning showed to have an important role in developing and using student metacognition. By using qualitative data from interviews and responses in student reflections, it can be seen that students gained a greater ability to articulate and analyze their own learning. The treatment included a lab reflection that specifically asked students to reflect on their interactions with their teammates and their own understanding of the lab. In participating in the intervention students practiced the skill of reflection, an important part of metacognition. Many students used the “in your own words section” to reflect on what went well or not so well in the lab, in comments such as, “We didn’t use enough salt to really see a reaction, but it still worked.” Or “I thought we worked together well. I just need to pay more attention to directions because we had to redo.” These same students later wrote comments such as, “I feel like the experiment went well, but I’m not seeing why it is connected to what we are learning or how it is necessarily important.” and “I think the experiments are cool, but it’s hard for me to connect them with what we do in the class.” thus showing a reflection developing into the high order thinking skill of metacognition as these students move the focus of their reflection from the lab to their own learning.

Second, by comparing the way many of the interviewees chose to answer the question, “From previous experiences, or experiences so far in chemistry, what is the most challenging part of chemistry for you?” from the pretreatment and the post treatment interviews, students’ showed increased ability to understand how they best
learn. In the pretreatment interviews, the students answered this question by telling about the problems with their last experiences, how long it had been since they had taken chemistry, or what aspect of chemistry they were most dreading. In the post treatment interviews, five out the six students told about how they have learned how to teach themselves what they need to know. Two interviewees had various strategies of when and how to read the book. Two other students told that they couldn’t read the book and had various online video sites that they consulted on topics they felt they needed extra support. Another interviewee told how she made quizzes for herself on a website. Finally, the last interviewee told about what he had not yet done, but what he knew he had to do in order to do well in the class. The first interviews in which they told about the problems were characterized by a matter of fact tone, and involved placing blame on teachers and content. The post treatment interviews in which interviewees told about how they solved problems of not knowing or understanding chemistry concepts, they used detail to describe the process they had created for themselves and showed pride in their ability to have solved the problem.

In another instance students were deliberately asked to use their high order thinking skills to evaluate, “How were these lab check out papers helpful to you and your group?” Of the twelve responses to this question, nine of these responses were positive and of the positive responses, five sited the metacognitive aspect of the intervention. The two highest-achieving students in the class specifically noted this positive attribute of the intervention by writing, “I don’t think they were really helpful, except for that you had us answer the questions regarding whether or not we understood the concepts. That part
helped me think and recall for myself what we did in the experiment and if it did or didn’t actually ‘connect’ (in my head) with what we were learning” and, “made me think about what we did, go through to make me better understand.” To varying degrees, participation in this intervention facilitated the use metacognitive skills.

**Aspects of the intervention that did not work**

There were three aspects of this intervention that were attempted but were abandoned by the students or myself. The first was the choosing and using of lab jobs. Students went about the process of choosing lab jobs. I have evidence from the first lab check out reflection that there was an attempt by individuals to fulfill their task for the group. In the class prior to the second lab, I announced that lab groups should discuss if they were going to keep the same job or change jobs, but after this no mention was made of it again. I did not observe students using different roles in the lab. Without any further mention of any expectations of preparing for the lab from Dr. Green, from my observations it seemed as though students did not read the labs ahead of time and they were not using different jobs. Giving students time to make these “plans” in the previous class period, proved to be a problem.

It was my intention to have a lecture check out paper as well as a lab check out paper. This check out paper would have the same structure as the lab check out. Part 1, was about finding an example that came directly from the lecture that day, and part 2, involved discussing how these found examples all represented a chemistry concept followed by individual responses. There was no reflection associated with the lecture check out. This intervention started after third lab check out. They responded negatively
when I asked them to do this lecture check out. It was my impression that asking the students to complete a lecture check out was a very strange request. Many students complained, “but we didn’t have a lab,” They were unable to transfer the cooperative group interaction to a context that was not a lab even though it was in exactly the same location with the same group. The lecture class is shorter than the class on lab days which made it difficult to give the intervention during the time of the class. Only half of the students present stayed to complete the check out paper after the class was technically over. In addition, in one case the material in the lecture check out was not covered in class thus turning the post assessment into a pre assessment which was not what was intended.

Similar communication problems made it difficult to coordinate with Dr. Green so that he could provide feedback to students about their questions and misconceptions in the lab check out papers, as I had intended. I twice tried to provide feedback to students’ lab check out papers. Once I copied their papers for research purposes and then returned their papers with comments about the relative correctness or incorrectness of their answers. In another case, I wrote a letter to the entire class clearly explaining a concept that so many students had misconstrued it merited a single response. Receiving papers from me, the researcher, was confusing for the students. They were confused by the “read only” papers and this further confused the students about my role in the classroom. Therefore I stopped this practice after these two attempts.
INTREPRETATION AND CONCLUSION

Overall, the data was inconclusive as to determining the effects of cognitive learning strategies in conjunction with cooperative learning on student understanding of chemistry and success in this class. A better understanding of the effects of the treatment can be seen by looking at the aspects of cognitive learning strategies and cooperative learning strategies separately.

Analyzing data from the assessments could not determine the effectiveness of the cognitive strategies. The limitations of this research situation made the probing for the applied use of these skills difficult. Previous research into the use of cognitive learning strategies recommends that they are deliberately taught so that students can have an awareness of how these strategies are used to relation to understanding of the concept being learned. This was seen in the study of fourth graders who had more success using a cognitive strategy when they were aware of both how it worked and when they were applying it.

The cooperative learning strategies aspect showed positive effects on achievement, and students’ attitude and motivation. Both survey questions that purposefully asked students if they preferred to work out or talk out problems with other people increased an average of 18% percent from pretreatment to posttreatment. When looking at the student reflections, 39% of the written comments students added after answering a Liket scale were in praise of their teammates. The lab check out papers urged students to talk to each other about chemistry which might not have happened otherwise, and it also urged students to consider other students as a source of help for the chemistry
problems they did not understand. I observed students using their social skills to learn chemistry. After the treatment was over students were curious enough to wander around the room to see what was happening in experiments of other lab groups. I saw the students from different lab groups converge at the supply table, which was the instructor’s teaching table in the front of the room to mix chemicals together instead of returning to their individual tables. The social learning benefits that I observed and the data from this research support what many other researchers have documented. In a meta-analysis of 148 studies, 17,000 early adolescents, in 11 countries, Roseth, D. W. Johnson, and R. Johnson (2009) found positive peer relationships explained 40% of the variation in achievement. The authors go on to recommend that teachers should deliberately,” facilitate the development of friendships” (p.372) in order to improve achievement (Johnson, D. W. and Johnson, R. 2009).

The academic improvement as a result of cooperative groups was seen in the data concerning the lowest achieving students. By comparing the improvement of pre and post treatment of the lowest performing students in each lab group, it can be seen that this group had the greatest benefits of cooperative learning. The researcher that also reported this finding recommended heterogeneously grouping students (Manion & Alexander, 1997). I did not specifically group students heterogeneously, yet in the lab group with the greatest difference in student abilities showed the greatest improvement in a student’s success. The lowest preforming student improved the most from 46% to 76%. In elementary education, cognitive learning strategies and cooperative learning situations
are more deliberately used throughout daily pedagogy, however my findings show that the same strategies are helpful to community college students.

Finally, the single best effect of this treatment was the student lab reflection questionnaire. This practice asked students to reflect, an important skill in developing higher order thinking skills, where there had been no formal request to think on this level previously in this course. Specifically, when asked to agree or disagree with the statement, “I feel like I understand how the experiment we did shows chemistry concepts we are learning,” had an impact on student thinking. Directly after this Likert statement, was space for students to respond in their own words to anything they wanted. Because it required writing, this section was seen as optional by the students. Even though it was optional, of the five lab check outs 53% was the lowest percentage of students who wrote comments. The highest was 82% who felt compelled to write comments. I interpret this to mean that students have a need to reflect on their learning beyond just politely filling out the paperwork because they were asked. Anything that compels students to write is meaningful.

The content of these comments can be grouped into three categories. Half of these comments reflected on the problems or merit of the lab. The next largest category was praise for the lab groups. The third category was made up of more personal reflections. In this category some students expressed personal frustrations about learning chemistry. Still other students seemed to expand on the last question by trying to see how the lab and the lecture were integrated.
This practice of reflecting on one’s learning, was taken up by all the students I interviewed. When comparing the pretreatment interviews to the posttreatment interviews, all the students included in their response to the questions a detailed description of processes they had developed to learn chemistry. This included when and what they read from the book, when they watched you tube videos, how they reviewed their notes, or what flashcards and study aids they made. Reflecting on these processes is cited as an important and essential aspect of cooperative learning groups that distinguishes cooperative learning from students sitting together in a group using the same materials. Research based on the application of the work of John Flavell on metacognition often combines cognitive strategies, cooperative learning, and self-regulating as important ways to develop the higher order thinking skills necessary for understanding conceptually. (Heikkila and Lonka, 2006; Zoller and Pushkin, 2007)

Without fully intending to be so, this research was a trial of the comparative ideas of Kagan and Johnson and Johnson about cooperative learning strategies. Roger T. Johnson, co-director of the Cooperative Learning Center at the University of Minnesota and his brother David have developed a model of cooperative learning that completely changes the traditional classroom structure. The way students interact with each other and the instructor, the instructor’s role in the classroom, the curriculum, and the assessments are transformed for the purpose of creating a cooperative paradigm. This is looked upon as the “replacement approach” by Spencer Kagan who is the director of Kagan Publishing and Professional Development, which trains teachers in cooperative teaching
techniques (Walters, 2000). Kagan maintains that through cooperative techniques, cooperative learning can be implemented and used in any situation.

I was depending on Kagan’s ideas to be true when I changed the lab group in a traditional chemistry classroom into cooperative groups. I used Johnson and Johnson’s three recommendations for creating cooperative groups: interdependent work, individual accountability, and a reflection component for processing the group work. Yet, despite these factors in its favor, the cooperative groups I established in Dr. Green’s classroom did not help students succeed to the degree it was designed because the overall structure of the classroom did not support this practice. This failure, leads me to believe the Johnson and Johnson model to be better for bringing about the change needed to support students to understand the integration of chemistry concepts in the lab and the lecture.

VALUE

Ironically, the value of the research to find the effects of cognitive learning strategies and cooperative learning strategies on students ability to integrate chemistry concepts from the lab with the lecture, came from what failed. The treatment included cognitive learning strategies, cooperative learning groups, and student reflections. These were in many ways, at odds with the policies and traditions in Dr. Green’s class. When initially interviewing students before the treatment, many were very anxious about the course for many reasons. One reason repeatedly mentioned was they wanted to know how to do well and what was expected. Students were also eager at the beginning of the semester because they wanted to do well. Even more than the previous classes I piloted this intervention with the year before, all the students I interviewed were very clear about
their future professions and why they needed to take chemistry. This eagerness was also evident in the response to the first two lab check out papers. Somewhere around the third lab check out paper, about a month into the course, students had determined how Dr. Green awarded points in this class. Students learned what Dr. Green emphasized in the tests, quizzes, and assignment and how best to spend their time to ensure they would have the needed points.

Students learned that one lab worksheet would be handed out to the lab group. If they were present the day of the lab, they wrote the names of all the lab group members at the top of the paper and they were given credit for the lab. The lab worksheet with measurements and calculations was never handed back or discussed after the lab. In this context, the lab check out paper I was asking students to fill out, discuss, and reflect on was often more than they needed to submit for the actual lab.

In this case, the point value did not reflect actual value. When responding to agreement or disagreement with the statement, “Doing experiments in the lab is the best way to learn chemistry concepts,” students’ agreement changed from 77% before the treatment to 64% after the treatment. Of the six students I interviewed, all six told me that the lab was very important because it was hands-on, visual, and related to everyday life and very important for learning chemistry. After the treatment, three students had changed their minds about the lab. One student told me that she did her best to ignore the lab because it confused what she knew and what she knew she would be tested on. I observed her doing this during the lab period. The high achieving interviewee told me that in order to understand the lab she had to think of it only as a lab and not try to relate
it to the lecture or chemistry concepts. The incongruity as to value of the lab in comparison to its point value or graded value in the class caused students confusion. It became clear to me that this intervention was designed to support the integration of the two ways of learning in a traditional chemistry class, the lecture and the lab, must have been confusing to students grappling with value of the lab. This misalignment is similar to the grafting of a cooperative learning structure into a traditional classroom.

The use of cognitive learning strategies to integrate examples from the lab and lecture into an understanding of chemistry concepts suffered from a lack of continuity. Although Dr. Green used examples to teach concepts and students were interacting with examples of chemical reaction in the lab there was no formal instruction of how to use this strategy to learn chemistry. In the work of Puskin and Zoller (2007), concerning the development of higher order thinking skills in science, they emphasize that these cognitive skills “clearly require consistent and persistent employment of explicit pedagogical and curricular practice (p.155). Furthermore, this emphasis and explicit teaching of cognitive strategies relevant to chemistry concepts must come from the instructor. The students themselves brought this to my attention when they shifted their agreement of the statement, “I cannot learn chemistry if the teacher does not explain things well in class.” from 77% to 94% with 0% disagreement. This shows, that if students are going to learn and use cognitive strategies, participate in cooperative groups, distil what is valuable from their lab and lecture experiences, and integrate the lab and lecture to understand chemistry concepts, it must come from the instructor and his or her pedagogical design.
Throughout my presence in Dr. Green’s class, the students were confused as to my role in the classroom. My description of the research project did not seem to make sense to most of the students and they interacted with me as student teacher or an assistant teacher. Each time Dr. Green was not lecturing they wanted my help with chemistry problems. This interfered with my ability to observe students interacting with their teammates in lab. In addition to this confusion, when I attempted to correct student misconceptions by returning the lab check out paper with comments, students were not sure why I was giving them feedback if I was not their instructor. This lead me to abandon the practice because not only was it confusing to the students it was introducing an additional treatment to the research process. In the end, one of the interviewees mentioned that she really liked the feedback, even though, it only said, “You got it!” it reinforced what she already knew. Although, it was not my research question, it became clear throughout my research in Dr. Green’s class giving students frequent feedback is strongly needed.

It seems clear to me that good educational practices like cognitive learning strategy instruction, cooperative learning strategies, and integration of lab and chemistry concepts in order to develop higher order thinking skills facilitate student learning irrespective of course level. The pedagogical techniques which would be standard practice in an elementary classroom were also beneficial in a community college classroom with introductory students of chemistry. In my research, I found an article in response to a national call for increased rate of certificate and degree completion in
postsecondary education. Peter Riley Bahr (2011) responds to this call after reading much of the recent research focused community college outcomes,

Though this recent work offers sophisticated quantitative methods, the question that underlies these studies – Do community colleges help or hinder students’ attainment? – can provide comparatively little information about specific obstacles at community college that impede student progress and the appropriate interventions to improve student success.

(P.7)

From my recent experiences I agree with this writer. Community college does seem to be an important educational facility that has not benefited by recent reforms and attention to craft, quality, and content. Research is needed to understand how to support the diverse crossroads of students found at the community college.

The experience of being a researcher in a community college introduction to chemistry class has been an invaluable experience. It has greatly deepened my understanding of the necessary intentional instructional decisions a teacher of chemistry needs to make to support students not only to learn content, but to become scientific thinkers, and better learners in general. I feel like the experience has raised my professionalism as a science instructor so that I can take on any grade level or challenging content. Understanding the methods of a research and the relationship between research and instruction will forever change my teaching practice to include more accountability and depth.
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APPENDICES
APPENDIX A

PRE AND POST TREATMENT SURVEY
CHM: 122 Survey

Participation in this activity is voluntary. Participation or non-participation in this activity will not affect your grade or standing in this class in any way.

Do not write your name.

Gender – circle one

M       F

Age _____________

Reason for taking this chemistry class:

_____________________________________________________.

Have you ever taken a chemistry class before? Yes no

If yes, how many years ago did you take the previous chemistry class

__________________________

How would you describe your previous experiences with chemistry? (circle one)

Very good good neutral bad very bad

How would you describe your previous experiences with science classes in general? (circle one)

Very good good neutral bad very bad

The grade I expect to get in this class is _____________.

In the following fifteen questions rate each statement by selecting the number between 1 and 5 where the numbers mean the following:

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

Choose of the above five choices that BEST EXPRESSES YOUR FEELING about the statement. If you don’t understand the statement, leave it blank. If you have no strong opinion, choose 3.

1. I think about the chemistry I experience in everyday life.

Strongly disagree 1 2 3 4 5 strongly agree

2. Knowledge in chemistry consists of many disconnected topics.

Strongly disagree 1 2 3 4 5 strongly agree

3. I am not satisfied until I understand why something works the way it does.

Strongly disagree 1 2 3 4 5 strongly agree

4. I do not expect equations to help my understanding of the ideas in chemistry; they are just for -doing calculations.

Strongly disagree 1 2 3 4 5 strongly agree

5. Nearly everyone is capable of understanding chemistry if they work at it.

Strongly disagree 1 2 3 4 5 strongly agree
6. To understand chemistry I discuss it with friends and other students.  
Strongly disagree 1  2  3  4  5  strongly agree

7. Doing experiments in the lab is the best way to learn chemistry concepts.  
Strongly disagree 1  2  3  4  5  strongly agree

8. I feel like I understand how experiments in the lab are examples of chemistry concepts.  
Strongly disagree 1  2  3  4  5  strongly agree

9. The symbols used in chemistry are the most confusing.  
Strongly disagree 1  2  3  4  5  strongly agree

10. Using math to solve problems is the hardest part of chemistry.  
Strongly disagree 1  2  3  4  5  strongly agree

11. I enjoy the lab, but I have no idea what it means in terms of chemistry concepts.  
Strongly disagree 1  2  3  4  5  strongly agree

12. I feel like I need to talk out new ideas to best understand them.  
Strongly disagree 1  2  3  4  5  strongly agree

13. The subject of chemistry has little relation to what I experience in the real world.  
Strongly disagree 1  2  3  4  5  strongly agree

14. I like when I have other people to help solve chemistry problems.  
Strongly disagree 1  2  3  4  5  strongly agree

15. I feel like I understand chemistry concepts in lecture but the lab confuses what I think I understand.  
Strongly disagree 1  2  3  4  5  strongly agree

16. I cannot learn chemistry if the teacher does not explain things well in class.  
Strongly disagree 1  2  3  4  5  strongly agree

17. I do not usually understand why chemicals react the way they do; I what happens.  
Strongly disagree 1  2  3  4  5  strongly agree

18. When I am solving chemistry problems, I often don’t really understand what I am doing.  
Strongly disagree 1  2  3  4  5  strongly agree
APPENDIX B

PRETREATMENT, AND POST TREATMENT INTERVIEW QUESTIONS
Nontreatment, Pretreatment, and Post Treatment Interview Questions

These interview questions will be asked in person with representative students from the class. Each of six students will be asked these same questions at three separate times: Pretreatment, midtreatment, and posttreatment.

Read to students before beginning: Participation in this activity is voluntary. Participation or non-participation in this activity will not affect your grade or standing in this class in any way.

Interview questions

1. From previous experiences, or the experiences so far in Chemistry: What is the most challenging part of taking chemistry for you?

2. Do you think the lab portion of the chemistry class is important to learning chemistry and why?

3. Do you feel like you understand how the chemistry concepts in the lecture are related to the experiments in the lab? Can you give an example?

4. How do you feel in previous classes or in this class so far about working in a lab team? (positive or negative)

5. Dr. Green often uses examples when he teaches chemistry concepts, why do you think he teaches in this way?

6. If there were one thing you could change in this class to make it a better learning experience for you, what would it be?
APPENDIX C

STUDENT REFLECTION DIRECTIONS
Directions for creating the lab-group self-assessment

Reflecting on your experience working in the lab group is important for building a strong and dependable lab group. You and your lab group will create a visual rating scale with which to answer some quick questions about how it went that day. This visual rating scale will be unique to your group. You will take some time now to find 5 images that reflect different numbers in the assessment scale. Work with your lab group to find five images that you can all agree on.

Suggested ways of working:
Have each person look for one or more image to fit each number. (for example: a butterfly flying for number 5, everything is awesome.) Compile all the images each person chose and then choose an image to represent each number for the whole group.
Alternative: Have each person take one of the five levels. Think of three different possible images to embody this level and then present them to your group to decide.
Email me a document with the names of the people in your group and all five images you have chosen copied into the file. Make sure the number is next to the image and it is clear which images is for what number. shifra797@gmail.com

The rating scale goes from 1, the worst to 5, the best. This is how they might be described as it relates to the working experience of a lab group.

1. Image goes here
   The worst. Some serious improvement need to be made.

2. Image goes here
   Slightly better than the worst. I am still concerned.

3. Image goes here
   Average. We did ok.

4. Image goes here
   Better than average. I am feeling pretty good about what we have Accomplished.

5. Image goes here
   The best! Awesome! I love my lab group. I could love chemistry!
APPENDIX D

EXAMPLES OF LAB GROUPS VISUAL LIKERT SCALE
Lab Group A

1. I did my part to prepare my team for the lab._____
2. I helped my team._____
3. Listened to the ideas of my team members._____
4. Shared my ideas with my team members._____
5. I felt important to the team._____
6. I felt like I contributed how the experiment we did allows chemistry concepts we are learning._____

In your own words:_____

Lab Group B

1. I did my part to prepare my team for the lab._____
2. I helped my team._____
3. Listened to the ideas of my team members._____
4. Shared my ideas with my team members._____
5. I felt important to the team._____
6. I felt like I contributed how the experiment we did allows chemistry concepts we are learning._____

In your own words:_____

Lab Group C

1. I did my part to prepare my team for the lab._____
2. I helped my team._____
3. Listened to the ideas of my team members._____
4. Shared my ideas with my team members._____
5. I felt important to the team._____
6. I felt like I contributed how the experiment we did allows chemistry concepts we are learning._____

In your own words:_____

The best! Awesome! I love my lab group! I can't wait to do more experiments!
Lab Group D

1. I did my part to prep my team for the lab. [ ]
2. I helped my team. [ ]
3. I listened to the ideas of my teammates. [ ]
4. I followed my team's instructions. [ ]
5. I felt like I understood how the experiment we did showed chemistry concepts we are learning. [ ]

In your own words:

Lab Group E

1. I did my part to prep my team for the lab. [ ]
2. I helped my team. [ ]
3. I listened to the ideas of my teammates. [ ]
4. I followed my team's instructions. [ ]
5. I felt like I understood how the experiment we did showed chemistry concepts we are learning. [ ]

In your own words:

Lab Group F

1. I did my part to prep my team for the lab. [ ]
2. I helped my team. [ ]
3. I listened to the ideas of my teammates. [ ]
4. I followed my team's instructions. [ ]
5. I felt like I understood how the experiment we did showed chemistry concepts we are learning. [ ]

In your own words:
APPENDIX E

DESCRIPTION OF LAB ROLES IN COOPERATIVE GROUP
Role descriptions for lab groups:
Please read and discuss these roles with your lab group. Discuss your member’s strengths and weakness in order to find the best role for each member. Each of these roles requires you to download and read the lab before coming to class. Each role has a different focus. You might have to look up information on the internet or textbook in order to complete your role for your group. When each member does a little bit more to prepare for the lab, the entire group can have a deeper experience learning chemistry in the lab.

1) Background information person: This person will read the lab carefully and define any terminology that is new or necessary to know to do this lab. This person helps the group to understand how this lab is relevant to the concepts being discussed in the lecture.
   Name ______________________________________

2) Materials person: This person is responsible for getting and returning any materials that are needed for this lab. This person tells the rest of the group about new or special instruments that are used in the lab.
   Name ______________________________________

3) Procedure person: This person is the expert in terms of the sequence of running the experiment or test. This person will make sure everyone in the group takes a measurement or an observation when it is needed.
   Name ______________________________________

4) Summarizer: This person will be responsible for the end of the lab calculation. This person will know how to do these calculations and help the rest of the group to make these calculations. This person will also make sure the group answered any questions that the group will need answer at the end of the lab.
   Name ______________________________________
APPENDIX F

LAB CHECK OUT PAPER NUMBER ONE
Before you turn in the lab, discuss these questions with your lab group and then answer the question individually. Secondly, flip the paper over, circle your name, and fill out the lab reflection. Participation in this exercise is not graded or reflected in your grade in any way. Thank you for your participation!

1) Find on your own:
Name a cation that created a precipitate __________________________

What anion did this cation join to create this precipitate? _____________

What do you think this precipitate might be called? (in words or symbols)
__________________________________________________________________

2) Discuss with your group:
Explain how these elements become cations with a charge of 1+ or 2+ or 3+. Use as much detail as possible in your descriptions.
APPENDIX G

LAB CHECK OUT NUMBER TWO
Before you turn in the lab, discuss the questions below with your lab group and then answer the question individually. Secondly, flip over the paper, circle your name, and fill out the lab reflection using the Likert number scale. You will not be graded or evaluated on your responses in any way. Thank you for your participation.

What ratio does Magnesium have to oxygen in the compound MgO, you just created in the lab?

Why does the compound MgO have to have this formula and this ratio ALWAYS? Explain.
APPENDIX H

LAB CHECK OUT PAPER NUMBER THREE
Please discuss these questions with your group and then answer individually. You are in no way graded for your participation in this research. Thank you for your participation.

1) What are moles?

2) In last week’s lab Chemical compounds and formulas you saw experimentally how magnesium and oxygen combine in a specific ratio proving that chemical compounds are neutral. In this week’s lab, you saw how anhydrous salt combines with a certain amount of water to create hydrated salts. How does this show the concept of chemical combining quantities?
APPENDIX I

LAB CHECK OUT PAPER NUMBER FOUR
Lab check-out #4

Please discuss the following question with your lab group and then answer the question in your own words below. Then complete the lab reflection on the other side. Again you are not graded on this in anyway. Thank you for your participation.

In laboratory activity 8, you mixed solutions of calcium chloride and sodium phosphate and you saw a solid precipitate form:

\[ \text{CaCl}_2_{(aq)} + \text{Na}_3\text{PO}_4_{(aq)} \rightarrow \text{Ca}_3(\text{PO}_4)_2_{(s)} + \text{NaCl}_{(aq)} \text{(not balanced)} \]

When a soluble ionic compound is in an aqueous solution (aq), water becomes the medium for the compound. Even though water is essential for the reaction to occur, it does not actually bond to the ions in solution. Polar water surrounds and separates the Ca\(^{2+}\) and the Cl\(^{-}\) in one solution and the Na\(^{+}\) and the PO\(_4^{3-}\) in the other solution. When these solutions are put together what is the one and only precipitate that could form?

Ppt. __________________

Explain why this is the only possible combination of the ions that would form a chunk of an insoluble solid (s).
APPENDIX J

LAB CHECK OUT PAPER NUMBER FIVE
Check-out paper for laboratory Activity 8 – Recovery of a substance by Filtration #5

Discuss these questions as a group and then answer individually. On the other side, fill out the lab group reflection for the last time. In the section that says in your own words, answer the question, “How did the check-out papers after the lab help me and my lab group?” In your opinion what was their value? You are not graded on this in any way. Thank you for your participation. I will see you after the break to finish interviews and give a survey and then again after two weeks to see how well you remembered the material you discussed with your lab group. Have a wonderful break! Shifra

Today, you are weighing a precipitate and doing calculations. What did you do last week to get this precipitate? (Literally)

This is a more open ended question:

How does the chemical equation represent what you did in the lab?
APPENDIX K

LECTURE CHECK OUT PAPER EXAMPLE
Lecture Check-out paper #1

This task is made up of two parts. First find examples from your notes or the text book and write them down in the space below. Part two is to use these examples to discuss the question below with your lab group and then answer the question individually. You will not be graded on your response but your participation is greatly appreciated.

The atoms in this compound are held together with **ionic bonds**.

The atoms in this compound are held together with **covalent bonds**.

You have heard Dr. Green talk about the octet rule many times. Sometimes he describes an ion or an atom in a covalent compound as being a “noble gas want-a-be” or being isoelectric with a noble gas. All three expressions describe the same phenomena at the molecular level in chemistry. How do ionic and covalent bonds satisfy the octet rule differently? After discussing this with your group, use the space below to draw or write your answer to this question.
APPENDIX L

RESEARCH TIMELINE
Timeline for research in Dr. Green’s Introduction to General Chemistry Class at SCC Spring Semester – January to March 2015

Nontreatment lectures:
Week 1:
Unit: Units of measurement and SI
Introduce myself and my research
Survey all students, interview 6 specific students
Observe lecture and lab
Week 2:
Observe lecture and lab
During last lecture and lab in this unit introduce cooperative groups and give groups first tasks: conversation, design self-assessment page, and chose roles.

Treatment lectures:
2nd Unit: Atomic Structures and the periodic table
Week 1
Monday – lecture: Intro to P, E, N Building the atom H to O s, p, d orbitals, observe lecture
Wednesday – lecture: chemical activity, properties, isoelectric, representative elements, decoding the periodic table, noble gas “wanta- bes”. Individual/group check- out work
Wednesday lab – Flame testing lab check out #1
Week 2
Monday – lecture formation of compounds feedback to address misconceptions, observe lecture
Wednesday – lecture 9 basic compound formulas
Wednesday lab – analysis of cations Lab check out #2
TEST 1 on unit 1 and 2

3rd Unit: Chemical compounds – Ionic and Covalent bonds
Week 1
Monday lecture – ionic compounds charge, salts lecture
Wednesday lecture – formation of a compound
Wednesday lab – Magnesium oxide formation of a compound
Lab check out #3 observe students

Week 2
Monday lecture – Covalent and polyatomic ions lecture check #1
Wednesday lecture – representative compounds, Lewis structures individual/group check- out work, observe students
Wednesday lab – Hydration of salts
Lab check out #4
Week 3
Monday lecture – balancing an equation lecture check out #2
Wednesday lecture – continue balancing an equation
Wednesday Lab – finish hydration of salts lab check out #5

Survey all students
Wednesday March 23 test II on units 3 and 4
Interview same 6 students
APPENDIX M

INSTITUTIONAL REVIEW BOARD DOCUMENT

MONTANA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 0000165

MEMORANDUM

TO: Suzanne Shifra Gassner and Eric Brunsell

FROM: Mark Quinn, Chair

DATE: November 14, 2014

RE: “Supporting the Integration of Concepts: The Effects of Cooperative Learning and Cognitive Learning Strategies on Students’ Understanding of Community College Chemistry Concepts” [SSG111414-EX]

The above research, described in your submission of November 14, 2014, 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) (5) 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.
APPENDIX N

INSTITUTIONAL REVIEW BOARD DOCUMENT FROM

EASTERN IOWA COMMUNITY COLLEGE
Hello Suzanne

Thank you for your careful application and preparation of materials sent to the EICC Institutional Research Board to request approval to conduct research at EICC.

The EICC Institutional Research Board has met and considered your application. You are granted approval to conduct your research at SCC.

Several members of the committee expressed a desire to see your final research paper once your project is completed. I would respectfully ask that you share it with us.

Please contact me if you have any question, or if I can be of help to you as you pursue your research.

Laurie

Laurie R. Hanson
Dean of Curriculum
Eastern Iowa Community Colleges
326 West Third Street
Davenport, IA 52801

Phone: 563-336-3351
Fax: 563-336-5239
Email: lhanson@eicc.edu

"Quality is never an accident; it is always the result of high intention, sincere effort, intelligent direction and skillful execution; it represents the wise choice of many alternatives."  - Willa A. Foster

----- Original Message ----- 
From: Gassner, Suzanne S [CO PD] <sgassner@iastate.edu>
Sent: Sunday, November 16, 2014 11:34 PM
To: Hanson, Laurie
Cc: shfira797@gmail.com
Subject: Application for IRB