

THE INFLUENCE OF COOPERATIVE GROUPS IN A
HIGH SCHOOL CHEMISTRY COURSE

by

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TABLE OF CONTENTS

1. INTRODUCTION	1
2. CONCEPTUAL FRAMEWORK.....	3
3. METHODOLOGY	7
4. DATA AND ANALYSIS	14
5. INTERPRETATION AND CONCLUSION	23
6. VALUE.....	26
REFERENCES	30
APPENDICES	33
APPENDIX A IRB Approval	34
APPENDIX B Cooperative Group Survey	36
APPENDIX C Chemistry Survey	39
APPENDIX D Chemical Quantities Pretest	42
APPENDIX E Chemical Quantities Posttest	44
APPENDIX F Cooperative Group Survey	46
APPENDIX G Stoichiometry Pretest	49
APPENDIX H Stoichiometry Posttest.....	51

LIST OF TABLES

1. Demographics of Research Project Participants	7
2. Data Triangulation Matrix	13
3. Student Response to Groups Clarifying Chemistry Concepts	21

LIST OF FIGURES

1. Arrangement of cooperative groups.....8

2. CGS and CGS2 Results of Student Group Positive Experience.....15

3. Student Cooperative Group Participation16

4. Comparison of Student Pretest, Quiz, and Posttest Percentages
for Treatment Unit17

5. Comparison of Student Pretest and Posttest Percentages for
Nontreatment Unit18

6. Individual Student Pretest and Posttest Scores for Treatment
Unit19

7. Individual Student Pretest and Posttest Test Scores for
Nontreatment Unit20

8. Student Attitude Towards Science and Chemistry23

ABSTRACT

High school students tend to have difficulty in chemistry classes. Instructors are always searching for strategies to help students perform better. One such strategy is cooperative learning groups. In this classroom research project, cooperative groups were employed to determine what effect they would have upon student understanding of chemistry concepts, and thus student confidence, student attitude towards science, and individual achievement.

Students were assigned to heterogeneous groups based on their algebra grades. Surveys, teacher observations and test scores were used to determine the effect the cooperative groups had during a stoichiometry unit. Students self-reported an increase in understanding; test scores showed a significant increase from pretest to posttest; but, student attitude towards science remained unchanged after the unit was completed.

INTRODUCTION AND BACKGROUND

Merrill F. West High School (West High) is one of the three comprehensive public high schools in Tracy, California, which, for the most part, serves as a bedroom community for the greater San Francisco Bay Area. As of 2015, Tracy had a population of 85,182 comprised mostly of Caucasians and to lesser degrees Hispanics, Asians and Black/African Americans; 44.1% held a high school diploma or less and 26.0% had some college education but had not attained a degree. The average household income was approximately \$96,357 with 59.4% of the households reporting less than \$100,00 income while the average house was valued at \$360,107 (“Marketing Profile”, September 23, 2015). The students that attend West High for the most part are residents of Tracy while others come from Manteca and some from Stockton area. *Merrill F. West High School Single Plan for Student Achievement (West High Plan) 2016/17* indicates there were 2106 students enrolled consisting of a mix of Hispanic, White, Asian, and African American with the majority, 50.95%, being Hispanic; 17.09% were English Learners and 35.75% were Fluent English Proficient/Reclassified Fluent English Proficient. West High had 54.65% of the students receiving free or reduced lunch (Brown, T., 2016).

The *West High Plan* indicates there was a noticeable decline in the percentage, from 36% to 27% schoolwide, of students meeting or exceeding proficient on the Smarter Balanced Assessment Consortium test, which includes both English and math, (Brown, T., 2016) and 46% of the students scoring below proficient on the California Standards Test 10th grade life science assessment, California Assessments of Student Performance and Progress (2015 CAASP Test Results, 2016).

After 15 years of teaching various levels of high school chemistry, it is apparent that students in college preparatory chemistry have difficulty with understanding chemistry concepts and applying their math skills to those concepts. Some examples of this would be conversions are set up incorrectly so there is no chance of ending with the correct units, not grasping the concept and that is can be done through calculations that one reactant can control the amount of product produced (limiting reactant) and generally low assessment scores. I have employed various teaching strategies such as Process Oriented Guided Inquiry Learning (POGIL), modified Cornell notes in composition books, increasing the use of short content specific videos and now, with this research project, purposely arranged cooperative groups. Though I have used what I thought were cooperative groups previously over the years, I have not designed the groups considering the students' math scores thus allowing for greater balance between heterogenous groupings; nor did I put in place the requirements I did, such as helping each other when one is not understanding or one group homework assignment based on each individual group member' with this research project. My desire was to determine if these arranged cooperative groups would allow the students to help each other understand the concepts being presented, understand how to apply their math skills and help and encourage their group members to work towards a common goal, thus improving their chemistry scores and their general attitude towards science. I developed the following questions:

1. What effect do cooperative groups have on individual learning in a high school chemistry course?

2. What effect do cooperative groups have on student attitude towards chemistry or science in general?
3. What effect do cooperative groups have on students' confidence about chemistry?

CONCEPTUAL FRAMEWORK

Hundreds of studies show that students in cooperative groups have higher achievement and are better adjusted among their peers (Johnson, Johnson and Smith, 1991). Classroom instruction can be designed in three different manners: competitive, where students work to out-perform one another, creating one winner and many losers within a class; individualistic, where each student's achievement is earned independently without any correlation to their classmates'; and cooperative, where students work together towards a common goal and achievement is shared. There are four major theoretical perspectives on the achievement effects of cooperative learning:

1. motivationalist, self-interest due to rewards
2. social cohesion, developing a cohesiveness and caring for each other in the group sometimes with the aid of task specialization
3. cognitive – development, group interaction that leads to brain development
4. cognitive – elaboration, group interaction that leads to changes in thinking.

These different perspectives are complimentary not competitive and work in conjunction with one another to produce the highest achievement levels (Slavin, 2014).

Cooperative groups are not just groups of students sitting near each other and working with the same material. For a group to be considered cooperative, it must contain five essential elements (Johnson and Johnson, 2002):

1. Positive Interdependence: members are granted group rewards, need information from other members and each member plays a role within the group. All members are intertwined and need each other to succeed.
2. Individual Accountability: though working within groups, each member is responsible for their own learning and work. No one person can ride the coattails of the other members.
3. Face to Face Promotive Interaction: group members are required to explain or present material to their group mates.
4. Social Skills: students are taught social skills by the instructor, encouraged to use them and are given feedback on the social skills used during cooperative groups.
5. Group Processing: time is given for students to reflect on their group work, how well their group is functioning and to address any problems within their group.

A meta-analysis of cooperative learning instructional methods showed that those students who were allowed to study in groups learned more individually when a group reward was granted for increasing individual group member's learning than did group study alone. The most successful cooperative learning was seen in groups that had both group reward and individual accountability (Slavin, 1983).

Successful cooperative learning was indicated in the results of a study conducted by Robert Felder of North Carolina State University Raleigh. Felder studied the effects of cooperative learning on 123 of his chemical engineering students over five consecutive semesters starting in the Fall of 1990. He found a shift in grades towards the higher end of the bell curve, a greater than normal sense of community and ability to solve problems.

Felder also credited the cooperative learning groups to a higher percentage of these students garnering chemical engineering positions upon graduation than was normal for the time and an increase in student interest in careers in academia (1996).

Students who tended to be more cooperative earned higher achievement scores in cooperative situations in separate studies completed by De Voe, Richmond and Winer, and Kagan (as cited by Zahn, Kagan and Widaman, 1986) and it was found that African-American and Hispanic students were more cooperative than Anglo-American students. In a study conducted by Winther and Volk (1994) in a large, midwestern, inner-city high school in an African-American neighborhood, a control group was taught via traditional methods, whole class lecture and discussion, whose test results were compared with the test results of an experimental group taught by employing cooperative learning methods and using *Chemcom* curriculum. Both groups consisted of all African-American students in grades 10 through 12; all took the same pre- and post-tests. At the end of the year, the post-test results showed a 39-point difference between the two groups with the experimental group achieving higher scores. Similar results were seen in Hispanic students in 4th grade social studies classes where, again, those in the cooperative learning group out performed on the post-test the students in the traditionally taught control group (Lampe, Rooze, and Tallent-Runnells, 1996).

It has also been found, that socially isolated, learning-disabled teens benefit from cooperative groups when there are group academic bonuses, social skills are taught and bonuses are given for using those social skills. These students felt more enjoyment in the subject matter when taught using cooperative groups, felt they had received all the help

they needed and contributed to other's learning and, especially in foreign language classes, felt improved confidence (Mesch, Lew, Johnson and Johnson, 1986).

Positive student attitude towards science has been shown to increase with cooperative group learning over both competitive and individualistic methods for learning science in two separate studies (Humphreys, Johnson and Johnson, 1980; Lazarowitz, Hertz-Lazarowitz, and Baird, 1994), indicating "that cooperative learning has important academic, personal and social advantages for students in high school science" (Lazarowitz, Hertz-Lazarowitz, and Baird, p. 1129). According to Okebukola, "students' attitudes towards science is powerfully related to achievement" (1985, p.6). Cooperative group learning is a research supported teaching strategy that improves the achievement of all students by developing critical thinking, problem solving and collaborative skills. These 21st – century skills are needed by students to be successful, not only in science but in their future. The National Science Teachers Association published a position statement (2011) in which is stated:

Exemplary science education can offer a rich context for developing many 21st-century skills, such as critical thinking, problem solving, and information literacy especially when instruction addresses the nature of science and promotes use of science practices. These skills not only contribute to the development of a well-prepared workforce of the future but also give individuals life skills that help them succeed. Through quality science education, we can support and advance relevant 21st-century skills, while enhancing science practice through infusion of these skills. It is essential, however, that quality science education is not diminished in support of 21st-century skills (p. 1).

Students will need to be able to communicate and work effectively together to "inform, instruct, motivate and persuade" in collaborative groups with each member assuming responsibility not only for their own goals but also the goals of the group ("P21

Framework Definitions”, 2015, p. 4). Having students work in properly designed and administered cooperative groups gives all students, regardless of color, the opportunity to develop, practice and prepare for a successful future.

METHODOLOGY

My classroom research project took place in my college preparatory chemistry class that contained 21 students (see Table 1) of whom 16 were Reclassified Fluent English Learners, 2 were English Learners, 2 were English only and 1 was Fluent English Proficient.

Table 1
Demographics of Research Project Participants (N = 21)

		Hispanic	Asian Indian	Other Asian	Filipino	White
Sophomores	Female	7				1
	Male	2	2	2	1	
Juniors	Female	1	2			1
	Male	2				

The participants’ math levels ranged from Algebra 1 to Algebra 2 pre – AP with most the students in geometry. However, math levels are not necessarily indicative of success though students with better Algebra 1 scores generally achieve greater success in college preparatory chemistry.

Treatment

Using the method described by Karen Lyn Davis (coolmath.com, n.d.) in *Survivor Algebra How to Set up The Tribes*, the students were arranged into seven heterogenous groups of three by their Algebra 1 grade if available; if not, the closest math class was

used. The grade was written on a card and then starting with the highest grade, seven cards were laid out left to right. In a snake pattern, going from right to left and then left to right, the remaining cards were laid out (Figure 1). This allowed for an even disbursement of math ability among the groups and did not allow for favoritism in group placement.

GROUPS						
I	II	III	IV	V	VI	VII
A	A	A-	A-	A-	B	B
C	C	C	C	C	B-	B-
C-	C-	C-	D+	D+	D+	D

Figure 1. Arrangement of cooperative groups. *Note.* Arrows indicate order of card placement.

Once groups were established, students were informed each group would have:

1. Facilitator, whose job it was to keep them on task and moving forward with an assignment or discussion;
2. Motivator, whose job it was to provide the encouragement and support needed by the group;
3. Checker, whose job was to check to ensure all had accomplished their assigned task, keep track of time and record the work completed by the group.

These tasks were not static and would rotate through the group weekly so everyone had an opportunity to play each role.

The start of the unit established a new routine for the class, one which was picked up on very quickly by the students. New material was presented via lecture and reading the text and students took modified Cornell notes which consisted of a left-hand column for student generated questions, notes taken in the center section of the page and at the end of section within the unit, a summary of the notes for that section, in composition their books. Students would then get into their groups and share their notes with one another to fill in gaps in their notes. During this time discussions within the groups would take place if there were any misunderstandings or further clarification was needed. Students would start to work on the given assignment, helping each other as needed. The following day the individual assignment was due but before going over the work as a class, the students got back into their groups and worked on any problems they may have had completing the work. At this point the assignment was discussed and any problem areas were gone over. A POGIL group assignment was also given to the groups and much discussion took place in each group as they worked through the pages.

Several times during this unit, the groups were given larger than normal assignments and were told to break the work up evenly between the members along with common problems to solve as a group. This gave each person a share of each type of problem so that all could practice all varieties of work. They were told that the following day, the individual work would be put together to form one large group assignment. The remainder of the class time, the students worked in their groups tutoring each other on the

common problems. The assignments were compiled the next day at the start of class for a common grade. Students became accustomed to each assignment being broken down and then reassembled the next period. Sometimes a common score was given and sometimes an individual grade. This way students were responsible both for their own assignment and for the group's. Students also became accustomed to asking each other for guidance when confused instead of the teacher using this method.

Individual and group quizzes were also administered. Students were given individual quizzes for an individual grade. Then groups were assembled and a group quiz was given. The quizzes were identical except compounds and amounts had been changed for molar conversion calculations. Students were directed to divide the quiz problems and discussion was also encouraged.

After practicing molar conversions for approximately two weeks, each group was given a piece of aluminum foil and asked to determine how many atoms thick the foil would be if the atoms were stacked one on top of another. This put their communication and conversion skills to use and proved to be a struggle for most of the groups. A second individual lab, had students massing various materials and converting mass to moles, molecules and atoms. Though all had different values for the materials, they could work in their groups, helping each other solve the questions. This unit tended to be difficult for much of the class as students had to apply their Algebra 1 skills to solve multiple step problems with units that are generally unfamiliar to many such as converting atoms to moles or grams into atoms.

During the times the groups worked together, I would walk among the groups listening to conversation and asking questions to verify that they understand what they were doing. Sometimes the questions were a check on the person explaining a concept or calculation to others who were confused. I would also query the group as to who was the leader and was the checker ensuring that the concepts were understood by all before moving on. When groups fell silent, I would check with them to be verify they were working on material and not just being silent.

Instrumentation

The research project took approximately one month, from the end of February to the end of March 2017, to complete and covered one unit, Chemical Quantities. Information was gathered concerning student thoughts about cooperative groups and their attitudes towards science through three surveys and teacher questions posed to students during class. Quantitative data was collected through pretests, posttests, and a quiz to measure the effect of cooperative groups on individual student achievement. Qualitative information was gathered through teacher observation. An exemption was granted for the methodology in this project by the Montana State University Institution Review Board and the compliance for working with human subjects was maintained (Appendix A).

Before any cooperative group work was started, students were administered the Cooperative Group Survey (CGS) in Appendix B and the Chemistry Survey (CS) in Appendix C. The CGS provided insight as to student experience with cooperative groups, how these groups were chosen, and did they find working in groups helpful with

understanding chemistry. The ratings on the survey were *Always*, *Often*, *Occasionally* and *Never* and given the numerical values of 4, 3, 2, and 1 respectively.

The CS provided information about the students' confidence in their reading and math abilities to be proficient for general chemistry, their comfort level in the class as far as asking questions, their confidence in their understanding of the chemistry that had been taught so far in the year, and if they liked chemistry or science in general. The ratings on the survey ranged from *Strongly Agree*, *Agree*, *Neutral*, *Disagree* and *Strongly Disagree* with each choice given a numerical value of 5 through 1 respectively.

Students were administered the Chemical Quantities Pre-Test (Appendix D) which was used for a base line of students' pre-knowledge of masses of atoms and compounds, counting the number atoms in compounds, percent composition and determining empirical formula. No previous knowledge was expected concerning percent composition and empirical formula but some indication of pre-knowledge for atom counts, atomic mass units and molar mass was expected from some students depending upon their biology or physics teacher in the previous year and some had been taught in this chemistry class.

At the end of the unit, the Chemical Quantities Post-Test (Appendix E) was administered as was the Cooperative Group Survey 2 (CGS2, Appendix F). The survey rating scale ranged from *Always*, *Often*, *Occasionally* to *Never*, with corresponding numerical values of 4, 3, 2, 1 and inquired about the students' experiences and thoughts about the cooperative groups used during this unit, along with any suggestions they could offer to improve the cooperative groups. Table 2 shows the triangulation matrix of the

data collection instruments used and the classroom research project questions they address.

After this unit, a nontreatment stoichiometry unit was completed. Students were given a Stoichiometry pretest (Appendix G) with the remainder of the unit being presented in a “traditional” manner of lecture, notes, individual work, lab and a Stoichiometry posttest (Appendix H). During this unit, students were neither encouraged nor discouraged from working with other classmates, they were not, however, organized into cooperative groups.

Table 2
Data Triangulation Matrix

Focus Question	Data Source 1	Data Source 2	Data Source 3
What effect do cooperative groups have on individual learning outcomes in high school chemistry?	Cooperative Group Surveys	Pre-and Post-Tests	Quiz Scores
What effect do cooperative groups have on student attitude for chemistry/science in general?	Cooperative Group Surveys	Chemistry Survey	Teacher Observation
What effect do cooperative groups have on student’s confidence in chemistry?	Cooperative Group Surveys	Chemistry Survey	Teacher Observation

To help develop reliability, posttest questions were repeated questions from the pretest with only changes in the substances, i.e. from H₂O to AlCl₃, to avoid memorization from the pretest. To help with validity, both the surveys and pre- and posttests were shared with a colleague as we are both interested in strategies to improve student understanding in our chemistry classes. She provided suggestions on how to phrase the survey questions to insure the questions were surveying what was intended.

DATA AND ANALYSIS

The CGS, taken before the research project began, indicates that all students ($N = 21$) have worked in groups in their high school classes. Some, 14.3%, *always* worked in groups – “I take an Engineering class and we do group work all the time” and “I’m always working in groups in my classes”. While the remainder were evenly split, with 42.9% in each category, between *often* and *occasionally* working in groups – “We occasionally work in groups but we mostly work individually” and “Most of my classes prefer quiet than group work”. None of the students responded with *never* working in groups. On the same survey, most, 47.6%, claim they *often* like working in groups, while 28.3% *always* like working in groups. Students had varying experiences corresponding to the difference between *often* and *always* liking to work in groups such as “depending on who I work with” versus because of “getting stuff done” and “it makes the task easier to accomplish quicker”. The CGS2 indicates that more students, 33.3%, prefer *always* working in groups in chemistry class compared to 28.6% *always* on the CGS, a gain of 4.7%. An almost identical gain, 4.8%, was seen in the *occasionally* prefer responses of 28.6% on the CGS2 compared with 23.8% on the CGS (Figure 2).

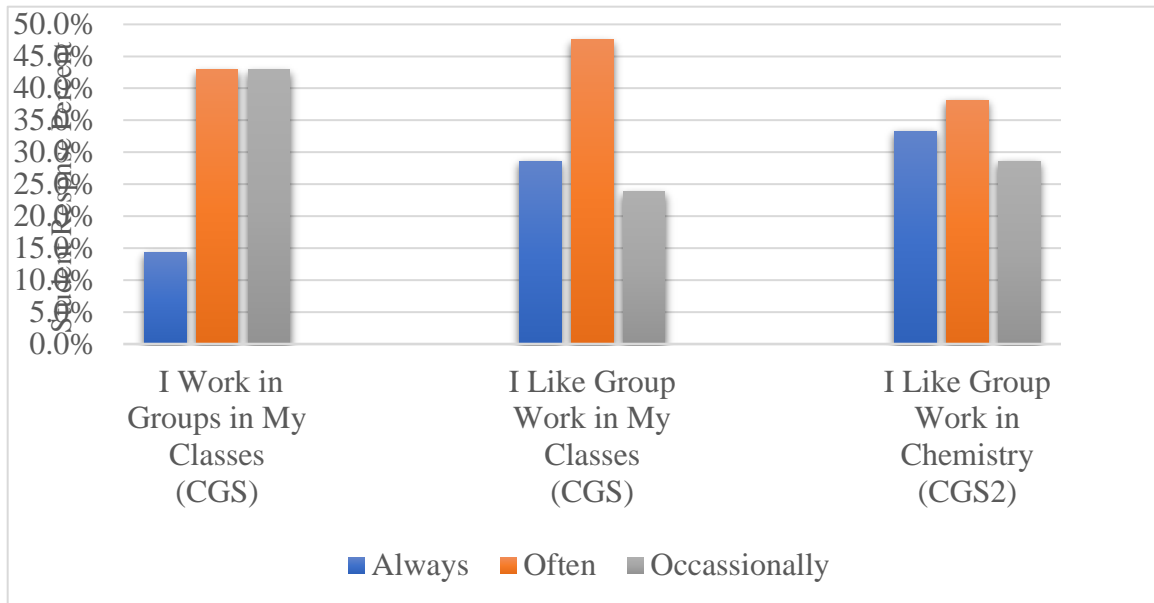


Figure 2. CGS and CGS2 results of student group positive experience, ($N = 21$).

Student active participation and non-participation within the cooperative groups was observed and recorded in the teacher notes and self-reported on both Cooperative Groups Surveys. One group did not communicate and was relocated to allow greater access by the teacher. The group would respond when asked a question by the teacher but would not normally instigate dialogue unless prompted. The group members stated, “It wasn’t that we hated each other it was more of us being shy,” “My group members were really shy and didn’t talk at all at times” and “Hardly will there be a conversation” (Figure 3). Other groups worked together extremely well, discussing problems, sharing techniques and questioning each other’s thinking processes, “We were always able to ask questions or say what (we) were confused on without being made fun of.”

In order to participate fully, students must come to class prepared and communicate within the cooperative group. Students self-reported their participation much higher on the CGS at 61.9% as *always* participating than their peers perceived them to be

participating on the CGS2 where they reported as being *always* prepared at only 9.5%. The same two students would very rarely arrive with work completed or even started and two others would arrive with the work partially completed. On the CGS, three students, 14.3%, reported that during group work, they were *always* asked questions about the material at hand and 52.4% were *often* asked. This is similar to the percent, 47.6%, of students who reported that their group were *always* able to speak to one another. These results are consistent with teacher observation of participation (Figure 3).

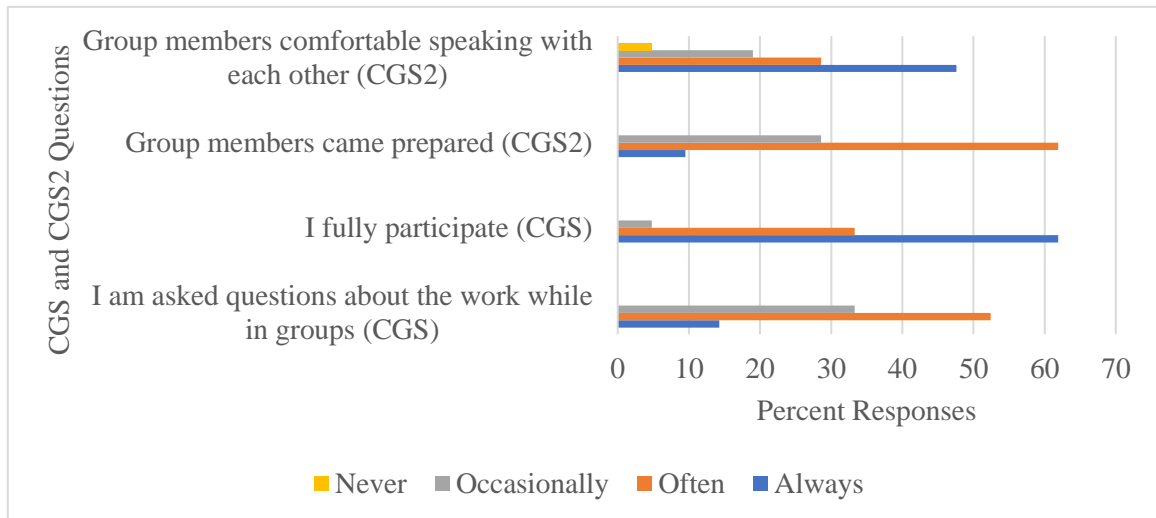


Figure 3. Student cooperative group participation, ($N = 21$).

The average pre-test score for the treatment unit was 14% with a range from 0% to 40%. An individual quiz was taken mid-way through the unit with an average score of 28%, with a range of 0% to 100%. The post-test showed growth, as was expected, with an average score of 86% and a range of 57% to 100%. Test scores improved from pre-test to posttest for every student, which was expected. The difference of the means of the pretest and posttest (shown by the x position in each box), 53%, is significant (Figure 4).

The nontreatment unit had a 47% increase in the mean score from pretest to posttest. The range for the pretest was 0% to 25% with a mean score of 13.75%. The posttest range was 15% to 104%. Extra credit was offered on the posttest making possible to earn more than 100%. Though the increase from pretest to posttest for this unit is also significant, it is 6% less than the growth for the treatment unit. A t-test was run on both units' pretest and posttest scores indicating that learning had taken place with $t(40) = 16.73$, $p << 0.001$ for the treatment unit and $t(38) = 5.57$, $p << 0.001$ for the nontreatment unit, and that the increase between pretest and posttest scores was not by chance.

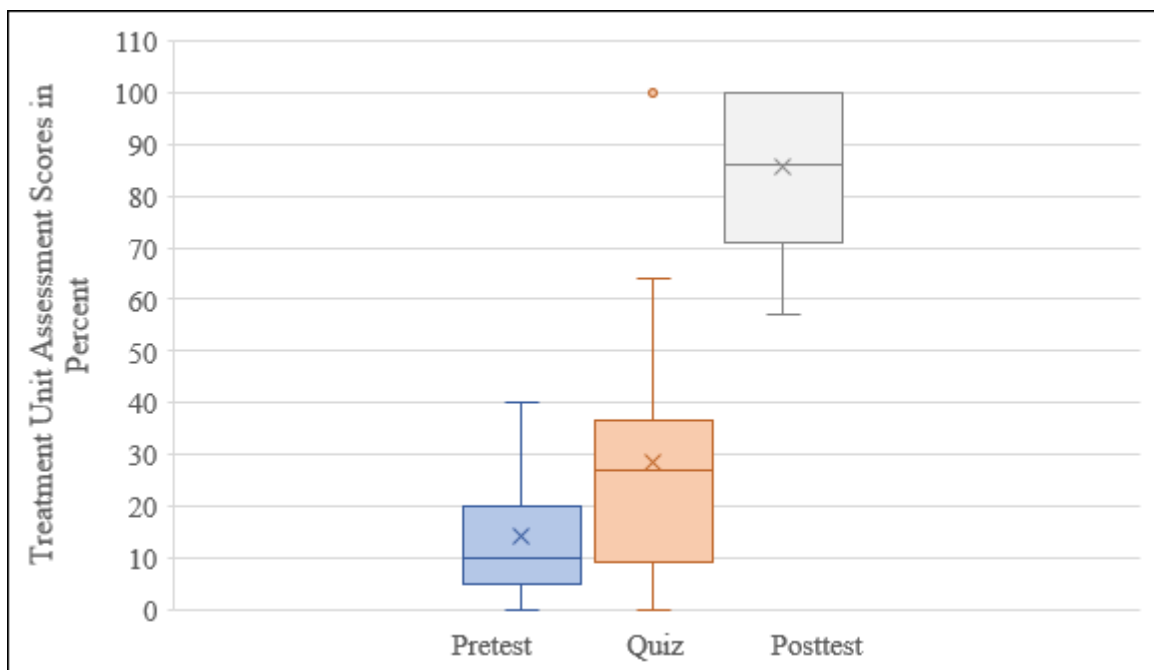


Figure 4. Comparison of pretest, quiz, and posttest percentages for treatment unit, ($N = 21$).

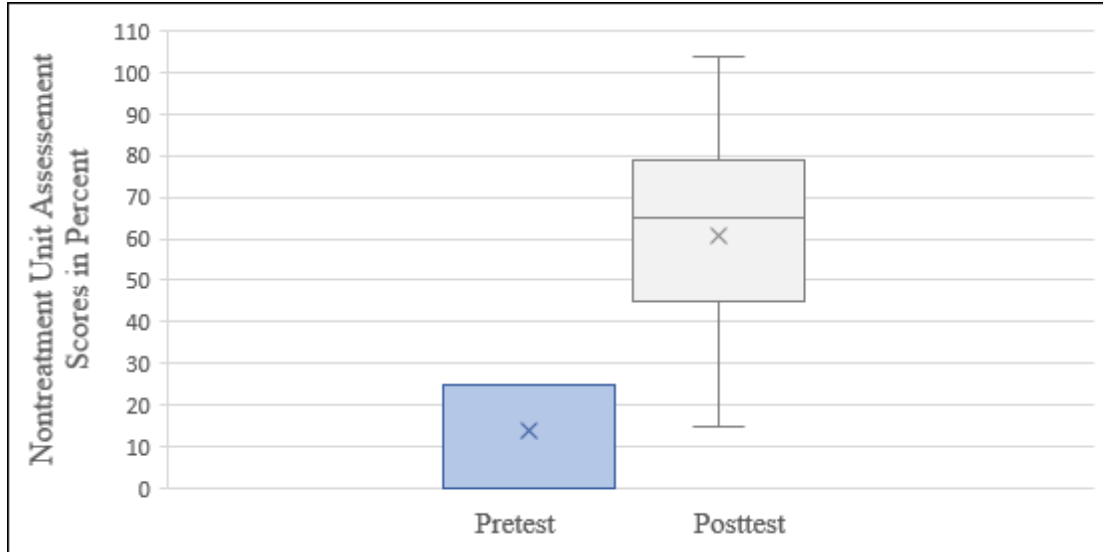


Figure 5. Comparison of pretest and posttest percentages for nontreatment unit, ($N = 20$).
Note. No mid-unit quiz was administered during nontreatment unit.

Individual student percentages for each treatment unit assessment are displayed in Figure 6. Five of the students scored zero on the pretest. All these students showed improvement from pretest to posttest, ranging from an increase of 57% to 100%. The most talkative group, determined through teacher observation, produced the largest gain from pre- to posttest with this same student reporting a 3 (occasionally) out of 4 (always) on the Cooperative Group Survey 2 stating “because we were able to work together and what one didn’t understand the other(s) did” when asked to explain if their group helped them understand the concepts better than if they had worked alone. Another student who had an increase pre- to posttest of 86% stated that “whenever I had any doubt, they (the group) used to clear it up for me.” However, one student, though scoring in the third quartile on the pretest with 20% showed the smallest increase in scores, 37%, and is amongst the outliers for the post-test. This student was in the least talkative group in the room.

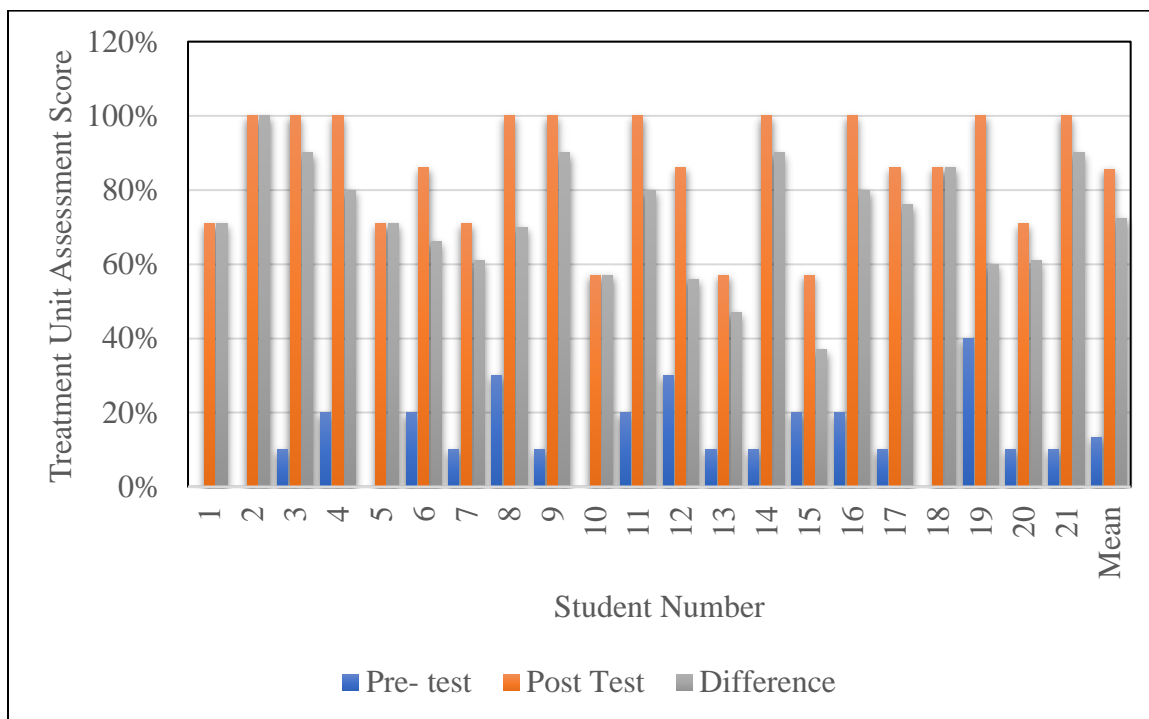


Figure 6. Individual student pretest and posttest scores for treatment unit, ($N = 21$). Note. No column is present for those students who scored 0% on pretest.

All but four students ($N = 20$) had larger posttest scores during the treatment unit. One of the four students had a negative increase due to extra credit being offered on the nontreatment unit test that was not offered on the treatment unit test. Extra credit was offered on the nontreatment test to help students bolster scores on the stoichiometry unit as this tends to be one of the hardest units for college preparatory chemistry as it combines both the treatment unit, Chemical Quantities, and balancing equations.. One of the four students with the highest difference in scores was a student in the group that did not talk. Perhaps because the other students were relying on her to explain or because she had to explain could be a reason for the 75% difference in scores. Student 1's scores provide great support for the use of cooperative groups. This student had given up on

chemistry with plans to take it next year. She put little to no effort into either group or individual work and when asked to try harder and do something to help with next year, she would just smile and wave her hand. However, she had a 46% higher score on the treatment unit posttest than on the nontreatment unit posttest. Therefore, something occurred within the group dynamic that did not seem to occur during traditional lecture, practice, test teaching (Figure 7).

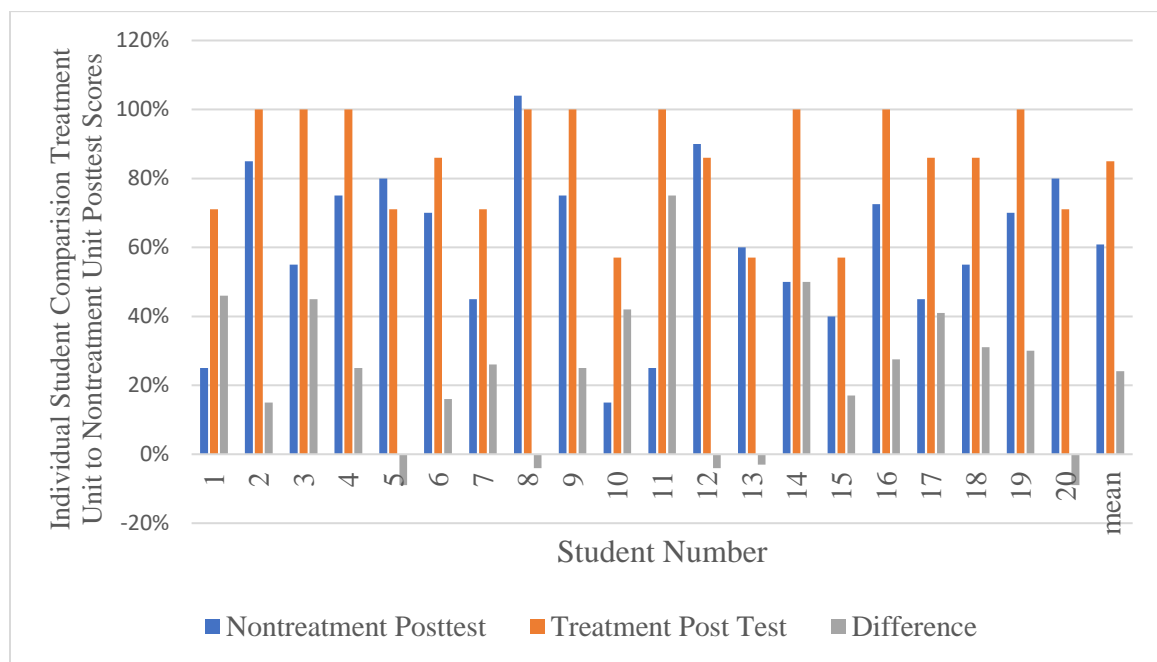


Figure 7. Individual student pretest and posttest scores for nontreatment unit, ($N = 20$).
Note. No column is present for those students who scored 0% on pretest.

On the CGS, no students reported that working in groups was *never* helpful as opposed to on the CGS2 where two students reported that their group was *never* helpful to them for understanding the concepts. Student written explanations for the *never* survey choice were “I still prefer working alone, I can focus better that way.” and “If no one can answer MY questions for the group, how can I improve?”. The number of students

choosing *occasionally* helpful declined from five to two. Student reasons for this choice were “my group members don’t always do their homework in order for us to compare and contrast.” and “I was mostly the one who helped them and when I needed help they didn’t understand it either so I had to ask for help to other people.” The number of students who found working in groups *often* helpful did not change from ten over the course of the unit. The number of students reporting *always* helpful increased from 6 on the CGS, to 7 on the CGS2. According to one student, “It actually is easier to work in groups because if everyone knows a little bit of how to do some parts of the problem, just combine it.” Another student responded to a question concerning the effectiveness of the groups posed by the teacher with “The groups are working. I am getting my questions answered and am able to help the group too.” Unfortunately, more students reported their groups were *never* helpful increased from CGS to CGS2. These students reported they were not able to get help from their group or could not collaborate with their group. From teacher observation, one of these students would not speak to their group. (Table 3).

Table 3
Student responses to groups clarifying chemistry concepts.

	Always	Often	Occasionally	Never
Cooperative Group Survey	6	10	5	0
Cooperative Group Survey 2	7	10	2	2

Note. Values are numbers of students, ($N=21$).

A Pearson’s correlation test was completed to measure the strength of correlation between student self-reporting of understanding chemistry concepts and posttest scores. The correlation test r value of -0.04 indicates that these two variables were not correlated.

These results are like those seen in a study done by Favazzo, Willford, and Watson (2014) showing that students tend to over-estimate their confidence when not required to complete a graded question. This changed when after completing each question that would be graded, they had to mark their confidence level in their answer being correct. There was a greater correlation between confidence and performance.

Though no correlation was indicated, four of the seven students reporting the groups *always* helped had large increases from 26% to 45% between treatment unit posttest and the nontreatment unit. Two students who had reported that the groups were *never* helpful showed large gains as well during the treatment unit from pretest to posttest, 76% and 80%. However, these two were friends and one student would leave his group to work with the other student who would not talk to his group mates. Though they were not working in their assigned group, they were collaborating. One of these students had a 41% higher score on the treatment unit posttest than the nontreatment unit. The other did not complete the nontreatment unit as they had left the district.

Working in cooperative groups had no effect on changing students' attitude towards chemistry or science in general. Though 10% *strongly agree* they liked science (CGS2) none *strongly agree* they liked chemistry and only one *strongly agreed* they were interested in learning chemistry (CGS). Most students reported they *agree*, 40 %, or were *neutral*, 45%, about liking science. Most students reported they were *neutral*, 57.9%, about liking chemistry and one student *strongly disagree* about liking chemistry. Students report reasons for taking chemistry as "It is a requirement for high school." or "A-G requirements" and "To graduate." One student's explanation supported biology as their

preferential course, “I can learn about my body and how it works. Like to learn about cells and atoms” (Figure 8).

The high percentage of students having little to no interest in chemistry is a cause for concern especially since they are in a chemistry course. One student who has consistently scored well *agrees* to liking chemistry because of “the elements of math shown in chemistry.” Another student who *strongly agreed* to liking but was *neutral* about chemistry stated he took chemistry “so I have time to learn geometry/Algebra 2 and 10 science credits to lead up to physics.” Chemistry appears to be the class that is required or is a stepping stone towards another desired course especially with this particular college preparatory class.

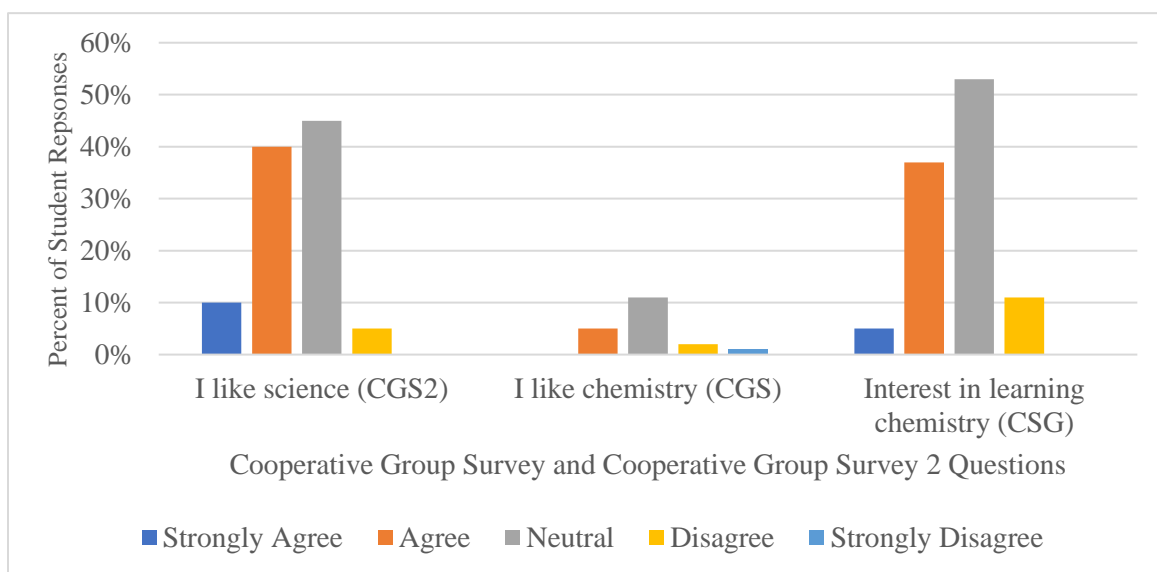


Figure 8. Student attitude towards science and chemistry. ($N = 21$)

INTERPRETATION AND CONCLUSION

The results of the CGS indicates 100% ($N = 21$) of the students have experienced working in groups in many classes and 33.3% enjoy working in groups *always* in

chemistry according to the CGS2 results ($N = 20$). Though most students indicated in the CGS explanations they would prefer to work with friends, it is important that the groups be carefully arranged to provide a heterogeneous mix to provide the personal and social advantages seen in other studies (Lazarowitz, Hertz-Lazarowitz, and Baird). Greater consideration needs to be applied to those students who find that chemistry comes easy to them when placing them in a group. These students will need support as well. For these students, the cooperative groups were not able to support the academic achievement that was found in Felder's chemistry classes. When there are only two strong students in a class, it becomes a difficult prospect for proper placement. Perhaps gender-homogeneous groups would be best for these students as suggested by Moody and Gifford (as cited by Slavin, 1996) as they stated larger achievement for these groups than gender-heterogeneous groups.

The results from the CGS2 indicates that 4.8% of students were *never* comfortable speaking while 19.0% were *occasionally* comfortable speaking with one another in their groups. Because, they cannot choose their friends for group members, the social skills needed for successful cooperative groups must be taught. The CGS2 results showed 28.6% came to class *occasionally* prepared, 61.9% were *often* prepared and only 9.5% were *always* prepared. This indicates greater steps need to be taken to promote individual responsibility that Johnson and Johnson (2002) describe as one of the five essential elements for successful cooperative groups so more students will arrive to class always prepared and not hinder their group's progress. Considering the training for cooperative groups could be several weeks or longer, starting earlier in the year could

have different results, and, perhaps, show a stronger correlation between the student belief that the groups clarify chemistry concepts, building their confidence in chemistry, and test scores could be established and, possibly, generate a more positive student outlook on science and increase the percent of students who *strongly agree* to liking science to more than the 10% indicated by the post-survey results, similar to the results seen by Okebukola (1985).

Though the time the groups were together was relatively short, approximately four weeks, through teacher observations the dynamics of most of the groups changed from just students sitting next to each other to groups feeling some responsibility for their group members' understanding. Members of two groups would come to class after school to study together on several occasions because "we work together well and help each other."

The data shows that individual test scores increase from treatment unit to nontreatment unit for 75% of the students. Therefore, cooperative groups have a positive effect on the individual learning outcomes for most students.

The majority of student attitude towards chemistry and 45% towards science remained neutral from CGS to CGS2. Cooperative groups did not appear to influence student attitude towards science or chemistry over the run of the four weeks of the treatment unit.

Students self-reported confidence in their understanding of chemistry concepts increased by 4.7% in the *often* and *always* helping categories and decreasing by 4.8% in the *occasionally* to *never* helping categories over the span of the cooperative group unit.

Therefore, cooperative groups had a positive effect and increased the percent of students feeling confident.

VALUE

With California on the verge of implementing the Next Generation Science Standards, what I learned during the research and implementation of this classroom research project will be useful. Science for all students will require developing new teaching strategies, or learning old ones and making them useful for situations. This research project indicates a correlation between the use of cooperative groups and achievement. To determine the extent of the correlation and how much of an effect cooperative groups have I would like to continue to use cooperative groups in my classes. Perhaps cooperative groups can be used to make science for all students understandable and perhaps developing an interest in science for some.

Developing a strong group dynamic takes time. Therefore, starting to build groups and teaching group techniques should be started much earlier in the year. In the coming year, I will start with teaching students how to ask higher level questions and how to explain their work so their classmates can understand at the beginning of the year by asking them to explain to a partner instead of a group, building to more people from that point. This will allow me to look to see which students perform best together and who has difficulty speaking with others. From this point, I will be able to tune lessons in group work for each class.

Teaching students the importance of communicating with others, whether verbally or through writing, is imperative to science learning with cooperative groups helping to

provide the practice needed for both. I found the cooperative groups allowed me to observe just how much the students had learned as they explained or questioned their group members about the material. This also allows students the opportunity to be the “expert” in a safe area. I found that I enjoyed hearing these discussions between the students.

Providing students with the responsibility to be a facilitator of a group gives them an opportunity to practice leadership skills. Working in groups of students who might not necessarily be their friends helps students learn to accomplish a goal in a group like a college or job setting where one does not get to choose who they work with for the most part. It has made me very aware of the group dynamics that need to be considered to create groups that provide support for all students will be challenging.

The use of surveys provided an insight that I found priceless and a useful tool. Because the students were told not to put their names on the papers, though many still did, the information seems more freely given and open. Noting student observations allowed me to look back to follow progression of behavior, look for improvement, and not rely so much on memory. This makes adjustment to teaching more precise for the need of the class or individual student. When writing the new curriculum for the Next Generation Science Standards chemistry courses, cooperative groups will play a large part. General high school chemistry, as I see it, will be moving away from a math based course into a more liberal arts style course, more conceptual, providing me the opportunity to fill the lessons with opportunities for discussions connecting chemistry to everyday life.

I have become keenly aware of the value of pre- and post-testing as an information feedback tool for teaching improvement. This will be more crucial with the changing of the curriculum to ensure that students are learning the material. This data, combined with observation, student surveys can be used to adjust curriculum and teaching strategies for current and future students.

My research indicated that cooperative group learning increases achievement for both African-American and Hispanic students. Classrooms are becoming increasingly diverse and West High School's Hispanic population fluctuates in the mid to low 50% range, making the incorporation of cooperative group learning advantageous to the school's population. One of my colleagues has already inquired about the results of my next step with cooperative groups which will be shared with her with my department and principal.

Entering the next unit outside of the research project, I have continued with cooperative groups but will be using gender-homogeneous groups, as suggested by the study by Moody and Gifford (as cited by Slavin, 1996) to pull the less talkative students into participating and to compare the results from this unit to the results from this project.

In the future, I would use a "personality" survey to find what the students think of themselves in their ability to work with others. Asking questions such as "Are you talkative around people you are not familiar with?" or "Do you see yourself as leader or a follower?" could provide me with enough insight that I could arrange groups that had more interaction throughout the class. Students asked that I provide more time for group work that was to be completed in class, I will need to adjust what I think should be done

in a certain amount of time to what is capable of being done by the students when working together and discussing material. New groups every quarter using different criteria to set them up each time would also be helpful in exploring the benefits of cooperative groups and allow students to learn how to work with different people as they will have to in the work world.

I feel that what I have learned can make me a better teacher and as I put this learning into practice, I will provide my students with a richer classroom experience.

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APPENDICES

APPENDIX A
IRB APPROVAL



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
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MEMORANDUM

TO: Kimberly Stewart and Walt Woolbaugh
FROM: Mark Quinn *Mark Quinn CJ*
DATE: February 13, 2017
RE: "The Influence of Cooperative Groups on Individual Learning Outcomes in a High School Chemistry Course"
[KS021317-EX]

The above research, described in your submission of February 13, 2017 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:

- (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.
- (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

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

APPENDIX B
COOPERATIVE GROUP SURVEY

Cooperative Group Survey

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

	Always	Often	Occasionally	Never
1. I work in groups in my high school classes.	4	3	2	1
1a. Please tell why you answered the way you did in the above question.				
2. I like to work in groups.	4	3	2	1
3. Have you had a good (or bad) experience in groups? Please explain.				
3. The groups are chosen by students.	4	3	2	1
4. There seems to be three kinds of groups when students choose partners: those that can do the work, those that are ok with the work and those that can't or don't care about the work.	4	3	2	1
5. Working in groups helps me understand concepts better.	4	3	2	1
5a. Please tell why you answered the way you did in the above question.				
6. Working in groups helps me understand CHEMISTRY concepts better.	4	3	2	1
7. I fully participate when working in groups.	4	3	2	1
8. When working in groups, I don't always write complete answers to questions because other group members can turn in the work for me.	4	3	2	1
9. While working in groups, the members ask me questions pertaining to the lesson.	4	3	2	1

10. I am able to stay on task while working in groups.	4	3	2	1
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Please answer the following questions completely.

10. What do you like or dislike about working in groups? You can use bullet points.

11. If you were able to choose group members, what type of person would you chose to work with and why? No names please.

APPENDIX C
CHEMISTRY SURVEY

Chemistry Survey

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

Strongly Agree Agree Neutral Disagree Strongly Disagree

1. I understand that science, including chemistry, is important for me to learn.	5	4	3	2	1
2. My future career plans involve science and/or chemistry.	5	4	3	2	1
2a. Please explain why you answered the way you did in the above question					
3. I like chemistry.	5	4	3	2	1
3a. What is it you like about chemistry? Please be specific.					
4. I am interested in learning about chemistry.	5	4	3	2	1
5. I am able to follow and understand the concepts being taught in chemistry.	5	4	3	2	1
5a. Please explain why you answered the way you did in the above question.					
6. I feel that I can ask questions in class if I don't understand what is being taught.	5	4	3	2	1
7. I feel that my math ability will not be a problem in solving chemistry problems.	5	4	3	2	1

8. I feel that my reading level is sufficient to understand the text and word problems.	5	4	3	2	1
---	---	---	---	---	---

9. What is/are the reason(s) you are taking chemistry? You can use bullet points. Please answer completely.

APPENDIX D
CHEMICAL QUANTITIES PRE-TEST

Chemical Quantities Pre – Test

Answer the following. Please write clearly. Any calculations must have boxed answers with correct units, report answers to the 1/100ths, 0.01 position.

1. What is the mass of one atom of carbon? _____ amu
2. What is the mass of one mole of carbon? _____ g/mol
3. How many atoms of each element are in ammonium phosphate, $(\text{NH}_4)_3\text{PO}_4$?
_____N _____H _____P _____O
4. What is the mass of one mole of $(\text{NH}_4)_3\text{PO}_4$? _____ g/mol
5. A bag contains 5 blue marbles, 6 green marbles, 3 red marbles and 6 cat's eye marbles.

What percent does each marble make-up of the bag?
6. What is the percentage composition (make-up) of water, H_2O ?
7. A substance contains 29.4% calcium, 23.5% sulfur, and 47.1% oxygen. Determine the empirical formula.

APPENDIX E
CHEMICAL QUANTITIES POST-TEST

Chemical Quantities Post-test

Answer the following. Please write clearly. Any calculations must have boxed answers with correct units, report answers to the 1/100ths, 0.01 position.

1. What is the mass of one atom of Na? _____ amu
2. What is the mass of one mole of N? _____ g/mol
3. How many atoms of each element are in one mole of $\text{Pb}_3(\text{PO}_4)_2$?
_____ Pb _____ P _____ O
4. What is the mass of one mole of $\text{Pb}_3(\text{PO}_4)_2$? _____ g/mol
5. A bag contains 5 blue marbles, 6 green marbles, 3 red marbles and 6 cat's eye marbles.

What percent does each marble make-up of the bag?
6. What is the percentage composition of AlCl_3 ?
7. A substance contains 34.95% carbon, 6.844% oxygen and 13.59% nitrogen. Determine the empirical formula.

APPENDIX F
COOPERATIVE GROUP SURVEY 2

Cooperative Group Survey 2

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

	Always	Often	Occasionally	Never
1. I liked working in the cooperative group during the last unit in chemistry.	4	3	2	1
1a. In the space to the right, please tell why you answered the way you did in the above question.				
2. My group members were comfortable speaking with one another.	4	3	2	1
2a. In the space to the right, please explain why you answered the way you did in the above question.				
3. This unit contained difficult to understand information.	4	3	2	1
3a. In the space to the right, please explain why you answered the way you did in the above question				
4. Because of my group, my understanding of the concepts is BETTER than what it would have been if I had worked alone.	4	3	2	1
4a. Please tell why you answered the way you did in the above question.				
5. Even though the leadership position rotated in my group, I found I played the leadership role most of the time.	4	3	2	1

<p>5a. In the space to the right, please tell why you answered the way you did in the above question.</p>				
<p>6. When working on a group assignment, each member came prepared with previously completed work.</p>	4	3	2	1
<p>6a. In the space to the right, please tell why you answered the way you did in the above question.</p>				
<p>7. I would prefer to continue working in the same group I am assigned to now.</p>	4	3	2	1
<p>7a. In the space to the right, please tell why you answered the way you did in the above question.</p>				
<p>8. I like science.</p>	4	3	2	1

8a. In the space to the right, please tell why you answered the way you did in the above question.

In the space below, please provide suggestions to improve the cooperative groups.

For each suggestion, provide a reason for its use. Please follow the numbering method in the survey above, i.e. number for suggestion and number and letter "a" for reason.

Suggestion

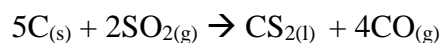
Reason

APPENDIX G
STOICHIOMETRY PRETEST

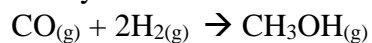
Stoichiometry Pretest

Show all work. Box answer with correct substance and units.

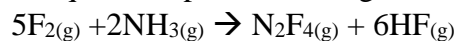
1. How many moles of CS₂ when 2.7 mol C reacts?



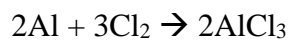
2. How many grams of H₂ necessary to react with 2.85 mol CO?



3. How many grams of NH₃ are required to produce 4.65 g HF?



4. What is the maximum amount of product that can be formed when 81.0 g Al is mixed with 376. g Cl₂?



APPENDIX H
STOICHIOMETRY POSTTEST

Stoichiometry Posttest Chem Prep Form A
Name: _____

Fill in the blank.

- The _____ controls the amount of the product that can be produced.
- The _____ tells the chemist how productive the reaction is.
- The _____ reactant has left overs when the reaction has run to completion.
- _____ is calculated and is the maximum amount of product that can be made.
- The _____ is the amount that is produced during a lab experiment.
- _____ comes from the balanced equation and is used to convert moles of given into moles of unknown.

Multiple Choice. Write the CAPITAL letter for the BEST answer on the binder paper.

- In the reaction $2\text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2$, what is the ratio of moles of oxygen used to moles of CO_2 produced?
 A. 1:1 B. 2:1 C. 1:2 D. 2:2
- Which of the following is the CORRECT interpretation of the balanced equation shown below?

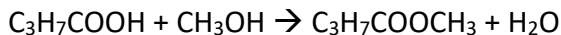
$$2\text{S} + 3\text{O}_2 \rightarrow 2\text{SO}_3$$
 A. 2 atoms S + 3 atoms $\text{O}_2 \rightarrow$ 2 molecules SO_3
 B. 2 g S + 3 g $\text{O}_2 \rightarrow$ 2 molecules SO_3
 C. 2 mol S + 3 mol $\text{O}_2 \rightarrow$ 2 mol SO_3
 D. None of the above
- How many moles of aluminum are needed to react completely with 1.2 mol of FeO?

- $$2\text{Al} + 3\text{FeO} \rightarrow 3\text{Fe} + \text{Al}_2\text{O}_3$$
- A. 1.2 mol B. 0.8 mol C. 1.6 mol D. 2.4 mol

Solve the following problems. Show all work legibly and orderly. All units must be included. Answer must be boxed. NO WORK, NO CREDIT.

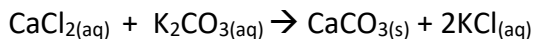
- Potassium chlorate is sometimes decomposed in the laboratory to generate oxygen. The reaction is $2\text{KClO}_3 \rightarrow 2\text{KCl} + 3\text{O}_2$. What mass of KClO_3 do you need to produce 0.50 mol O_2 ?(3pt)

11. Methyl butanoate ($C_3H_7COOCH_3$), an oily substance with a strong fruity fragrance can be made by reacting butanoic acid (C_3H_7COOH) with methanol (CH_3OH) according to the following equation:



What mass of methyl butanoate is produced from the reaction of 52.5 g of butanoic acid? (3 pts)

12. The following data was collected during a lab. Use this data answer the questions.



1.38 g $CaCl_2$ and 1.36 g K_2CO_3 were measured, dissolved in water and the solutions were mixed. The mass of the filter paper before the lab was 0.88 g. A solution was poured through the filter. The filter with the solid product was set out to dry overnight. The next day, the filter with the product was measured again. The mass of the filter paper and solid was now 1.68 g.

- Determine actual yield. (1 pt)
- Determine theoretical yield (2 pts)
- Determine limiting reactant (1 pt)
- Determine percent yield (1 pt)

Extra Credit. (1 point each)

The graph below shows the formation of $AgCl$ from the reaction of $NaCl$ and $AgNO_3$.

- Write a balanced equation, with states, for this reaction.
- Which line segment represents $NaCl$ as the limiting reactant?
- Which line segment represents $AgNO_3$ as the limiting reactant?
- Where the segments intersect (cross), how many moles of $AgNO_3$ are used in the reaction?

