

THE EFFECTS OF USING COOPERATIVE LEARNING STRUCTURES IN A HIGH  
SCHOOL CHEMISTRY CLASSROOM

by

Mary Cecilia Ragusa

A professional paper submitted in partial fulfillment  
of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY

Bozeman, Montana

July 2013

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.

Mary Cecilia Ragusa

July 2013

TABLE OF CONTENTS

INTRODUCTION AND BACKGROUND .....1

CONCEPTUAL FRAMEWORK.....3

METHODOLOGY .....8

DATA AND ANALYSIS .....13

INTERPRETATION AND CONCLUSION .....22

VALUE.....24

REFERENCES CITED.....27

APPENDICES .....28

    APPENDIX A: Student Interview Questions .....29

    APPENDIX B: Cooperative Learning Attitude Survey .....31

    APPENDIX C: Shortened Time-on-Task Log .....34

    APPENDIX D: Regular Time-on-Task Log .....36

    APPENDIX E: Student Artifacts .....38

LIST OF TABLES

1. Data Collection Techniques .....	13
2. Unit Test Averaged Scores .....	20
3. Final Exam Averaged Scores .....	21

LIST OF FIGURES

1. Student Pre/Post-feelings Towards Engagement During Structures .....	14
2. Approximate Percentage of Student Engagement During Outside Observations .....	16
3. Student Pre/Post-feelings Towards Learning During Structures .....	20
4. Student Learning From Round Robin Group Artifact .....	22

## ABSTRACT

The problem in this action research was poor student engagement in the classroom. This study analyzed the effects of utilizing specific cooperative learning structures on the engagement of students in a chemistry-accelerated classroom. It was found that student engagement was increased in the classroom with the use of varied cooperative learning structures during a treatment period of four months. Students enjoyed the use of varied structures in the classroom.

## INTRODUCTION AND BACKGROUND

Over the past three years, I have taught sophomore level chemistry-accelerated at Stevenson High School in Lincolnshire, Illinois, which is a northern suburb of Chicago. When I started teaching at Stevenson, the school held roughly 4,600 students in grades 9 to 12. During the 2012-2013 school year, about 4,000 students enrolled at Stevenson (Adlai E. Stevenson, n.d.). The students from this school come from a wide variety of cultural backgrounds and many students speak multiple languages fluently including Russian, Indian, Korean, and Hebrew. Many students were born in, or have parents who were born in, Russia, India, Korea, and Israel.

To be placed in the chemistry-accelerated course, the students need to score well on an entrance math exam. During the first semester of the course, the students learn about concepts involving density, solubility, chemical equations, stoichiometry and gases. There are few behavioral concerns in the classroom and in general, the students are college-bound and are driven to succeed. For the 2011-2012 school year, it was reported that 98% of all students who graduated from Stevenson attended college the following year (Adlai E. Stevenson, n.d.). Stevenson High School's main objective is success for every student. The school continually strives to achieve this by focusing on critical thinking, social-emotional learning and collaborative learning. Collaborative learning has become a new focus of the school, and teacher professional development has been available for teachers to learn more about this topic. In the fall of 2011 I attended a workshop about Kagan Cooperative Learning structures. I learned many new ideas from

this workshop including specific learning structures that can be used in the classroom to improve student engagement. This led me to many questions about my chemistry class and the amount of student engagement in my classroom. I felt that my teaching was too focused on me and not directed enough on the students. The same students always raised their hand to answer questions and many students were not highly engaged throughout the lesson.

This questioning led me to interview students in my chemistry-accelerated course. My students were asked questions about their initial thoughts regarding learning in a collaborative environment (Appendix A). Through the interview process, benefits and drawbacks of learning in a collaborative environment were found. In terms of the benefits, the main themes that were stated by students included being able to get help from other peers, being able to socialize with other students during class, being able to meet new people, sharing the learning, and improving upon teamwork and communication skills. The main drawbacks of learning in collaborative groups involved distractions from other group members, work between group members being uneven, students in the group rushing ahead or slowing other group members down and trying to solve problems when no one in the group knows the answer.

The purpose of this study was to find the effect of using cooperative learning structures on the student engagement in my chemistry-accelerated classroom. I believed that if I could increase student engagement, then I could increase the general student attitudes and overall learning. These sub questions were addressed:

1. Does the use of cooperative learning structures increase student learning?



2. Does the use of cooperative learning structures increase overall student attitudes towards their chemistry-accelerated class?

## CONCEPTUAL FRAMEWORK

There are three main types of interactions between students as they learn. These interactions include competitive, individual, and cooperative interactions. The first includes students seeing the learning process from a competitive standpoint where some students are winners and others are losers. Individualistic learning requires students to learn on their own terms. Their successes and failures are not dependent upon other students. The last situation, called cooperative learning, involves students working in small groups towards a common learning goal. The students are structured so that each student is helping and guiding other group members in the learning process (Johnson & Johnson, 1999).

Cooperative learning structures seek to provide higher student engagement in the classroom. Cooperative learning is not just placing students together in small groups. Small-group instruction in the loosest sense is physically arranging students in groups as instruction proceeds. However, a stricter sense of small group instruction refers to using specific instructional strategies while students are placed into small groups for learning (Abrami, Lou, Chambers, Poulsen, & Spence, 2000). Cooperative learning would lean toward a stricter sense. Cooperative learning is more than just group work. It is structured to maximize learning and communication within the group (Kagan & Kagan,

2009). A cooperative learning group is also seen as a group that works together to accomplish a common learning goal and regularly checks for progress and performance toward a learning goal. The ultimate outcome is that everyone in the group will gain in academic performance (Johnson & Johnson, 1999).

There are five elements that distinguish cooperative learning from other strategies. These five elements include: positive interdependence, face-to-face promotive interaction, individual and group accountability, interpersonal and small group skills, and group processing. Positive interdependence refers to the sense of the group succeeding or failing together. Face-to-face promotive interaction requires students to help each other learn as well as to applaud success and effort of their team members. The individual and group accountability measure indicates the importance of each group member making contributions to the team. Interpersonal and small group skills require communication, trust and team building. Finally, group processing is referred to as groups reflecting on their progress toward a common goal (Marzano, Pickering & Pollock, 2001).

The five elements of cooperative learning would never be possible without certain planning and teacher techniques. The teacher role in cooperative learning is different from other methods of instruction. The teacher role becomes that of a coach and mentor to whom students can go for assistance (Kagan & Kagan, 2009). In order to promote cooperative learning, the teacher needs to clearly describe the assignment and the strategies used for the group to complete the learning goal. The teacher also needs to clearly define the role for each student within the group. As the lesson progresses, the

role of the teacher is to monitor the groups' learning and to intervene when necessary (Johnson & Johnson, 1999).

As an instructor is planning a lesson that involves cooperative learning, the instructor also needs to consider the size of the cooperative learning groups. Group sizes should be based upon the amount of resources needed to complete an activity (Johnson & Johnson, 1988). The smaller the amount of resources needed, the smaller the cooperative groups need to be. The most effective teams consist of three to four members (Marzano et al., 2001).

How the groups are formed is also important to consider. In order to create student groups, unit test scores are analyzed from the beginning of the year. Homogeneous groups are groups that contain students with similar learning abilities while heterogeneous groups contain students with differing levels of learning ability. Homogeneous ability grouping was found to give middle ability students the most student achievement gains, while heterogeneous grouping was found to give low ability students the most achievement gains. However, in their earlier research, Lou and colleagues (1996) had found that heterogeneous grouping is more successful for low, medium and high ability students. Their research indicated that homogeneous grouping was not favored for low ability students. A heterogeneous group of four students would contain a low, low-medium, medium-high, and high ability student in each group (Kagan & Kagan, 2009).

There are many examples of cooperative learning structures that aim to promote active engagement and learning for all students in small groups. One example of a

cooperative learning structure is called *timed-pair-share*. In this structure, the teacher explains to the class a specific question or topic, announces how long each student will share their response, and provides time for each student to think about their response. The first student uses the allotted time to explain their response to their partner. The other partner will respond with positive feedback before they switch roles (Kagan & Kagan, 2009).

Another example of a cooperative learning structure involves movement. *Quiz-quiz-trade* is a structure that requires the teacher to create a set of question/answer cards for the class. Each student receives a question/answer card. The students are first directed to stand up and put their hand up in the air to find another student with their hand raised. As soon as they find a partner, they read the question on their card to each other and try to solve the question they were given by their partner. Both partners help one another by providing feedback for the answers given. Before they leave to find a new partner, they offer positive support and switch cards. This continues for an allotted amount of time (Kagan & Kagan, 2009).

Cooperative learning structures can also involve groups of three or more. One example of such a structure is called *all write round robin*. In this type of structure the teacher announces a given question that could contain multiple responses and provides think time for the students to write down their ideas on their own paper. Each student in turn explains what he or she wrote down, while the other group members listen and add their group's thoughts to their own sheet of paper. This structure aims to promote active listening and extension through new ideas (Kagan & Kagan, 2009).

According to Kagan and Kagan (2009): “Hundreds of lab and field research studies demonstrate that cooperative learning has a positive impact on classroom climate, student self-esteem, empathy, internal locus of control, role-taking abilities, time on task, attendance, acceptance of mainstreamed students, and liking for learning” (p. 32). When students were placed into small groups during instruction, statistical differences were found between students that were grouped and students that were not grouped. These differences were seen for both student attitudes toward a subject as well as student achievement. In-class grouping was shown as successful toward student attitudes (Abrami et al., 2000).

The effects of using cooperative learning on student performance at the college level in a communications course found statistically significant increases for individual test scores, group test scores and final test scores. The 24 students who participated used cooperative learning for a group research project (Tsay & Brady, 2010).

Cooperative learning was also found to be effective in an eighth grade science class from Denizli, Turkey ( $N = 68$ ). One group was taught using cooperative learning strategies and another group was taught using direct instruction for a unit on reproduction of organisms. When assessed for student achievement there was no significant difference in pre-assessment scores between the two groups; however there was a significant difference between the two groups for the post achievement test ( $p < 0.05$ ). The students’ attitudes toward science were also assessed, and there was no significant difference in the pre-attitude test between the two groups. However, the results demonstrated that

cooperative learning was statistically more effective for general attitudes toward science in the post-attitude test (Kose, Sahin, Ergun, & Gezer, 2010).

Other studies have discussed areas of concern for teachers using cooperative learning. Teachers may fear that poor student behavior can negatively impact the functionality of the group (Lin, 2006). To decrease the likelihood of these occurrences, the instructor is encouraged to form heterogeneous-ability groups, to encourage students to recognize problems as the entire group's problems, and to model desired language or group behavior for a particular structure. Also, if students are able to rate their performance and their group members' performance, this can help with some of the concerns. Allowing *think time* for students who are shy or who tend to not participate is suggested as well as breaking the curriculum into small parts to promote active engagement and success at each part of the learning process (Kagan & Kagan, 2009).

Cooperative learning in the classroom has the potential to change any classroom environment. It involves active participation from each student in the classroom through guided structure from the teacher. The benefits of cooperative learning can be vast when implemented properly. If used correctly, student engagement and student learning can drastically increase in any classroom.

## METHODOLOGY

During the treatment period, students were introduced to various types of cooperative learning structures. For each new learning structure, the teacher introduced

the structure by describing and modeling the structure for the students. The role for each student was addressed, and the teacher used various tools such as number charts and timers to encourage equal participation between members of the groups. For example, one cooperative learning structure used in the classroom was called *rally coach*. This structure was used was to help students practice balancing equations. Each pair of students was given one set of practice problems and one pencil. As one student (the coach) described step-by-step how to balance the equation, their partner wrote down what the coach was stating and asked them questions for clarification as they worked through the problem. For each problem students were asked to switch roles. Student engagement data were collected through a teacher journal of the activity and student artifacts from the activity. The student artifacts were also analyzed for student learning during the cooperative learning structure. 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 treatment period was four months long and was conducted in a chemistry-accelerated class. The class consisted mainly of sophomore students with a handful of freshman and junior students ( $N = 72$ ). Students were seated in groups of four at the beginning of the year and groups changed to heterogeneous-ability groups by the end of the first six-week term. The heterogeneous-ability grouping was formed based upon unit test scores from the chemistry-accelerated class during the first six-week term. Each group of students contained a high, medium-high, medium-low and lower level student based upon scores from previous unit exams.

Data during the treatment period were focused on finding general student attitudes towards using cooperative learning strategies, the effects of using these strategies on student engagement and the effect of these strategies on student learning. A teacher journal was used throughout the treatment period to track each of the various cooperative learning strategies used, how the students interacted with each other during the strategies, and general notes and thoughts of making each learning strategy better.

Student attitudes were measured by the Student Interview Questions at the beginning and the end of the treatment period (Appendix A). A total of 12 students were asked questions regarding their attitudes toward using cooperative learning structures in the classroom and how using cooperative learning structures affects their learning in the class. They were also asked questions regarding how the teacher could make cooperative learning most effective in the classroom. Responses from each question were recorded on paper and were analyzed by grouping similar responses together. Percentage of themes seen for each interview question was recorded as well as outliers.

The Cooperative Learning Attitude Survey was administered to students at the beginning of the treatment period just after the class had used and practiced their first type of cooperative learning structure (Appendix B). The main objective of the survey was to gain information about whether they have used cooperative learning strategies in the past and how well they like to work collaboratively with other students while learning in class. The Cooperative Learning Attitude Survey was also given at the end of the treatment period to see if there was any change in attitudes towards working in cooperative groups and to gain perspective from the students on their engagement during



the structures. A rating scale from *strongly disagree* to *strongly agree* was included in the survey to track changes in attitude. Each rating was given a numerical value from one to five where a value of one was represented by *strongly disagree*, two was *disagree*, and so on. The mean and mode for each question was calculated in order to look for trends in the survey.

Data for student engagement in the classroom were mainly from teacher journals and field notes from an outside observer. The outside observers were administrators and other science teachers at the school. The cooperative learning structures that were observed for less than 10 minutes were tracked for student engagement using the Shortened Time-on Task-Log (Appendix C). The observer moved throughout the room and spent 10-20 seconds observing each student. Each student was marked “E” for *engaged* or “NE” for *not engaged* during that time frame. Engaged students could have been speaking, writing, listening, or asking questions about the task at hand. Non-engaged students may have either been off-task, copying or not focused. Student engagement was analyzed by the percentage of students marked as engaged or not engaged during the structure.

For structures observed for more than 10 minutes, student engagement was tracked using the Regular Time-on-Task Log (Appendix D). The main difference in the regular Time-on Task Log from the shortened version is that student comments and what they were actually doing to be marked as *engaged* or *not engaged* was recorded. Some observers spent five minutes with each group of students and recorded what was said, what was being done and what questions were asked by specific students. Others spent

time frames of about 30 seconds per student and marked E or NE with a small description of what the student had done or said. For each observation, an approximate percentage of time on task was calculated for each student within a particular group to analyze student engagement. This percentage came from both the data percentages of the outside observer as well as the teacher journal notes that were written after the lesson.

Student learning was measured from average student scores on the chemistry-accelerated final exam and chemistry-accelerated unit tests. When analyzing results from the final exam, only average scores from the chemical reactions, stoichiometry, gases and atomic structure units from 2010 and 2011 were compared to the current treatment year's results. The average scores for the chemical reactions, stoichiometry, gases and atomic structure unit tests were also compared from the previous two years to the current treatment year. However, because so many factors could have been present to alter test scores throughout the year, student learning was also measured by examining specific student artifacts. These artifacts came directly from the cooperative learning structure and were a handwritten form of what they had learned and accomplished during the structure. For example, the *round robin* Group Artifact was analyzed for group accuracy for completing a balanced chemical equation with correct formulas (Appendix E). The following matrix summarizes the data collection techniques that were used to address the research questions involved (Table 1).

Table 1  
*Data Collection Techniques*

Research Questions	Data Source #1	Data Source #2	Data Source #3
How do cooperative learning strategies affect student engagement in the classroom?	Outside Observer Notes: Time-On-Task Sheet	Cooperative Learning Attitude Survey	Teacher Observations/Journal
How do cooperative learning strategies affect student attitudes in the classroom?	Cooperative Learning Attitude Survey	Student Interview Questions	Teacher Observations/Journal
How do cooperative learning strategies affect student learning?	Chemistry-Accelerated Final Scores (past 2 years and current)	Chemistry-Accelerated Unit Test Scores (past 2 years and current)	Student Artifacts: Cooperative Learning Structure Handouts

## DATA AND ANALYSIS

According to the Cooperative Learning Attitude Survey, the number of students who *strongly agreed* that cooperative learning techniques helped to keep them engaged in the classroom increased from 17% to 26% from the beginning to the end of the treatment period ( $N = 72$ ). The amount of students who *agreed* also increased from 40% to 44% (Figure 1).

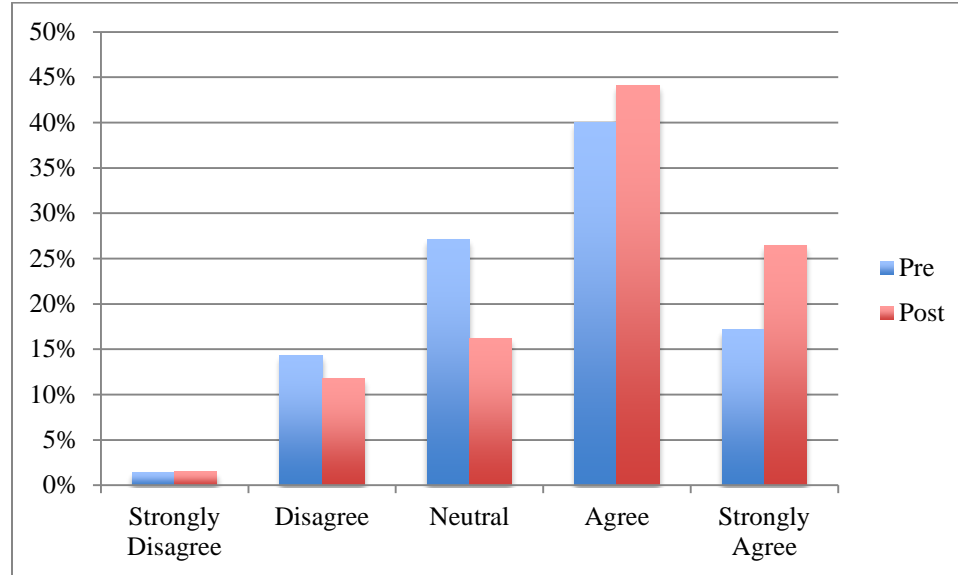


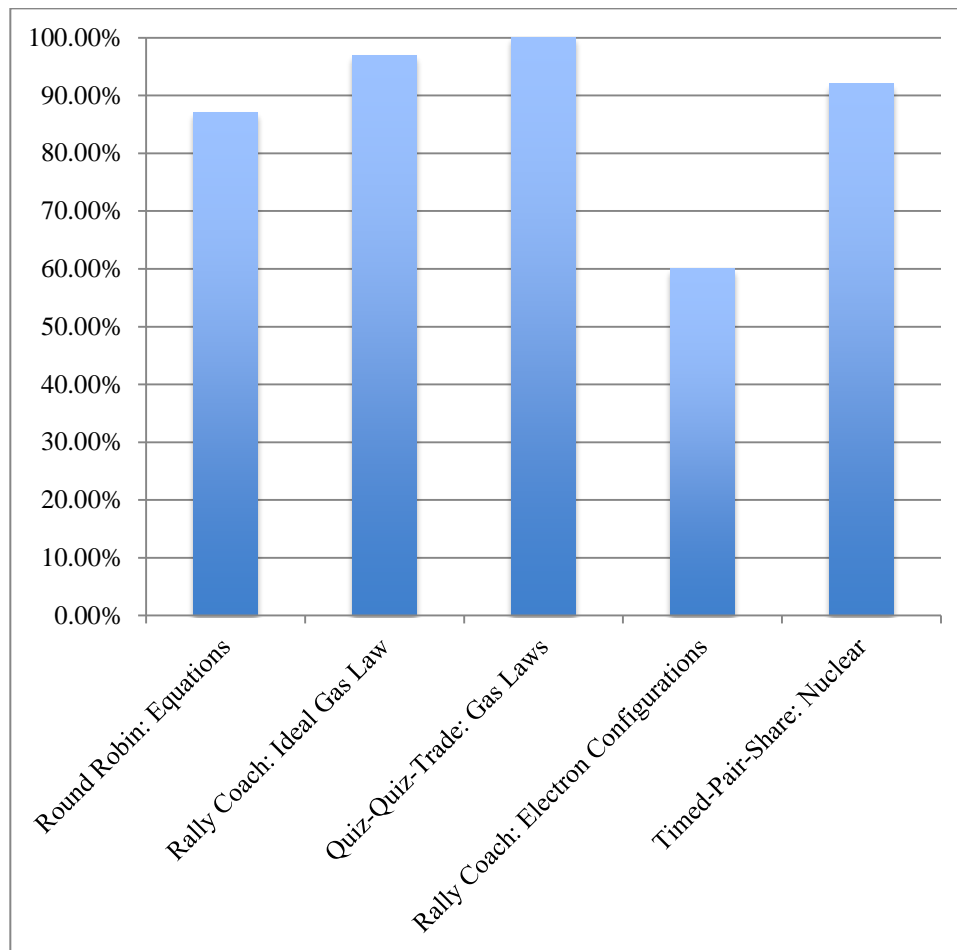
Figure 1. Student pre/post-feelings towards engagement during structures, ( $N = 72$ ).

During the *round robin* cooperative learning structure for equation writing, 87% of students were engaged for 100% of the time they were observed ( $n = 16$ ). Each group was observed for five minutes during the *round robin* structure and each group contained four students per group. One of the observed groups contained students who were off-task during the five-minute observation period. This group contained four students who were engaged when the teacher was at that particular group with guiding questions. When the teacher was not at that specific group, two of the students were writing down the equations and working through problems and the other two students were talking about things unrelated to the task. Every other group consisted of four members who were following the directions for the activity and consisted of students who were writing, passing the group page, checking answers, erasing, correcting other students, answering teacher questions, asking questions to their group members and listening.

Outside observation notes during a *rally coach* structure for gas laws demonstrated that approximately 97% of the students were engaged during the structure that lasted twenty minutes. Students were talking back and forth with one another, working diligently, asking questions and showing excitement after finishing a problem. A few students were seen giving one another a high five. Each pair of students was observed to have a sustained communicative pattern back and forth as they solved difficult gas law problems. These problems required multiple steps and higher levels of critical thinking. They were seen trading roles and working through each problem step-by-step. Observation notes were also taken for a *quiz-quiz-trade* structure and this structure represented 100% engagement for all students during the ten minutes for which it was used. Students traded question cards and found new partners as they moved throughout the lab area during this structure. The observation notes indicated that the students immediately got right to work and continuously found new partners to work with as they continued to exchange question cards during the activity.

During a *rally coach* warm-up structure that involved writing electron configurations, 60% of students were reported as *engaged* during the structure ( $n = 24$ ). During this particular activity, engagement was increased when the teacher made an announcement to class re-stating the instructions and what the expectations were for the rally coach activity. Unengaged students were typically talking about another topic instead of writing down the configurations. During a *timed-pair-share* structure about nuclear chemistry, 92% of the students were *engaged* and 8% of the students were marked as *not engaged*. To be engaged, the students needed to be talking about their

given question for the full allotted amount of time given by the teacher at the beginning of the structure. The approximate overall percentage of student engagement during all of the outside observations was compared (Figure 2).



*Figure 2.* Approximate percentage of student engagement during outside observations, ( $N = 24$ ).

From the teacher journal notes, the students were observed to be most engaged when new structures were introduced for the first time. The overall engagement from the class increased with the use of the structures, but the best structures came from modeling the structures for the students. Also, stating clear expectations for the students during a structure was seen as helpful to keeping the students engaged. Towards the end of the

treatment period, the journal notes indicated that the students were more likely to ask their team members a question when they were confused rather than going straight to the teacher. The overall communication between students increased throughout the treatment period.

Exit tickets were also analyzed for the cooperative group work done in class with equation writing ( $N = 72$ ). When asked what things they would like to see regarding group work in the future, 56% of students stated they would like to see the same type of group activities done in the future. These students did not mention any way for improvement of the group activity. One student stated, "The activity today helped me because when I got stuck, my partners helped me out. I would like to see more of it because four brains are better than one, even mine!" Sixteen percent of the students thought that their partners did not go through problems step-by-step and these students thought it would be better to explain explicitly to students about how to respond to others when a group member is confused. As one student noted, "I would have liked my group to be able to explain step-by-step to me a problem that I was confused on. As soon as they got the problem they moved on and I felt rushed when trying to understand." Another 12% of students would like to see more cooperative group work in the future, but added that they would like the student groups to continually switch members. Finally, the last 16% of students stated comments that did not fit in a general theme. For example one student stated, "I would like more time with the group activities." Another student responded, "I would rather work in pairs because I think I can get more done in the same amount of time."

According to the Cooperative Learning Attitude Survey, 67% of the students *agreed* or *strongly agreed* that they liked using cooperative learning structures in the classroom at the beginning of the treatment period as compared to 72% at the end of the treatment period ( $N = 72$ ). When asked if they felt that cooperative learning strategies were overused in the school, 45% of students *disagreed* and 42% of students felt *neutral*. According to the initial Student Interview Question responses, 72% of students preferred sitting in groups of four during chemistry class ( $n = 11$ ). When asked about why they preferred this, 75% of the students stated that it is more helpful to work with other people because they can get help and feedback from other classmates ( $n = 6$ ). One student stated, “Groups of four is helpful because the teacher can’t always get around to everyone. You can ask other people for help.” Another student stated, “You have a wider variety of people to ask for help from. It’s like more resources.” In terms of the benefits of collaborative learning, the main themes that were stated by students included being able to get help from other peers, being able to socialize with other students during class, being able to meet new people, sharing the learning and improving upon teamwork and communication skills. As one student stated, “One person might be goofing off, but chances are that not everyone is goofing off. So there are more chances of other people being able to help you.” The main drawbacks of learning in collaborative groups involved distractions from other group members, work between group members being uneven, students in the group rushing ahead or slowing other group members down, and trying to solve problems when no one in the group knows the answer. As plainly stated by one student, “Sometimes you get that rotten egg in the group that distracts other



students. They might try to work ahead, or they slow everyone down or they just don't care about what we are doing.”

After the treatment period, the main themes for the benefits of working in a collaborative setting were very similar. The main idea shared by 58% of the interviewed students was that the best part about learning collaboratively is that the learning is shared ( $n = 12$ ). As one student stated:

I don't have to just go to the teacher every time I need help. My classmates turned out to be very helpful. If I missed something in class, typically at least one or two of my team members were able to explain it to me.

The main drawback explained at the end of the treatment period were students not knowing for sure if their group was heading in the right direction. As one student explained, “because we worked in teams, we either were all correct or we were all wrong. When we were corrected it felt like we had to start all over again and fix everything.”

According to the Cooperative Learning Attitude Survey, given to the students after their first cooperative learning structure was used, 58% of the students *agreed* or *strongly agreed* that cooperative learning techniques help their learning of chemistry concepts in the classroom and 44% of students felt *neutral* with regard to how these techniques help their learning ( $N = 72$ ). After the treatment, 66% of students *agreed* or *strongly agreed* that the structures improved their learning while 25% of students remained neutral (Figure 3).

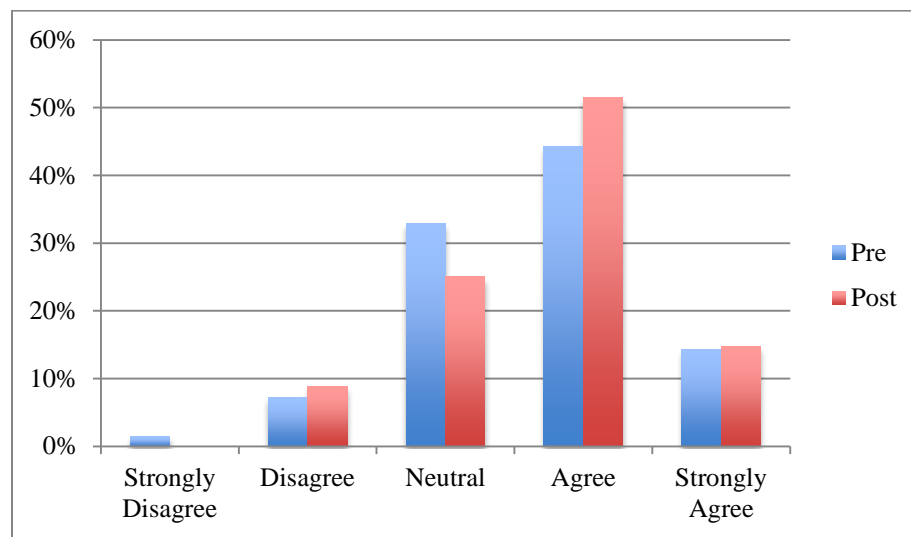


Figure 3. Student pre/post-feelings towards learning during structures, ( $N = 72$ ).

Unit test scores during the units for the treatment period demonstrated no drastic increase or decrease in student learning from 2010 to 2013. Averaged scores from the chemical reactions, stoichiometry and gases unit all changed less than 1% from 2010 to 2013 ( $N = 72$ ). Averaged scores from the atomic structure unit test increased slightly from an 85% to an 89% over the past year. The following table summarizes the unit test scores for the chemical reactions, stoichiometry, gases and atomic structure units (Table 2).

Table 2  
*Unit Test Averaged Scores*

Year	Chemical Reactions	Stoichiometry	Gases	Atomic Structure
2010-2011	86%	83%	78%	86%
2011-2012	86%	83%	78%	85%
2012-2013	85%	82%	77%	89%

Unit Final Exam Data from 2010 to 2013 demonstrated a slight decrease in student learning for two of the units covered during the treatment period. The

stoichiometry unit fell from 83% to 81% and the gases unit fell from 83% to 80% from the current year to the previous year ( $N = 72$ ). Final scores for the chemical reactions and atomic structure units demonstrated a slight increase in learning from 2011-2013.

Student averages increased from an 87% to an 88% on the chemical reactions portion and from a 90% to 91% on the atomic structure portion. Nuclear was a new unit introduced just this year and the students averaged a 94% on the nuclear portion of the final. The following table summarizes the unit final scores for the chemical reactions, stoichiometry, gases and atomic structure units (Table 3).

Table 3  
*Final Exam Averaged Scores*

Year	Chemical Reactions	Stoichiometry	Gases	Atomic Structure
2010-2011	89%	81%	84%	90%
2011-2012	87%	83%	83%	90%
2012-2013	88%	81%	80%	91%

Student artifacts from the *round robin* cooperative learning structure were graded for student learning and found that 84% of the chemical equations were correct ( $n = 39$ ). Six group pages from this activity were analyzed and the average number of full chemical equations that were written and balanced by any particular group was six and a half chemical reactions. The group that finished the most equations contained nine fully balanced equations on the group task sheet. Two of the six groups received a score of 100%. Two receive full points for a problem students needed to have successfully predicted the products, named the type of reaction, wrote down the formulas and balanced their equations. Two other groups got more than 80% of their chemical

equations fully correct and the last two groups were less than 75% fully correct (Figure 4).

The most common mistake came from writing the chemical formulas for the reactants or products correctly.

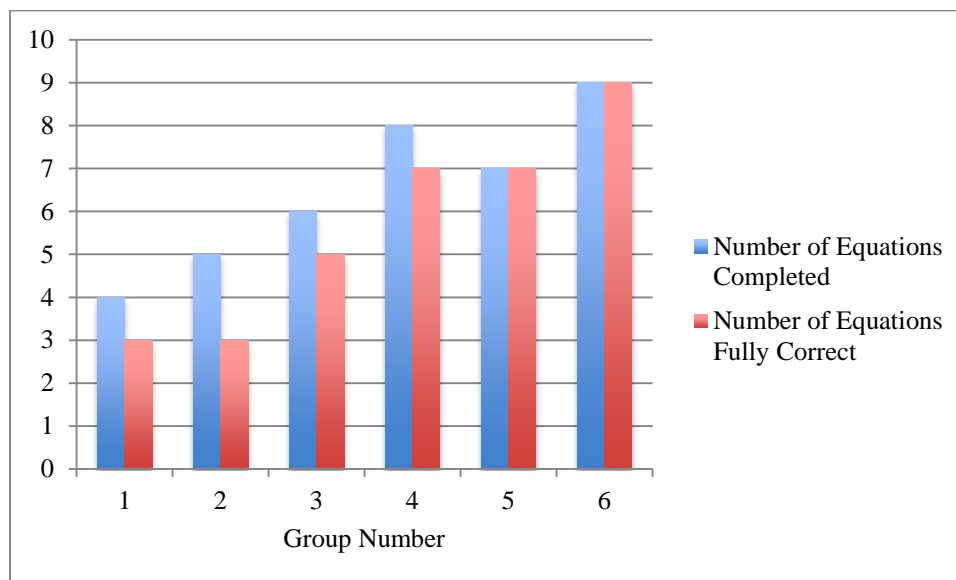


Figure 4. Student learning from round robin group artifact, ( $N = 6$ ).

## INTERPRETATION AND CONCLUSION

The largest transformation in this study was the difference in student engagement and student attitudes towards their engagement in the classroom. The number of students who *agreed* or *strongly agreed* that cooperative learning structures help to keep them engaged increased from 57% to 70% over the treatment period. When looking at the teacher journal notes and the outside teacher observations, the data indicated that the students were highly engaged in the classroom from the moment that the structures were being used in the classroom.

During some of the structures that demonstrated more students becoming disengaged in the classroom came about after using the structures for multiple times in the classroom. Cooperative learning structures that worked really well in the classroom were the *rally coach* and *round robin* structures. Over half of the students indicated in their *exit tickets* about these structures that they really liked using them and they wanted to see them used more in the classroom. This was very encouraging and I tended to use this structure more frequently in the classroom. The data indicated less engagement for the students toward the end of the treatment period. I think that this indicates that too much of anything, even something that worked well, is not beneficial for the students' learning. We spend a lot of time with our students over the year and as a teacher, the data indicated that continuously striving to change how the material is delivered and practiced is what keeps the students most engaged.

The data demonstrated that the students enjoy working together and using cooperative learning strategies in the classroom. The number of students who liked using cooperative learning structures increased over the treatment period and the students spoke and wrote about how they like to learn from one another and share in the learning process while in a chemistry class. The students demonstrated throughout the treatment period that the students were able to communicate more with one another in a group setting with the help of a structure set in place. The students liked being able to sit in groups of four and share in the learning. By the end of the treatment, students talked about being able to share in the learning experience. This demonstrates maturity and growth in the students as they realized how they could help one another be successful.

The overall learning that was assessed was greatest in the short term. Students demonstrated good knowledge gained of material covered during any particular learning structure from artifacts collected from that same day. In the long term, the overall final exam scores decreased slightly. These scores covered units in the first part of the treatment. The second semester midterm scores demonstrated slightly increased overall averages. This midterm represented material from the second portion of the treatment period.

#### VALUE

This study was valuable to my students and to me because it changed how I taught chemistry to my students. I wanted the focus of my classroom to be on the students rather than myself and I truly wanted every student in my classroom to be involved in learning on a daily basis. I wanted to stay away from having a few students always raising their hands to answer a question. Instead, using cooperative learning structures in my classroom helped every student be involved by thinking, writing, listening and learning together in smaller groups. Through the use of the cooperative learning structures I learned the importance of setting clear expectations at the beginning of a structure and that modeling a new structure is crucial for success of the structure. I learned that teaching students how to interact and communicate together takes some planning on the teacher part, but when used truly increases the overall engagement of the students.

In terms of students working together to improve their learning, using the structures helped me to be creative in coming up with various roles for students as they problem solved. Many concepts in chemistry involve critical thinking and multistep problem solving skills. For example, in the ideal gas law *round robin* structure, students took turns at solving one particular section of a given problem. They could not solve the entire problem until each member had contributed their share. I felt that giving each student a particular role in a problem really helped with communication between the members of the cooperative groups. Switching roles kept equality within the group and the students truly learned how to talk with one another to solve a higher-order thinking problem.

It was very encouraging to see students asking each other questions when something did not make sense and having their group members explain concepts to each other. Typically when students start in my class, as soon as they have a question they raise their hand and ask the teacher and this can be daunting. It was clear in the observation notes that students were not asking the teacher questions. They were asking each other questions and I was the one that could go from group to group to check in on progress on the group and make clarifications for the group when the entire group needed help.

I also learned the power of true accountability of each member of the group as well as the power of peer pressure within a group for increased student engagement. I felt that with using cooperative learning structures, if one student was not doing their part that the other students in the group urged that member to do their share. This was mainly

because the other members could not move on without the input from that one member.

As a teacher, I need to focus on true student accountability during class. No student wants to feel as if they are doing all the work, but when they see the value of helping one another in the learning process that is when true learning occurs.

Over the action research process I have changed as a teacher by placing the focus of the classroom on the students instead of me. As they enter my class, the students no longer expect me to be standing in the front of the room lecturing and giving them notes. Instead, my teaching has changed to a form where I model for the students how to interact with one another and how to teach one another the content for the class. I have changed my teaching from students conversing back and forth with me to conversing back and forth with one another. Even in their seating arrangements, they look at their group members and not the teacher in the front of the room. I have learned that students can only listen to a teacher talk for just a short amount of time. If there is a new concept, I have changed my teaching to not talking to them for more than ten minutes before they are discussing and engaging in the material with one another. Whether the students are learning something new or are reviewing material, I have taken steps towards students learning in a cooperative environment.



## REFERENCES CITED

- Abrami, P.C., Lou, Y., Chambers, B., Poulsen, C., & Spence, J.C. (2000). Why Should We Group Students Within-Class for Learning? *Educational Research And Evaluation (An International Journal On Theory And Practice)*, 6(2), 158-79.
- Adlai E. Stevenson High School. (n.d.). Retrieved October 6, 2012, from <http://www.d125.org/>
- Johnson, D., & Johnson, R. (1988). Cooperative learning: Two heads learn better than one. *In Context*, 18, 34. Retrieved from <http://www.context.org/ICLIB/IC18/Johnson.htm>
- Johnson, D., & Johnson, R. (1999). Making Cooperative Learning Work. *Theory Into Practice*, 38(2), 67-73.
- Kagan, S., & Kagan, M. (2009). *Kagan cooperative learning*. San Clemente, CA: Kagan Publishing.
- Kose, S., Sahin, A., Ergun, A., & Gezer, K. (2010). The Effects of Cooperative Learning Experience on Eighth Grade Students' Achievement and Attitude toward Science. *Education*, 131(1), 169-180.
- Lin, E. (2006). Cooperative Learning in the Science Classroom. *The Science Teacher*, 73(5), 34-39. Retrieved February 23, 2012, from Platinum Periodicals.
- Lou, Y., Abrami, P.C., Spence, J.C., Paulsen, C., Chambers, B., & d'Apollino, S. (1996). Within-class grouping: A meta-analysis. *Review of Education Research*, 66(4), 423-458.
- Marzano, R. J., Pickering, D. J., & Polluck, J.E. (2001). *Classroom instruction that works: Research-based strategies for increasing student achievement*. Alexandria, VA: Association for Supervision and Curriculum Development.
- Tsay, M., & Brady, M. (2010). A Case Study of Cooperative Learning and Communication Pedagogy: Does Working in Teams Make a Difference? *Journal Of The Scholarship Of Teaching And Learning*, 10(2), 78-89.

APPENDICES

APPENDIX A

STUDENT INTERVIEW QUESTIONS

- 1) When learning in the classroom, would you rather be seating individually, in pairs, or in groups of 4? Why?
- 2) Do you see learning in groups as helpful or unhelpful in terms of your learning in this class?
- 3) What do you like about learning in groups?
- 4) What do you not like about learning in groups?
- 5) What can the teacher do to help make learning collaboratively most effective?
- 6) Is there anything else you'd like to share about learning while in collaborative groups?

APPENDIX B

COOPERATIVE LEARNING ATTITUDE SURVEY

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

Definition of a cooperative learning structure: Any classroom structure that promotes positive interdependence, individual accountability, equal participation and simultaneous interaction

Circle only one of the following:

1) Are you male or female?

2) I feel that cooperative learning strategies help my learning of chemistry concepts  
Strongly Disagree    Disagree    Neutral    Agree    Strongly Agree

3) I like using cooperative learning strategies in chemistry class.  
Strongly Disagree    Disagree    Neutral    Agree    Strongly Agree

4) I feel that cooperative learning techniques helps to keep me engaged in the classroom.  
Strongly Disagree    Disagree    Neutral    Agree    Strongly Agree

5) I like being “called on” in class to answer a question  
Strongly Disagree    Disagree    Neutral    Agree    Strongly Agree

6) I worry that I might answer a question incorrectly if I raise my hand.  
Strongly Disagree    Disagree    Neutral    Agree    Strongly Agree

7) When learning in the classroom, I like to interact with other students.  
Strongly Disagree    Disagree    Neutral    Agree    Strongly Agree

8) I wish that I could work individually on practice problems in class  
Strongly Disagree    Disagree    Neutral    Agree    Strongly Agree

9) I wish that I could work individually during Laboratory Activities  
Strongly Disagree    Disagree    Neutral    Agree    Strongly Agree

10) I feel that my full learning potential is lost when I am forced to work with others  
Strongly Disagree    Disagree    Neutral    Agree    Strongly Agree

11) I feel that cooperative learning techniques are overused  
Strongly Disagree    Disagree    Neutral    Agree    Strongly Agree

12) I feel that I get distracted easily when I am working with other students in the classroom  
Strongly Disagree    Disagree    Neutral    Agree    Strongly Agree

13) What is your favorite seating arrangement?

Individual seating                  Pairs                  Groups of four

14) What do you like best about working with other students in chemistry class?

15) What do you like least about working with other students in chemistry class?

16) Are there any comments you have about this topic?

APPENDIX C

SHORTENED TIME-ON-TASK LOG



### Student Engagement Time-On-Task Log

Each box represents a student in the classroom. As you observe the class, spend 10-20 seconds per pair of students and for each student (box), mark either “E” for engaged or “NE” for Not Engaged in the box. Continue this process to mark as many students (boxes) as possible.

Please mark “Engaged” if they are participating with the task in hand. (i.e. speaking, writing, listening, questioning about the given topic)

Please mark “Not Engaged” if they are doing anything beyond the scope of the given task. (i.e. talking about a dance, copying off of another paper, etc.)


APPENDIX D

REGULAR TIME-ON-TASK LOG

Student Engagement Time-On-Task Log

Choose any pair of students and log their student engagement every 20 seconds.

Please check “Engaged” if they are participating with the task in hand. (i.e. speaking, writing, listening, questioning about the given topic)

Please check “Not Engaged” if they are doing anything beyond the scope of the given task. (i.e. talking about a dance, copying off of another paper, etc.)

	Time Log	Engaged	Not Engaged	Brief Description of what they were doing (i.e. listening, questioning, writing)
Student “A”	20 sec			
Student “B”	20 sec			
Student “A”	40 sec			
Student “B”	40 sec			
Student “A”	1:00 min			
Student “B”	1:00 min			
Student “A”	1:20 min			
Student “B”	1:20 min			
Student “A”	1:40 min			
Student “B”	1:40 min			
Student “A”	2:00 min			
Student “B”	2:00 min			

\*\*Continues in similar pattern\*\*

APPENDIX E

STUDENT ARTIFACTS

Team members: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Period: \_\_\_\_\_

## Chemical Reaction Round Robin

**GROUP PAGE****Directions:**

- **Player A:** Draw a card, show it to the rest of the team, and then write down the reactants on the team packet. Pass the packet to player B.
- **Player B:** Name the type of reaction out loud to the team and with approval records it in the team packet. Pass the packet to player C.
- **Player C:** Complete the reaction by naming the product(s) and with approval record this information in the team packet. Pass the packet to player D.
- **Player D:** Balance the equation and review the information the information with the rest of the team. At this time, each team member records the final balanced equation and reaction type on their individual pages. Rotate roles.

Chemical Equation:	→
Reactants	Products
Reaction type:	

Chemical Equation:	→
Reactants	Products
Reaction type:	

Chemical Equation:	→
Reactants	Products
Reaction type:	

Chemical Equation:	→
Products	Reactants
Reaction type:	

\*\*Continues in similar pattern\*\*

**Nuclear Power Plant: ALL-WRITE ROUND ROBIN**

1. You will sit in groups of 4
2. At the start you will have 30 seconds to draw **one** component of a nuclear power plant on paper. Label the component by a symbol and describe the function below the drawing
3. When time is called rotate your paper and add **one** new structure to the new paper.

Picture

Key

Symbol	Function


### Using the Ideal Gas Law

Partners \_\_\_\_\_

#### Rally Coach

\_\_\_\_\_

**Directions:** For each of the following problems one partner will be the coach and the other will be the writer. You will switch roles for every problem. The responsibility of the "coach" is to mentor your partner through the problem step-by-step giving them directions. It is the responsibility of the writer to write down what the coach is stating. For each of the problems follow the following format:

- Name the unknown variable and units of the unknown variable.
- Name the variables that are known or given in the problem (volume, temp., etc.).
- Name and convert any variables that need to be converted into another unit. (Make sure to factor label any conversions)
- Utilize the Ideal Gas Law equation to solve for the unknown. Make sure to include units and watch for sig figs!

1. Radon, a radioactive gas formed naturally in the soil, can cause lung cancer. It can pose a hazard to humans by seeping into houses, and there is a concern about this problem in many areas. A 1.5 mol sample of radon gas has a volume of 21.0 L at 33°C. What is the pressure of the gas in atm?

- 
- 
- 

d)

2. A 5.0 L flask contains a sample of oxygen gas. The temperature of the gas is 23°C and the pressure is determined to be 1250 mmHg. How many moles of oxygen gas are in the flask?

- a)
- b)
- c)

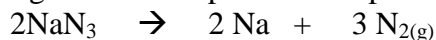
d)

3. What is the molar mass of a gas if 150 ml have a mass of 0.922 g at 99.0°C and 107 kPa?

- a)
- b)
- c)

d)

4. Automobile air bags inflate following a serious impact. The impact triggers the following chemical reaction:



If an automobile air bag has a volume of 11.8 L, how much N<sub>2</sub> in grams is required to fully inflate the air bag upon impact? Assume STP conditions

- a)
- b)
- c)

d)



5) Sulfur dioxide ( $\text{SO}_2$ ) is emitted primarily as a by-product of electricity generation and industrial metal refining.  $\text{SO}_2$  is a lung and eye irritant that affects the respiratory system. What is the density of  $\text{SO}_2$  gas (in g/mL) if 0.0851 moles of it are found at 753 mm Hg and 85.6K ?

- a)
- b)
- c)

d)

6. What is the molar mass of a gas if 0.858 g of it occupies 150.0 ml at 15.2 psi and at  $2.00^\circ\text{C}$ ?

- a)
- b)
- c)

d)

7. Olympic cyclists fill their tires with helium to make them lighter. Calculate the mass in grams of helium in a helium-filled tire that has a volume of 855 mL, a pressure of 125 psi and a temperature of  $25^\circ\text{C}$ .

- a)
- b)
- c)

d)

8. What is the density (in g/mL)  $\text{NO}_2$  gas if it occupies a 486 ml flask at  $10.0^\circ\text{C}$  and 1.25 atm of pressure?

a)

b)

c)

d)

### Balancing Practice: Rally Coach

Names \_\_\_\_\_

**Directions:** The partner sitting on your left will start with the pencil and may only write down what your partner (your coach) tells you to write down! The coach (on the right-hand side) will guide you through writing the formulas for the equations and balancing the equations. For the next question, you and your partner will switch roles. Be sure to remember **BrINClHO**F for those elements that stand alone!!

1. magnesium bromide + chlorine  $\rightarrow$  magnesium chloride + bromine

2. iron (III) bromide + ammonium sulfide  $\rightarrow$  iron (III) sulfide + ammonium bromide

3. sodium chloride + Magnesium hydroxide  $\rightarrow$  magnesium chloride + sodium hydroxide

4. aluminum oxide + barium hydroxide → barium oxide + aluminum hydroxide

5. lead + hydrogen nitrate → lead nitrate + Hydrogen gas

6. potassium perchlorate → potassium chloride + Oxygen gas