THE EFFECT OF STRUCTURED COOPERATIVE LEARNING STRATEGIES ON STUDENT ACHIEVEMENT IN SCIENCE

by

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ABSTRACT

The focus of this classroom research project was to determine if implementing structured cooperative learning groups as a teaching method would increase students' achievement in the chemistry classroom. Additionally, the investigation explores students' ability to retain the content as well as examining their overall attitude towards working in groups.

A treatment and nontreatment group were established to compare the results of administering structured cooperative learning versus teacher led instruction. Test scores as well as student surveys, interviews and teacher journaling were used to measure the outcome of the treatment.

Results of the action research showed no significant difference in the students' achievement in terms of test scores among the treatment and nontreatment groups. Further examination of the results however, indicated that students were more engaged in the learning process and did recognize benefits of working in structured cooperative learning group. Overall, students believed that cooperative learning did help them to remember content material and was a positive learning experience.

INTRODUCTION AND BACKGROUND

I have been teaching at Rancocas Valley (RV) Regional High School in Mount Holly, New Jersey for the past 18 years. Due to my comprehensive certification, over the years I have taught biology, physical science, and three levels of chemistry. Our regional high school houses more than 2000 students who hail from five sending districts: Eastampton, Westampton, Hainesport, Lumberton, and Mount Holly, spread out over approximately 40 square miles of Burlington County ("Rancocas Valley Regional High School," n.d.). The population of Burlington County as a whole is made up of 70.6% White, 16.6% Black, 6.4% Hispanic or Latino, 4.3% Asian, and another 2.3% of two or more races (City-Data.com, 2012). Students of Rancocas Valley High School are diverse and active learners. My goal is to channel this energy and diversity into a productive learning environment. I believe that with the proper implementation of structured cooperative learning techniques students will gain an increased understanding of the curriculum, greater achievement on assessments and an overall improvement in the collaborative spirit among fellow students. The key is to find the right combination of grouping strategies and facilitation techniques to make it a productive learning activity.

There are hundreds of studies that describe the benefits of cooperative learning in the classroom. Certainly there is merit in the old saying "two heads are better than one" when it comes to problem solving, so perhaps three or four heads may prove even more beneficial. The problem lies in distinguishing between grouping students to actively engage in the learning process, and simply putting students together in a group setting. Over the years I have been engaged in professional development training that introduced cooperative learning structures. In my classroom I have made attempts at setting up cooperative learning groups but have not been able to realize the benefits many researchers describe and as a result quickly abandoned the process. In my experience with establishing cooperative learning groups, student discussion quickly disintegrates into talk of daily activities, student conflicts, current TV shows, and any number of other topics other than the task at hand. Even as I circulate the room, my job becomes exhausting in refocusing the groups rather than facilitating productive discussion. I do believe cooperative learning can offer benefits to both student and teacher and therefore I am interested in investigating how to master the art of its implementation.

My primary focus for this project was to research the effect of using structured cooperative learning strategies to improve student achievement in the science classroom. Within the scope of my research I wanted to address several secondary questions to help measure the success of my implementation. I explored whether students' retention of content improved through the use of cooperative learning. In addition, I investigated whether productivity and participation increased when students were assigned specific roles within the group. In accordance with that, I explored student attitudes towards heterogeneous grouping and the combinations of members that affect their comfort level within the group. Finally, I looked at students' attitudes toward using cooperative learning strategies as a way to master the science content.

CONCEPTUAL FRAMEWORK

In preparing students for college and career readiness it seems only appropriate that they should learn how to work with others in a cooperative and productive manner.

Whether tackling a lab, embarking on a project, problem solving, or developing mastery of a new scientific concept, it would seem beneficial to be able to work together with their classmates to collectively solve the challenges of the day while developing social interaction skills. The notion of a cooperative learning classroom conjures up visions of students actively engaged and positively interacting with each other in the learning process. Unfortunately, placing students together in a group to accomplish a task is not always as cooperative, productive, or as beneficial as many teachers envision (Johnson, 1989). Understanding what is and isn't cooperative learning, its pros and cons, and what strategies will yield the greatest benefits to student learning is crucial in orchestrating a successful cooperative classroom as a method of teaching.

"Cooperative learning is the instructional use of small groups so that students work together to maximize their own and each others' learning." (Johnson, Johnson,. & Holubec, 1993, p.1). Johnson et al. go on to describe five basic components necessary for cooperative learning to be productive. First, students must recognize positive interdependence. In other words, students must embrace the fact that they must work together for the benefit of the entire group. If one member fails, then the whole group fails. Second, groups must have both individual and group accountability in achieving goals. Individual and group efforts must be evaluated to recognize strengths and weaknesses. The third component is called promotive interaction meaning that students provide supportive roles to each other in attaining their goals. Fourth, students must be taught the interpersonal and social skills necessary to be successful in a group atmosphere and finally, groups must reflect on their cooperation efforts to review what worked and what didn't in meeting their goals. Although there are variations to these five components, proponents of cooperative learning recognize them as key to successful implementation of the process. Simply placing students into groups of three to five members and asking them to work together does not constitute cooperative learning. It instead is a very complex system of very deliberate steps that must come together for a successful outcome. (Johnson, Johnson,. & Holubec, 1993, p.7-8)

Ultimately there are hundreds of studies touting the benefits of a cooperative learning classroom. The methodologies vary greatly and can involve very specific and structured techniques or simple grouping methods. Research by David Johnson and Roger Johnson led them to conclude that "Generally achievement and productivity are higher in cooperative situations resulting in more frequent use of higher-level reasoning strategies, more frequent generations of new ideas and solutions and greater transfer of learning than individual or competitive efforts" (Johnson & Johnson, 1989, p. 57). Time after time studies conducted on cooperative learning have yielded similar conclusions. Analysis of over 1200 studies shows, "Cooperative learning promoted higher individual knowledge than did competitive and individualistic learning, whether the task required verbal, mathematical, or physical skills. Most important, the retention of knowledge was greater." (Herreid, 1998, p. 553). Herreid describes improved attitudes toward learning science, better social skills, and a greater appreciation for differences in viewpoints when cooperative learning is used versus traditional teacher-centered learning. In addition, students benefit from more active participation and personal responsibility since they must contribute to the success of the group. The cooperative learning approach has also shown benefits to the subject of mathematics. In a study conducted in secondary mathematics, students experienced greater understanding with complex problem solving when working with a group versus individual learning. (Whicker, Bol, & Nunnery, 1997). This easily translates to the type of complex problem solving encountered in the chemistry classroom as well where students could benefit from the collaboration with their classmates. In a study of undergraduate students of physics, scores on tests requiring higher order thinking skills were improved when students were given the opportunity to work collaboratively on problems (Gokhale, 1995). Gokhale found that students benefitted from sharing their ideas and reasoning with each other, allowing time to reflect on and internalize their own understanding. Certainly this coincides with constructivist teaching which promotes active learning to build meaning for the student and help them retain the information. In addition to building higher order thinking skills, cooperative learning also provides benefits to students socially. A study conducted with middle school students found that the more frequently cooperative learning strategies were used, the more positive students felt about the social support in the classroom (Johnson, Johnson, Buckman, Richards, 1985). From various studies, it seems clear that cooperative learning can provide many benefits to all types of learners and can foster positive feelings of achievement for both the individual and group as a whole in mastering the science content. This type of learning seems especially appropriate to science since the scientific community often works in groups to investigate and analyze specific issues.

There are many suggestions for success and many factors that can contribute to the breakdown of a successful group interaction and goal achievement. One example of a negative effect is that of the 'free-rider effect' (Kerr, Bruun, 1983, p. 92) which describes a loss of motivation of group members as they perceive a lack of worth in their contribution to the group's outcome. Alternatively, the 'sucker effect' (Kerr, 1983, p.819) occurs when a high performing student is stuck doing all of the work while the rest of the group flounders. Kerr found that the larger the group, the more likely it is that some members would feel dispensable within the group and therefore put forth less effort (Kerr & Bruun, 1983). One way to combat both situations seems to be through the use of peer evaluations to ensure that all members are contributing to the overall success of the group (Dingel, Wei, & Huq, 2013). A similar study indicated that peer evaluations used early and with some frequency could reduce the incidence of "free-riders" or the "sucker effect" as well as provide valuable feedback in the learning process (Brooks & Ammons, 2003). However, it was noted in the study by Dingel (2013) that while peer evaluation can be a valuable tool as part of the instructor's assessment of individual performance, students' evaluations are usually a judgment of each other's effort during the process and not necessarily the quality of their work.

Students' participation as an active member of the group is paramount to their mastery of the topic at hand. As indicated by Webb (1993), success as a group may not reflect individual learning aptitudes. Problems such as free-riders or the sucker effect means that not all students may be active participants in the learning process and when assessed individually, their scores reflect a lack of mastery of the material being covered. Additionally, high performing students who routinely participate may exacerbate the situation by monopolizing the group and reaping the benefits, referred to as the "rich get richer" effect (Johnson, 1989). These students tend to perform better because they have played an active role and processed the information more fully in their contributions.

Each of the pitfalls above can be attributed to the difficulties in finding the perfect grouping strategy. Many studies have been conducted with varying results. According to one study, having only one high achiever in a group, termed the "superstar effect" can lead to discourse among group members since the high achiever tends to dominate and override the rest of the group (Nihalani, 2010). While in another study students who were categorized by their problem solving style were more successful when there was a mix of styles to complement each other (Lamm, Shoulders, Roberts, Irani, Snyder & Brendemuhl, 2012). Most would agree that heterogeneous grouping provides the most benefits. This type of grouping allows for greater diversity in ideas and perspectives, while encouraging cooperation among both high and low achievers and the development of social skills (Jacobs, Power & Inn, 2002). There are many other considerations in grouping students according to Jacobs, Power, and Inn, including gender, ethnicity, social class, work ethic, personality, aptitude level, and special needs. In one study of secondary mathematics students, researchers found that while students enjoyed the cooperative learning techniques and social interaction, they favored frequent changing of the group members (Whicker, Bol, & Nunnery, 1997). Clearly there is a lot of thought that could go into the grouping process and once groups are formed, work may need to be done to develop harmony within the group such as using team building or social skills activities to foster camaraderie among members. The amount of time spent forming groups may be dependent on the goals and scope of the lesson. For quick reviews or small lab assessments groups may be quickly arranged and varied often giving students the opportunity to work with more of their classmates. However, for long term projects or labs that may require a greater interdependence, there are benefits to maintaining more carefully considered and established groups.

Assuming that students are appropriately and strategically placed into groups, the next obstacle becomes keeping students on task and actively accomplishing the goals of the lesson. Again there have been many studies to support the benefits of cooperative learning but defining cooperative learning or differentiating it from "group work" is the key. Studies have shown that there is a big difference between structured and unstructured grouping methods. In one such study, students who received training in cooperative learning techniques prior to its implementation reported a greater overall satisfaction and positive cooperative spirit among group members (Gillies, 2004). According to Gilles, these students valued their member's contributions and were less likely to cause disruptions or interrupt each other. Unfortunately, those in the unstructured groups did not receive the same training and displayed more behavioral issues in addition to being off task. A similar study reported that although there was not a significant difference in knowledge or comprehension, students did perform better in application questions indicating higher-order thinking skills were improved (Chang & Mao, 1999). This same study reported the teacher's acknowledgement that they too enjoyed the cooperative spirit of the students but that the implementation of cooperative learning requires significant planning and time management skills from the teacher. Gilles (2010) reported the same findings in another of her studies examining teacher perceptions of cooperative learning. Interviews with the teachers in Gilles study revealed the teachers feelings of a more friendly and relaxed classroom and an ability to elevate expectations of the students. However, the same teachers also reported an increase in time required to plan, implement, and manage the students to maintain an effective cooperative learning atmosphere.

There are many sources available to aid teachers in developing a structured or cooperative learning method of presenting subject material. Some of these are Student Teams Achievement Divisions (STAD), Teams Game Tournament (TGT), and Jigsaw II (Slavin, 1994). Another very popular resource for cooperative learning strategies are those of Dr. Spencer Kagan. Kagan structures have been adapted for use in all subjects and grade levels to provide fun and active ways of presenting material. In addition, they can be custom fit into any time frame and to accommodate any number of student grouping schemes from two to four or more students (Plumb, 2005).

One of the ways to ensure students are actively participating as part of the group is to assign specific roles for each student to assume. At Franklin & Marshall College in Lancaster, PA a new method of teaching introductory chemistry was introduced to students (Farrell, Moog, Spencer, 1999). Using a system known as Process Oriented Guided Inquiry Learning (POGIL), students were assigned roles within the group such as manager, recorder, spokesperson and process analyst. Students in each group worked together to examine or interpret information or models in an effort to construct understanding of the chemistry concept. Results of the study showed a decrease in withdrawals from the course and an increase in exam scores (Farrell et al., 1999).

Proponents of POGIL methodology point to an increase in critical thinking and application skills as well as better communication among group members since all are held responsible for their part in the activity (POGIL, n.d).

"It is only under certain conditions that group efforts may be expected to be more productive than individual efforts" (Johnson & Johnson, 1989, p. 75). Finding the right balance to meet the needs of the students' learning styles while providing a structured and productive learning environment can be a significant challenge. There are many things to consider in implementing cooperative learning. Addressing high and low achievers, varying learning styles, and maintaining active participation are just a few of the considerations in putting together a positive group experience. The benefits to cooperative learning, however, are numerous and if this balance can be achieved both students and teachers will enjoy the fruits of a more active and fun way to learn and reach higher achievement and understanding of the science curriculum.

METHODOLOGY

My classroom research project focused on implementing structured cooperative learning as a teaching method and evaluating its effect on student achievement, content mastery and retention. My research goal was to investigate and answer the questions: what are student attitudes towards cooperative learning?; do they enjoy working collaboratively or would they prefer individual or teacher led instruction? My research also examined whether student achievement can be improved if students are assigned specific roles within the group, and finally, does cooperative learning affect their attitude towards learning the science content? The emphasis for me was to utilize very structured cooperative groups that are designed to maximize student participation and accountability.

Participants

Having two classes of the same level in chemistry allowed me to maintain a treatment and nontreatment group to explore how cooperative learning techniques impact student learning. For the Spring semester, I taught two honors chemistry classes which consisted of primarily eleventh grade students and a few sophomores. There were 26 students in the treatment group and 25 students in the nontreatment group. Of the 51 students participating there are 24 males and 27 females. The population of students was comprised of 66% white, 14% black, 12% Asian, 6% Hispanic and 2% American Indian. This classroom research project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

Implementation

During the classroom research both the treatment and nontreatment groups covered the same two units of Properties of Matter and Atomic Structure, which generally span over a period of about six weeks. In each group a pretest was given to gather baseline data regarding the material to be covered. The nontreatment group received teacher-centered instruction including PowerPoint notes, worksheets, textbook questions, labs, and station learning activities as utilized in the typical classroom. The treatment group experienced primarily structured cooperative learning activities particularly to introduce and reinforce concepts presented. In addition, the treatment group also participated in station learning activities and labs as part of the unit instruction.

Prior to the first group activity, students in the treatment group received instruction and practice in utilizing cooperative learning skills. I think it was important for the success of the treatment, to prepare the students for their active participation by providing examples and making the expectations clear. Activities implemented required the students to assume roles within the group assigned and to reflect and evaluate participation of group members following the exercise. Several different formal and informal checks were utilized to monitor student accountability such as oral questioning, short quizzes and essays, and group reflection sheets.

To communicate the expectations of the group roles, examples of appropriate behavior and responses were provided to the students in the form of role cards (Appendix A). An example of how the groups should work together was presented by modeling a short group activity on lab safety. Following the activity, students were asked to critique their group interactions. Discussion regarding effective communication and participation among the group members was conducted to help to facilitate positive behavior and lay the groundwork for productive group activities in future lessons.

An example of one of the cooperative learning activities in the Properties of Matter unit, is the utilization of a Process Oriented Guided Inquiry Learning (POGIL) exercise to introduce the classification of matter into elements, compounds and mixtures. Groups were arranged using a random group generator and group size was limited to no more than four students per group. Each group member was assigned a role in the group and reminded to make sure that all group members were given the opportunity to contribute to group discussions and that all members should share and record the same answers for the lesson. Following the POGIL activity, students were asked to complete a short analysis of their group's participation and productivity (Appendix B). In addition, students were given short follow up quizzes pertaining to the material covered to assess understanding. An example of one quick quiz used to check understanding is given in Appendix C.

Other examples of cooperative learning activities within the properties of matter unit included a group sorting activity on physical and chemical properties along with experimentation design, a physical and chemical change lab, a POGIL activity on the kinetic molecular theory as it applies to the gas laws, and the examination and explanation of gas law demonstrations as station learning.

The Atomic Structure unit included POGIL activities on exploring the structure of atoms and isotopes, the determination of average atomic mass using the Boss/Secretary Kagan strategy, and representation of electron configuration, as well as lab activities on average atomic mass, flame tests of inorganic salts and Bohr model designs. Each time a cooperative learning activity was implemented students were assigned new group members and assumed different roles within the group. The nontreatment group was provided the same labs and station learning activities as the treatment group, but were otherwise taught content through traditional teacher led instruction. Both groups were given several different assignments to check understanding of content material such as quizzes, homework assignments, discussion questions, and unit tests.

Data Collection

Data was collected through the use of short quizzes, homework and oral questioning as well as pre and post test comparisons of the two groups (Appendix D). The quick checks administered allowed for assessment of individual accountability of each student. By comparing the pre and post scores of the treatment and nontreatment groups, I was able to evaluate the differences in topic mastery and retention of the material. In addition, student surveys and interviews were used to assess student attitudes regarding the cooperative learning process and its use as an instructional method as compared to traditional methods. Student surveys (Appendix E) were administered to the treatment group prior to and following the cooperative learning treatment to compare their attitude towards group work before and after the experience. Students were chosen for the interview (Appendix F) by selecting one male and one female representing each academic level (high, medium, and low) for a total of six students.

In addition, a teacher journal was consistently maintained to document observations on student participation during the cooperative learning activities. These observations included monitoring students' discussions and overall attitudes during the activity as well as assessing student involvement and contributions to the group. Efforts were made to ensure that each group member was fulfilling their assigned role by requiring specific tasks to be performed for each role. For example, those designated as the spokesperson were required to answer for their group and formulate any questions the group had about the activity. A summary of the data collection tools used is provided in Table 1.

Table 1
Data Triangulation Matrix

Primary Question - What is the effect of using structured cooperative learning strategies to improve student achievement in the science classroom.			
Subquestions	Data Source 1	Data Source 2	Data Source 3
1. Is retention of course content improved by the implementation of cooperative learning groups?	Pretest and Post-test summative data	Formative assessments/Formal and Informal checks	Student surveys
2. Are students more engaged and productive when assigned specific roles within the cooperative learning group?	Teacher observations and journaling	Student surveys including self and peer evaluation forms	Student Interviews
3. What are students attitudes about working in heterogeneous groups?	Teacher observations and journaling	Student surveys	Student Interviews
4. Does working in structured groups improve student attitudes towards learning the science content?	Teacher observations and journaling	Student surveys	Student Interviews

DATA AND ANALYSIS

Two honors level chemistry classes made of up primarily juniors were chosen for this action research project. Data collection for the study began with an assessment in basic science calculations to obtain a comparison of the treatment and nontreatment groups' baseline knowledge. Results of the test revealed that students had a good grasp of basic math skills required for chemistry and a two-tailed t-test conducted on the data showed no statistical difference between the treatment group which had a mean of 91.1% and a standard deviation of 8.89 and the nontreatment group with a mean of 91.4% and a standard deviation of 7.97; *t*(49)=2.01, p=0.892. These results indicated that both groups were very comparable in their background and ability level for chemistry.

Impact of Cooperative Learning on Content Retention

Working in structured cooperative learning groups did not significantly impact retention of course material. Results of the post tests for both unit 2 on properties of matter and unit 3 on atomic structure showed no significant difference in tests scores between the treatment group and nontreatment group. Students receiving the treatment had a mean score of 87.42% and a standard deviation of 9.85 on the unit 2 test while the nontreatment group had a mean score of 88.48% and a standard deviation of 7.60. While the overall mean of the unit 3 test displayed lower results most likely due to the increased rigor of the material, the results again demonstrated no significant difference in test scores between the treatment group (M=82.62%, SD=12.64) and the nontreatment group (M=83.40%, SD=14.51). Figure 1 displays the results of the mean scores for both groups.

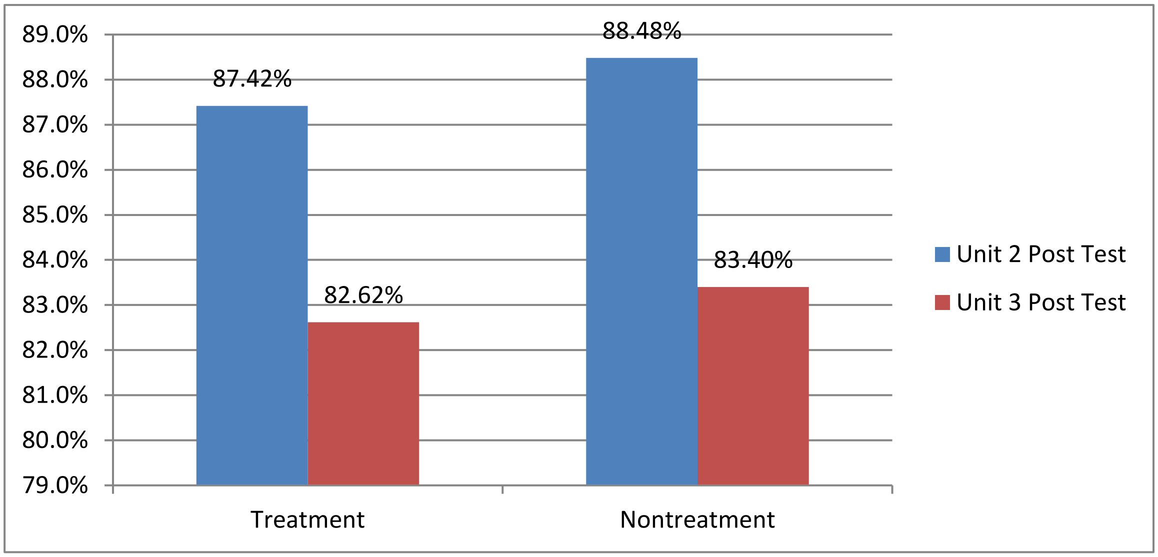

Figure 1. Treatment and nontreatment mean test scores, Unit 2 and Unit 3, (*N*=51).

Prior to starting the cooperative learning treatment, a Likert survey was conducted on the group designated for the treatment to assess their attitude toward cooperative learning (Appendix E). When asked if students felt cooperative learning helps them to understand the subject better, 58% agreed or strongly agreed that it did help them in learning the material while another 38% remained neutral and only 4% disagreed. Following the treatment a shift in the responses showed that only 42% still felt that cooperative learning helped in their understanding , 46% were neutral, and those that disagreed or strongly disagreed increased to 12%. Figure 2 depicts the shift the students responses.

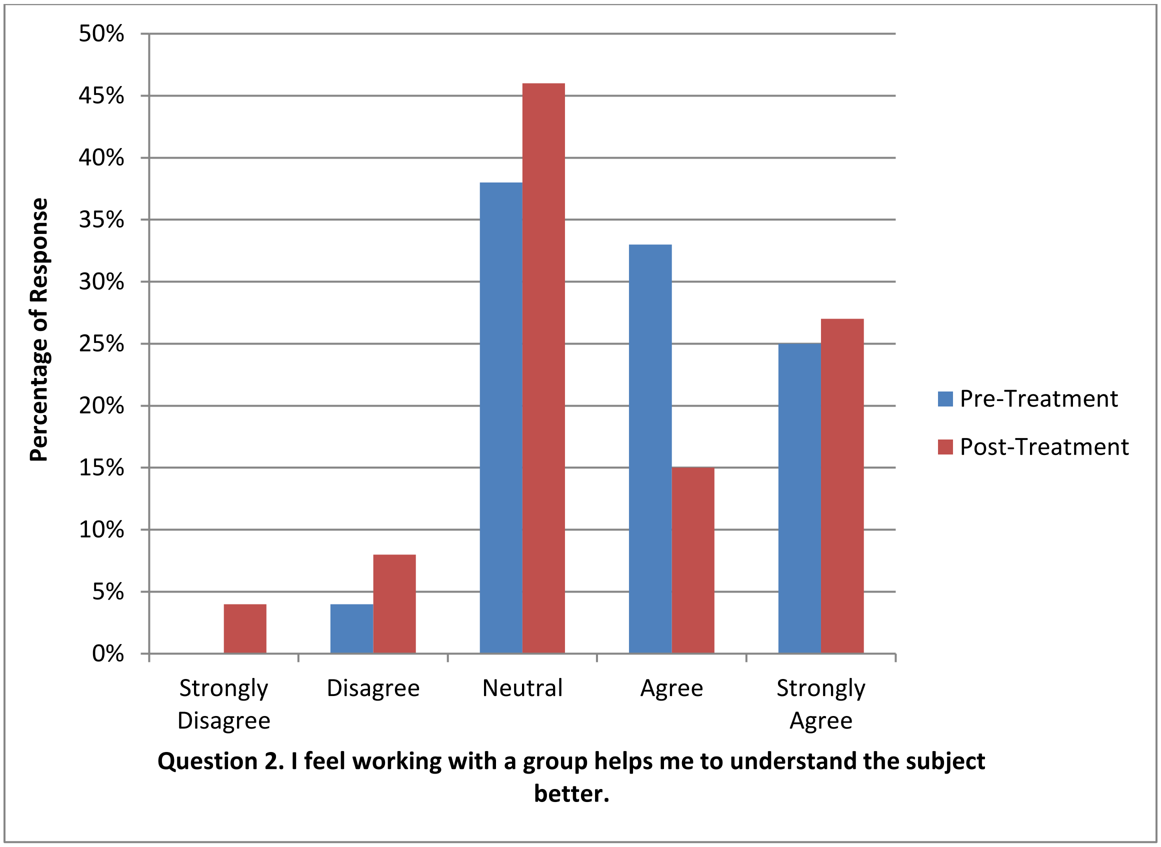

Figure 2. Student pre and post response to Question 2 of student survey, (*N*=26).

In a similar question students were asked if they felt they had an easier time remembering the lesson when working in a group. Here students' responses were slightly more positive, shifting from 63% to 69% that agreed or strongly agreed while those who were neutral or disagreed dropped from 37% to 31% as shown in Figure 3.

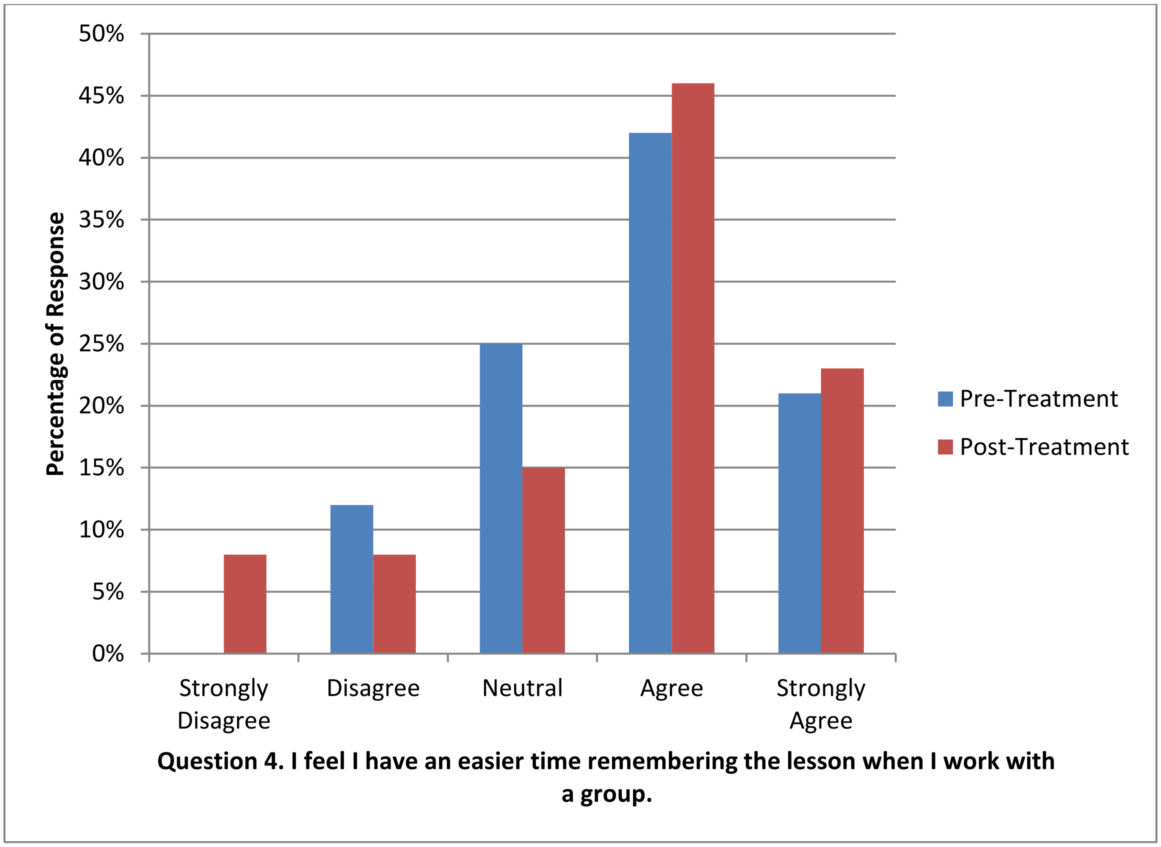

Figure 3. Student pre and post response to Question 4 of student survey, (*N*=26).

Quick checks, exit tickets, and direct questioning showed no significant difference in students' ability to recall the lesson. Appendix C shows an example of a Quick Check Quiz used in evaluating students' proficiency following a lesson. These short quizzes were used to assess understanding and served as a quick recap after completion of the activity. Students in both the treatment and nontreatment groups demonstrated an understanding of the content material and were able to successfully complete informal questioning.

While the test scores did not indicate a significant change in retention, the majority of students who were interviewed supported cooperative learning as a means to improve retention understand the course content. Students cited the discussion and contributions of each member as a benefit to their own understanding since it allowed them to hear other viewpoints and process the information. One student stated, "I find that I actually understand the material more as I am forced to reflect more deeply upon it to explain it to someone else." Another student commented, "For me, a conclusion reached through engaging in a discussion with you and the group is retained for a longer period of time than just listening in class."

Impact of Cooperative Learning on Student Engagement

Students are generally more engaged and productive during cooperative learning. As a data collection source, teacher observations and journaling was conducted during all cooperative learning activities with the treatment group. Consideration was given to time on task for student groups, pacing of students progress within a group and from group to group, contribution to discussion of team members overall and within the scope of their assigned roles, and indicators of understanding of the learning activity. With regard to time on task, it was noted that students were actively engaged in addressing the questions posed during the activity. Debate between group members was observed and students worked cooperatively to reach agreement on their final answers. Students were reminded that as questions arose, only the person designated as the spokesperson could address the instructor to ask for help. With this stipulation, more often students would resolve the issue amongst themselves without invoking help from the instructor. Pacing within and among groups is always a factor when facilitating cooperative learning activities. Frequent stop, or check points were used to maintain consistency in pacing while questions directed at the groups' spokesperson was used to verify understanding as the activity progressed.

Following the first cooperative learning activity students in the treatment group completed a Process Analysis Survey (Appendix B) which provided a self evaluation as a group in terms of their time use and effectiveness. All groups indicated nearly 100% productive use of time and team effectiveness when evaluating themselves using the scale diagram. When asked what the assigned group did particularly well, students answered that they stayed on task and were able to work together in answering each other's questions. For areas of improvement, some said that they needed to communicate more and make sure everyone is working at the same pace. Overall, students reported no frustrations with the process. Additional Process Analysis Surveys showed similar results indicating that students were comfortable with the process and understood the expectations.

It was noted that early use of cooperative learning groups yielded the best and most productive participation. As students became more familiar with the process and with each other, communication and cooperativeness remained consistent, however time on task declined slightly due to faster accomplishment of the learning activity's goals and greater socialization. Enforcement of the structured roles was more difficult to maintain as comfort levels grew and even as the facilitator, it was difficult to refrain from answering questions from random from group members instead of the designated spokesperson.

Based on the student survey, 75% of the students from the treatment group either agreed or strongly agreed that working in a group kept them interested and motivated while working on the lesson. Comparatively, 79% of the respondents disagreed or strongly disagreed that working in a cooperative group setting was distracting to them and preferred to work alone.

One of the key components of the research project was how assigning specific roles affected the productivity of the group. The consensus on whether or not the roles were helpful was split among those interviewed. While a few saw the roles as effective in maintaining order and assisting in keeping everyone involved, others felt that the roles were not always taken seriously or even hindered groups by restricting their role. For example, one student noted, "When a person has a question they should be the one to ask it since they will be able to word their question the best and decide if the answer given answered their question."

Impact of heterogeneous vs. homogenous groups

Students were indifferent to working in heterogeneous groups. Groups were chosen using a random group generator which allowed for heterogeneous grouping both academically and by gender. Questions six and seven of the student survey focused on the issue of group selection. When asked if students prefer to pick their own group members the majority seemed indifferent with 42% pre-treatment and 46% post-treatment remaining neutral over group selection. Responses to the survey question as to whether they were more productive when the teacher formed the groups showed little change, with 21% neutral, 38% agreeing and 25% strongly agreeing pretreatment, and

35% neutral, 31% agreeing and 26% strongly agreeing post treatment. Through the interview process students stated that they felt the groups were more productive and focused when the instructor picked the group members. One student commented that it prevented people from only working with their friends and was a more efficient method since students did not have to waste time selecting group members. All but one student interviewed agreed that choosing the groups at random was the best method as it allowed students to learn to work with many different people. One student believed that picking groups with a strategy would be better stating, "this way the teacher can control who gets paired with who based on what would benefit the student the most." This student further pointed out that a random group may not have any members that understand the task and would not be productive.

Impact on students attitude towards learning science content

According to the results of the pre-treatment student survey, students viewed working in groups as a positive experience and believed that it helped them in learning the content material. Although shifts in the ratings occurred following the implementation of the treatment, responses still indicated an overall positive opinion of cooperative learning. Initially, 38% of the students agreed and 38% strongly agreed that they liked working on assignments with a group of students. After the treatment, the post survey showed a drop to 31% strongly agreeing but a jump to 46% who still agreed that they liked the method. Of note were the responses to question nine of the survey which specifically questioned whether they viewed working in a group as a positive experience for learning science. Prior to treatment 54% of the respondents strongly agreed and 25%

agreed that working in groups was positive for learning science. Following the treatment, the ratings flipped to 27% strongly agreeing and 54% agreeing.

Observations recorded during cooperative learning activities showed positive interactions among the groups. Students seemed very cooperative and supportive of each other and often solicited responses from members to make sure all were in agreement. Occasionally pacing did become an issue as some of the faster working students were forced to wait for others in the group to catch up. This was reflected in one of the comments as one student stated, "I like working through the material but everyone works at a different pace. I find it time consuming to wait on others to finish." When asked what students found helpful about learning in a group setting they answered that it was helpful to be able to discuss the content with others in their group, adding that since each person has a different way of thinking it brings up other ideas.

INTERPRETATION AND CONCLUSION

The goal in implementing this action research project was to determine the value of facilitating structured cooperative learning activities into classroom instruction. Research in preparation for the action research project indicated that many benefits could be achieved in implementing cooperative learning strategies in the classroom. The results of the studies indicated that cooperative learning promoted higher individual achievement and greater group productivity than competition (Johnson & Johnson, 1989, p. 170). Working together, students would obtain higher order thinking skills and develop a greater appreciation for others' viewpoints while building social skills. In addition, students would establish a deeper understanding of content material and enjoy a more positive learning experience in science.

Based on the evidence, it appears that although there was no significant difference in actual test scores between the treatment and nontreatment groups, there were definitely benefits realized as an instructor and as perceived by the students. As a facilitator of the activities, it was observed that students were more actively engaged in discussion of the chemistry lesson and were able to assist one another in developing a better understanding through their discussions. Circulating through the classroom and listening in on group interactions revealed positive interactions and real debate over questions encountered within the activity. Admittedly, these were honor level students which tend to take their work seriously and put forth their best effort. Even among other honors level classes I have taught over the years, this was an exceptional group in terms of their cooperative and dedicated spirit. So it does lead to question whether the same results would be achieved in the average college prep class and especially those that might have a wide range of academic ability. Students interviewed in this class believed that working in structured groups was beneficial to their understanding and retention as they described the group discussions as more memorable than listening to the teacher lecture. As an instructor, I appreciated the active learning environment and felt that the activities used allowed students to explore the explore the information, interpret the models, and apply the concepts to develop understanding.

Although the activities used provided many opportunities for the students to discover the information for themselves, it was noted that sometimes there were key concepts that were not covered enough within the activity. For example, the use of the Classification of Matter POGIL provided a great example of the differences between elements, compounds, and mixtures through models and concept questions, however it did not extend into differences between heterogeneous and homogeneous mixtures. As a result, it was necessary to introduce a supplementary activity to cover the material which required additional time in group effort. Other similar experiences led to the realization that some of the activities used may need to be revised to include missing components and that follow up lecture and notes may be necessary to round out the instruction.

Overall, I believe the students felt learning in a cooperative group was a positive experience and that it worked well as a method for science. Groups were supportive of each other and tended to work well in making sure everyone was on par with the material before moving on. Students in science already have experience in working cooperatively since they often have to do so for laboratory experimentation. However, groups of three or four students require greater interaction and cooperation among members as well as patience in working with others who may not work at the same pace or process information in the same manner. While heterogeneous grouping did not seem to pose a problem to most students, there were occasionally times when the randomness of grouping placed the lower end of the academic group together and challenged them to come up with answers. This may certainly be a consideration for grouping strategies in making sure the groups are in fact heterogeneous academically.

Finally, in terms of the attitude of the students towards working in structured cooperative learning groups, I believe that although it is overall a positive experience for them, this is not a teaching strategy that should be exclusively. Like everyone, students enjoy and benefit from a variety of teaching methods which allows engagement of all types of learning styles. Observations s of student participation and attitudes throughout this process revealed a decrease in enjoyment of this method as it became monotonous and somewhat predictable. A steady diet of cooperative learning activities is not sustainable and eventually may lead to a level of discontent and passiveness among the students. Like the saying goes, "everything in moderation." I think that definitely holds true for teaching strategies in order to maintain student interest and involvement.

VALUE

As professionals it is always important and beneficial to reflect on our own teaching methodologies and to find ways to grow and improve. This action research project has allowed me to address questions I have had for some time in terms of cooperative learning strategies. Over the years I have had many encounters with cooperative learning methods through professional development opportunities but had not taken the time and effort necessary to really explore how they might impact my methods of instruction or my students' academic success.

In the past, my efforts to employ cooperative learning quickly deteriorated into group work that seemed ineffective and became more of a social outlet for students rather than active learning. Through this project I was able to properly and consistently implement structured cooperative learning and measure its benefit to students academically and socially. Although I didn't see a increase in test scores, I was extremely pleased with the responses and participation of the group members. I still wonder if the trial were repeated would I achieve the same results. This was an exceptional group in their willingness to cooperative and support each other. I plan to continue to implement cooperative learning in the future with consideration to a few alterations.

One, though it's obvious that each person in the group needs to participate to get the most out of group work, I don't know that it is necessary to assign a specific role to each person. Most of the students did not seem to completely buy into the role they were given except the designated spokesperson since they had a clear responsibility of asking and responding to questions. I do, however believe that it is necessary to establish clear expectations for the group behavior and goals. With that in mind, I will continue to set clear objectives, monitor the group's discussion and install checkpoints to maintain pacing and understanding.

Secondly, I think that it is important to offer a variety of teaching methods to sustain student interest. Note taking and lecture is not all bad and is sometimes necessary to supplement the activities to make sure students get all the information. Some students prefer to work alone and at their own pace and may benefit from seatwork that gives them that opportunity as well. Through the classes at Montana State University and my research throughout this project I have been exposed to even more approaches to science instruction. While I think I have always known it to be true, this research project has confirmed that there is no one right way to teach and the more varied the instruction, the more likely you are to reach all types of learners.

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APPENDICES

APPENDIX A

COOPERATIVE LEARNING ROLE CARDS

Manager/Facilitator

Job Description:

<u>Keeps the group on task and moving forward</u>

Good phrases to use:

- "I think we need to get back to the questions we're trying to answer for this activity."
- "I think we need to focus on _______ now in order to complete this section of the activity."

- **Ensures everyone in the group contributes to the discussion and solution to problems**

Good phrases to use:

- "(name of group members), what do you think about ......?"
- "I'd like to hear what you think, (name)."

- **Verifies everyone in the group has appropriate answers to questions**

Good phrases to use:

- "(Name), how did you phrase your answer for number....?
- Everyone else listen and say if you think that answer is complete or still needs something to make it complete."

Spokesperson

Job Description:

<u>Communicates group questions and clarifications with the teacher or other groups. (This is the only group member designated to do so.)</u>

Good tools/phrases to use:

- "Our group is confused about how _____ relates to _____."
- "Our group reached consensus that the answer to number _____ was ______."

• **Ensures all group members have had the opportunity to respond to the question before asking outside sources.**

Good tools/phrases to use:

- "Does anyone in our group know the answer to _______?"
- "Before we ask the teacher, could someone in our group clarify the answer to…."

• **Ensures that everyone in the group agrees on what question to ask if an outside source is needed.**

Good tools/phrases to use:

- "Does everyone agree we need to find out . . . ?"

• **Presents conclusions of the group to the class, as requested.**

Good tools/phrases to use:

"The reasoning we used to answer number ______ was . . ."

Recorder/Quality Control

Job Description:

<u>Guides consensus-building process; group must agree on responses to questions.</u>

Good tools/phrases to use:

- "Would you all agree that _____ is an acceptable answer for question number _____?"
- "Could you please rephrase what you just said?"
- "Is your response/answer completely supported by your explanation/calculations?"
- "Would that response make sense to someone from another group?"

• **Verifies that ALL individual responses are: 1) consistent on paper, 2) reflect the group's consensus, and 3) are high quality.**

Good tools/phrases to use:

- ***Look*** at responses from individual papers (sampling!).
- Have all group members shown work on quantitative problems?
- Do all group members' responses have complete thoughts or explanations?

• **Ensures that accurate revisions happen after class discussions.**

Good tools/phrases to use:

- Can all group members respond **correctly** to a question about what you learned?
- "(Name) when you read (name's) answer, do you see any differences?"

Process Analyst

Job Description:

<u>Observe group dynamics and behavior with respect to the learning process</u>

Things to notice:

- Is everyone in the group participating?
- Are group members listening carefully to each other?
- Is the group waiting for the recorder to catch up before moving on (and is the recorder being included in the discussion)?
- Are people being patient and respectful toward each other?

- **Comment on group dynamics and behavior with respect to the learning process at regular intervals to the group**

Good phrases to use:

- "I'm noticing that......"; "I think it is working well the way we are...."; "I think it would be helpful if we could try to...."

- **Be ready to report to the group (or the entire class) about how well the group is operating; Or.. report on what unresolved questions remain**

Good phrases to use:

- "Our group worked well today on the process skills of _____ and _____."
- We are still unsure about the concept of...."

APPENDIX B

PROCESS ANALYST REPORT FORM

Process Analyst Report Form

Activity Title ______________________ Team Members ____________ _____________

____________ _____________

1. Use of Time

|——————————————————|——————————————————|

100% Socializing | 100% On Task

2. What did your group do particularly well?

3. What needs improvement? Explain.

4. What frustrated your group most today?

5. Team Effectiveness:

|——————————————————|——————————————————|

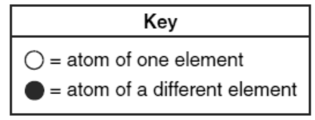
We were NOT Effective (0%) | We Rocked! (100%)

APPENDIX C

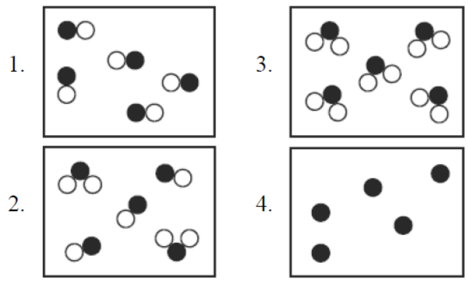
EXAMPLE QUICK CHECK QUIZ

Classification of Matter - Quick Check

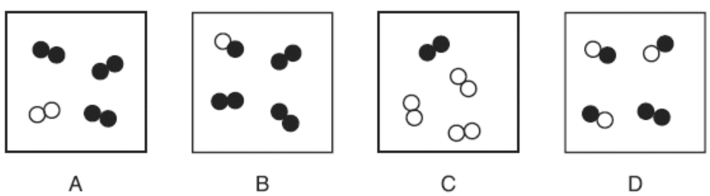
Use the key to the right for questions A- C



______ A. Which particle diagram represents a sample of matter that *cannot* be broken down by chemical means?

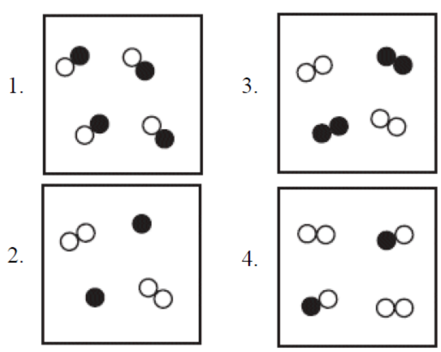


______ B. Which two particle diagrams represent mixtures of diatomic elements?



1. *A* and *B* 2. *B* and *C* 3. *A* and *C* 4. *B* and *D*

______ C. Which particle diagram represents a mixture of an element and a compound?



______ D. Which list of formulas represents compounds, only?

1. CO_2, H_2O, NH_3
2. H_2, N_2, O_2
3. H_2, Ne, NaCl
4. MgO, NaCl, O_2

______ E. Which two substances *cannot* be broken down by chemical change?

1. C and CuO 2. CO_2 and CuO 3. C and Cu 4. CO_2 and Cu

APPENDIX D

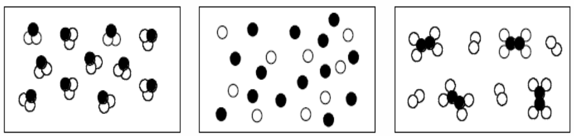
PRE AND POST UNIT TESTS

Chemistry 272 Pre/Post-Assessment - Properties of Matter

Directions: Read each question carefully. Select the best possible answer from the choices.

1. Which of these diagrams illustrate a pure substance?

A **B** **C**



a. A
b. B
c. C
d. B and C
e. All of these are pure substances.

2. Which of the following is NOT an example of matter?
a. air
b. heat
c. smoke
d. water vapor
e. water

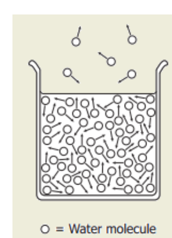
3. A student investigating acetone, a component of fingernail polish, observes several properties. Which of the following is a chemical property of this substance?
a. melting point
b. density
c. flammability
d. odor
e. color

4. A substance goes through an endothermic change. What happens to the molecules of the substance?
a. The molecules of the substance lose energy and slow down.
b. The molecules of the substance gain energy and slow down.
c. The molecules of the substance gain energy and speed up.
d. There is no change in the molecules energy.

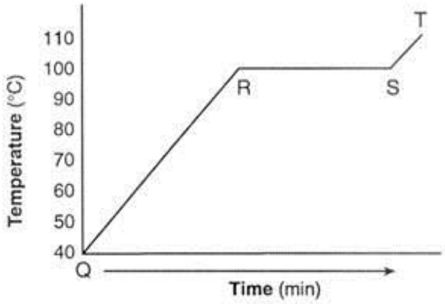
5. A student places a piece of zinc in 6 M hydrochloric acid and then makes several observations: (1) a gas evolves and (2) the test tube becomes warm. From this information, what can be concluded by the student?
a. An exothermic chemical change took place
b. An endothermic chemical change took place
c. An exothermic physical change took place
d. An endothermic physical change took place
e. no reaction took place

6. Which example indicates that a chemical change has occurred?
a. When two aqueous solutions are mixed, a precipitate is formed.
b. As ammonium nitrate dissolves in water, it causes the temperature of the water to decrease.
c. Alcohol evaporates when left in an open container.
d. Water is added to blue copper(II) chloride solution. The resulting mixture is lighter blue in color.
e. Water boils when it reaches the boiling temperature.

7. The diagram shows water molecules in an open beaker and water molecules that have evaporated into the air above the beaker. Which change in this system will increase the rate of evaporation?



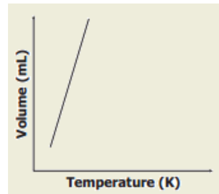
a. Adding salt to the water.
b. Increasing the temperature of the water.
c. Increasing the pressure of the air above the water.
d. Increasing the humidity of the air above the water.
e. Adding more water to the beaker.



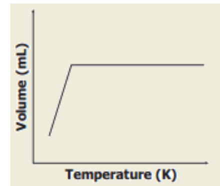
8. Using the heating/cooling curve above, for section QR of the graph, what is happening to the water molecules as heat is added?
   a. The water molecules are becoming a vapor.
   b. The water molecules are condensing.
   c. The kinetic energy of the molecules is decreasing.
   d. The kinetic energy of the molecules is increasing.
   e. The kinetic energy of the molecules is remains the same.

9. Which of the following is **NOT** one of the assumptions of kinetic theory?
   a. Gases consist of hard spherical particles.
   b. Most of the volume of a gas is empty space.
   c. All gas particles move in constant random motion.
   d. There are no attractive or repulsive forces between gas particles.
   e. Collisions between molecules are elastic.

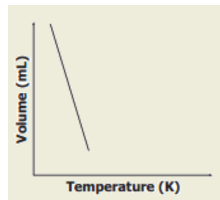
10. Which statement best explains why a confined gas exerts pressure?
   a. The molecules travel in straight lines.
   b. The molecules collide with the container walls.
   c. The molecules are in random motion.
   d. The molecules attract each other.
   e. The molecules are in rapid motion.



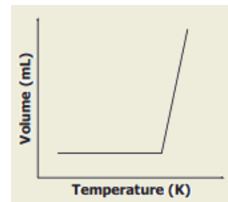
A.



B.



C.



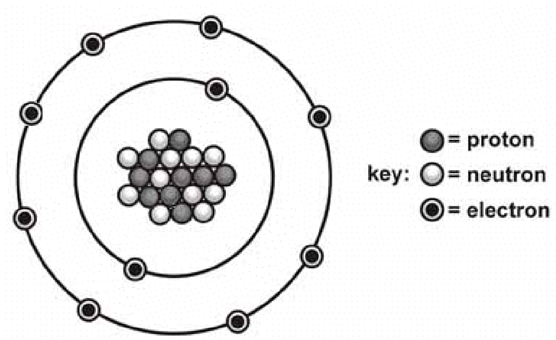
D.

11. Which graph above *best* shows the relationship between the volume of a gas and its temperature as the gas pressure remains constant?
   a. A
   b. B
   c. C
   d. D

12. The volume of a gas is reduced from 4 L to 0.5 L while the temperature is held constant. How does the gas pressure change?
   a. increases by a factor of four
   b. decreases by a factor of eight
   c. increases by a factor of eight
   d. increases by a factor of two
   e. decreases by a factor of two

Pre/Post-Assessment - Atomic Structure

Directions: Read each question carefully. Select the best possible answer from the choices.



1. What is the mass number of the atom shown above?
   a. 30
   b. 20
   c. 19
   d. 18
   e. 11

2. Which is the correct symbol for the atom shown above?
   a. $^{9}_{20}F^{1-}$
   b. $^{11}_{9}F^{1+}$
   c. $^{20}_{11}F^{2+}$
   d. $^{30}_{10}F$
   e. $^{20}_{9}F^{1-}$

3. Which lists the correct mass and charge of a neutron?
   a. 1 amu/ +1
   b. 1 amu/ no charge
   c. 1 amu/ -1
   d. 0 amu/ no charge
   e. 0 amu/+1 charge

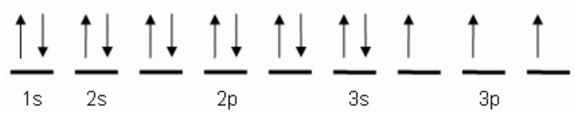
4. There are three isotopes of the element argon: argon-36, argon-38 and argon-40. These isotopes differ from one another in:
   a. their number of neutrons
   b. their number of protons
   c. their number of electrons
   d. their atomic number
   e. their charge

5. From the symbol ^{88}Rb, you could determine this isotope has
   a. 51 neutrons
   b. 88 neutrons
   c. 37 neutrons.
   d. 125 neutrons
   e. 51 electrons

6. A certain element has two naturally occurring isotopes of mass 35 amu and 40 amu. If the average atomic mass for the element is 39 amu, which of the following statements are **true**?
   a. A majority of the isotopes of this element have a mass of 35 amu.
   b. A majority of the isotopes of this element have a mass of 40 amu.
   c. Each isotope makes up 50 % of all of the atoms.
   d. The nucleus has insufficient neutrons.
   e. None of these are true.

7. Which of the following statements is **correct** according to the Bohr atomic theory?
   a. Electrons in an atom travel in steps around the nucleus.
   b. Electrons in an atom travel in shells around the nucleus.
   c. Electrons in an atom travel in jumps around the nucleus.
   d. Electrons in an atom travel in orbits around the nucleus.
   e. Electrons in an atom travel in shifts around the nucleus.

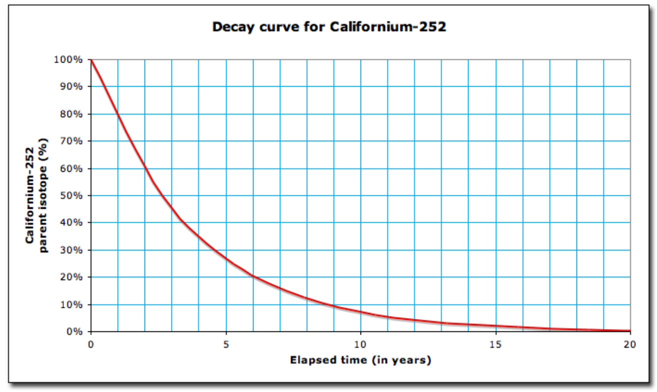
8. Which neutral atom has the electronic configuration of $\mathbf{1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1}$?
   a. Na
   b. K
   c. Ca
   d. Ba
   e. Cu



9. The orbital notation shown is for the element
   a. aluminum
   b. phosphorus
   c. sulfur
   d. argon
   e. arsenic

10. An atom/ion is referred to as a **cation** because:
   a. the number of electrons are greater than the number of protons
   b. the number of protons are greater than the number of electrons
   c. the numbers of protons and electrons are equal
   d. the numbers of protons and neutrons are equal

11. An electron emitted from the nucleus during some kinds of radioactive decay is known as:
   a. a gamma ray
   b. an alpha (α) particle
   c. a beta (β) particle
   d. a positron
   e. a neutron



12. What is the half life of californium-252?
   a. 2.5 days
   b. 2.6 years
   c. 5 years
   d. 133 days

APPENDIX E

STUDENT SURVEY

Student Survey

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

Please rate each of the following statements by circling the appropriate number.

1= Strongly Disagree **2**= Disagree **3**= Neutral **4**= Agree **5**= Strongly Agree

1.	I like to work on assignments with a group of students.	1	2	3	4	5
2.	I feel working with a group helps me to understand the subject better.	1	2	3	4	5
3.	I generally contribute to the discussion when working in a group.	1	2	3	4	5
4.	I feel I have an easier time remembering the lesson when I work with a group.	1	2	3	4	5
5.	Working in a group keeps me interested and motivated while working on a lesson.	1	2	3	4	5
6.	I prefer it when we can pick our own group members.	1	2	3	4	5
7.	I think we're more productive if the teacher forms the groups.	1	2	3	4	5
8.	It matters to me if others in my group learn faster or slower than I do.	1	2	3	4	5
9.	Working in a group is generally a positive experience for learning science.	1	2	3	4	5
10.	Working in a group is distracting to me. I would prefer work on my own.	1	2	3	4	5

APPENDIX F

STUDENT INTERVIEW QUESTIONS

Student interview questions

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

1. How do you feel about the group's focus and productivity when I pick the group members?

2. Do you think it's better to pick the group members randomly or should there be specific strategy to how they are formed?

3. How does being assigned a specific role within the group affect how members work?

4. Should groups be rotated or do you think it would be better to keep them the same?

5. How does working through the material in a group affect your learning and retention of the lesson?

6. What do you find helpful about learning in a group setting?

7. What are some downsides to working this way?

8. Is there anything else you would like to share about your experience of working in groups to learn science?