

IMPROVING CHEMISTRY PASS RATES IN UNDERACHIEVING ALGEBRA
STUDENTS BY USE OF REVIEW SESSIONS

by

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TABLE OF CONTENTS

1. INTRODUCTION AND BACKGROUND	1
2. CONCEPTUAL FRAMEWORK	3
3.METHODOLOGY	7
4. DATA AND ANALYSIS	11
5. INTREPRETATION AND CONCLUSION	18
6. VALUE	20
REFERENCES CITED.....	23
APPENDICES	25
APPENDIX A: IRB Exemption.....	26
APPENDIX B: Practice SOL Assessment.....	28
APPENDIX C: Pre-Treatment Student Survey	42
APPENDIX D: Pre-Treatment Student Interview Questions	46
APPENDIX E: Post-Treatment Student Survey	48
APPENDIX F: Post-Treatment Student Survey	52
APPENDIX G: Final SOL Data	54

LIST OF TABLES

1. Research Matrix	10
2. Normalized Gains on Practice SOL Assessment	14

LIST OF FIGURES

1. Pre-treatment Practice SOL Assessment Data.....	12
2. Post-treatment Practice SOL Assessment Data	13
3. Summative Unit Assessment Median Scores	14
4. Pre-treatment Survey Response Data.....	15
5. Survey Data for Question 1.....	17

ABSTRACT

Mount Vernon High School in Alexandria, Virginia struggles to meet state requirements on test scores and student achievement. With over 50% of our students receiving free or reduced lunch and nearly 20% of our students in the English for Speakers of Other Languages program, teachers face many challenges. Pass rates in chemistry and its associated End-of-Course, Standards of Learning exam have missed state and county targets for many years. For this reason I designed a program to provide extra support to a pre-identified group of at-risk students.

Algebra 1 is a pre-requisite to be enrolled in chemistry and the class relies heavily on its use. Any student who has trouble in algebra is likely to struggle in chemistry. At the beginning of the school year I identified all of my students who received a D in algebra or failed the corresponding state exam in algebra. I asked these students to participate in a voluntary program for extra review, practice and remediation. This was accomplished during a non-academic study period and was available for one hour, once a week, for the duration of the school year.

Pre- and post-assessment data was collected to analyze the effectiveness of the program. In addition students' attitudes were investigated as being a large part of student's success in the classroom. Surveys, interviews and journals were used to track student changes in attitude over the year. What developed throughout the program was a strong student-teacher relationship in the small number of students who participated.

Results indicated that students were able to perform near the level of their peers with a stronger algebra background if they participated in the treatment. More than half of the students who met the criterion for inclusion in the program chose to participate. These students' normalized gains were far above the non-treatment group giving strong support to the success of the program. Students also showed gains in their attitudes about school in general.

INTRODUCTION AND BACKGROUND

Mount Vernon High School (MVHS) in Alexandria, Virginia is part of Fairfax County Public Schools which is the eleventh largest school system in the United States. In 2015 MVHS ranked 22nd out of 22 high schools in the county based on academic performance. MVHS faces many challenges. Over 50% of its population receives free or reduced lunch. Nearly 20% have limited English proficiency and 16% receive special education services. According to the Virginia Department of Education (VDOE) the overall graduation rate is 83%, but is much lower in certain populations. The Hispanic graduation rate is only 73% and the rate plummets to 56% for students with disabilities (Mount Vernon High, 2016). The school houses students from over 60 different countries with a variety of languages and cultures. This makes educating its population challenging.

In Fairfax County most students must pass chemistry to graduate. Students take biology in 9th grade, chemistry in 10th grade if they passed algebra, physics in 11th and an integrated science class called geosystems in 12th grade, which has a chemistry prerequisite. Even a basic diploma requires three science credits so chemistry is a stumbling block for many students, particularly those that have trouble in algebra.

My most recent teaching assignment included three sections of general chemistry in the school. I was one of 4 general education teachers and there were also two special education chemistry teachers. The six chemistry teachers worked closely as a collaborative learning team (CLT) and gave common assessments for every unit. We met weekly to analyze assessment data, share strategies and discuss problems and successes. The biggest concern the chemistry CLT faced was our low pass rates on both the state of

Virginia's End-of-Course Standards of Learning (SOL) Assessment and in the class as a whole. The SOL test is a minimum competency exam given once near the end of the course. When analyzing the historical demographics of which students were failing, it was found that overwhelmingly the students who failed chemistry also had low grades in their Algebra 1 class taken prior to enrolling in chemistry.

Chemistry is a math-based science course, so it seemed logical that weaker math students would have trouble with chemistry and would be considered at-risk for failure. I chose to focus my action research on these underachieving math students. If I could increase the achievement of this group of students then perhaps the overall pass rate in chemistry class and on the chemistry SOL would improve. The school's accreditation is dependent upon improving test scores so the stakes are high.

I chose to work with a very specific population of students within my general chemistry classes. I identified all the students in my classes who earned a grade of "D" as their final algebra grade in the previous school year. Algebra is a prerequisite for chemistry so all students had passed the class prior to being enrolled in Chemistry. This small population of underachieving math students was invited to participate in a special review program that met during a block period known as "Major Time." (My school is the Mount Vernon Majors, hence the course name). During this period students can travel to visit any teacher who writes them a pass, or they can stay in their Major Time room and use it for general study time and homework completion. Major Time occurs every other day for approximately 90 minutes, 60 of which are dedicated to meeting with teachers. During this Major Time period, I met with the willing students once a week for a special math review session. The hope was that the weekly review sessions would

improve a student's performance in chemistry, build a student's relationship with the teacher, and instill a student's confidence in their own ability to be successful in chemistry.

With identified students and a very specific need, my primary research question is as follows: What is the impact of using a weekly math review session on reducing the failure rates of underachieving math students in chemistry? This primary question is very broad so the following sub-questions were used to further break down the research:

1. What effect does a weekly review session have on students' grades in chemistry?
2. What effect does a weekly review session have on student-teacher relationships and the associated attitudes in chemistry?
3. What are the challenges to the teacher(s) who has to plan and prepare materials for a weekly review session?

CONCEPTUAL FRAMEWORK

The link between chemistry and mathematical ability has long been established. A study in 1979 showed that math pre-test scores were useful predictors of students' chemistry grades (Ozsogomonyan & Loftus, 1979). In addition, math SAT scores were shown to have a positive correlation with first year chemistry grades (Andrews & Andrews, 1979). Further studies showed that students with lower range math SAT scores had more failures in chemistry, regardless of previous knowledge in the subject, race, and gender (Spencer, 1996). Mathematical ability is clearly a limiting factor in academic achievement in chemistry so underachieving math students can be considered to be at-risk in the chemistry classroom.

One way to improve mathematical ability in the chemistry classroom is to make abstract concepts more concrete. In a study of 546 college chemistry students, the use of tactile models showed measureable improvement in student achievement in stoichiometric calculations when the models were coupled with structured worksheets (Marais & Combrinck, 2009). Other studies have shown that getting students attention with jingles, poetry and rhymes can aid in student understanding (Heid, 2011). The student needs to be able to make a connection to the math concept being presented in the chemistry content so that it does not become a barrier to achievement.

Providing pre-instruction on missing concepts can be a valuable tool as well in addressing the at-risk student. A study was done with 49 college freshmen who had not taken any previous course in high school chemistry. Traditionally, this group performed far below their peers with a background in the subject. By participating in a voluntary pre-lecture set of online resources and quizzes, these students were able to match the level of their better prepared peers (Seery & Donnelly, 2012). Seery and Donnelly (2012) went on to state that “the use of pre-lecture resources is considered to be an effective intervention worthy of consideration” (p. 676).

Mathematical ability is not the sole predictor in determining an at-risk student in chemistry. At-risk students suffer from a combined effect of low math ability in conjunction with affective behaviors. These include issues with attitude, self-confidence and motivation (Chan & Bauer, 2014). To fully meet the needs of an at-risk chemistry student, instructors must do more than just address math deficiencies. A problem lies in designing a program to help these students rather than just labeling them.

According to Chan and Bauer (2014), “students are at-risk because they come to the learning situation with negative attitudes, poor self-perceptions, low confidence, weak metacognitive self-regulation or learning strategies, low intrinsic goal orientation, learning beliefs and task value” (p. 1423). Dealing with the affective issues of the at-risk student involves more than providing extra practice and concrete examples. Forging a relationship between the teacher and student is a proven way to address these issues.

Affective behaviors can be influenced by the classroom teacher and can have a direct impact on final grades and achievement. In one study, 354 students in a challenging college level chemistry class were asked to identify their relationship with their professor. Those that stated the relationship was positive had statistically higher final grades (Micari & Pazos, 2012). Looking beyond the effects on a final grade, in a study of 223 middle school students in a suburban environment, Smart (2014) states that “significant positive correlations were identified between students’ mastery orientation, students’ value for learning and efficacy for learning science and their perceptions of their teachers’ leadership and friendly/helpful behaviors” (p. 12). The relationship between student and teacher has a real impact on the affective behaviors necessary to be successful in chemistry. Addressing the needs of the high school student, Ellerbrock et al. (2015) stated that “all adolescents need to feel their teachers care for them” (p. 49). When the student-teacher relationship is positive, then students feel better about their own abilities and increase their own self-efficacy (Smart, 2014). At-risk students benefit from positive relationships with their teachers.

Positive relationships bring about changes in attitudes. Attitude is a key characteristic to be addressed with the at-risk student. In a study of 1088 secondary

school students, negative emotions were shown to be related to lower motivation. Positive emotions had a positive effect on academic success (Raufelder, Hoferichter, Schneewiess & Wood, 2015). Self-concept was found to have a direct relationship to performance on a chemistry exam. In a study of 780 general chemistry students at the college level, those students who believed in their ability to succeed on the test performed measurably higher than those with a lower self-concept (Lewis, Shaw and Heitz, 2009). This lends weight to the idea that the classroom needs to create a positive learning environment to help develop positive attitudes and increase achievement.

One way to help students feel more confident is to offer a voluntary transition program to help them prepare for content. One such program provided a direct link to a gain in confidence after completion of a transition program in a chemistry curriculum for underprepared students (Shields et al., 2012). The change in confidence can be a powerful source of motivation, and can stem directly from the interaction with the teacher. As Raufelder et al, stated, “Strengthening the social and motivational relationships with teachers might be essential in supporting self-determined forms of academic self-regulation and intrinsic motivation” (p. 458).

No one factor can predict a students’ future achievement in chemistry. A combination of math ability, affective behaviors and relationships all have a part to play in finding a way to make at-risk students become more successful. An intervention plan that addresses all of the factors mentioned above is necessary and is addressed by the methodology that follows.

METHODOLOGY

Treatment

During the 2015-2016 school year, I had 78 students in three general chemistry classes. My project did not include all of these students in the treatment. At the beginning of the year, I sorted my students and created a target group. These targeted students all received a grade of D or D+ in their Algebra 1 course during the previous school year. There were 21 students who met the criterion for participation in the study, but I had only 12 students who elected to participate in the voluntary program. These 12 students included 7 ESOL (English for speakers of other languages) students. Spanish is the first language of five Hispanic students, and two African students are from Ghana with a native language of Twi. Two other students are African American. Another Hispanic student who has graduated from our ESOL program has an IEP (individualized educational plan) for learning disabilities related to writing difficulties. Most of the 9 students who chose not to participate stated that they were unwilling to give up their free time during Major Time.

After the completion of Unit 1 near the end of September, the group of participating students began meeting with me once a week for one hour during Major Time. With such a small group, an individualized program was created for each student. After the first unit test, each student received a list of particular objectives that were not mastered on the test. Review and practice sheets were created to assist each student with their most problematic objectives. This remediation process continued for every unit test throughout the entire treatment period. Since chemistry is a cumulative course and

MVHS uses a spiraling method of instruction it was imperative that these students learn the content of the objectives they did not master in order to be successful on future units.

The MVHS spiraling method of instruction involves eight units of instruction with two units each marking period. Every unit includes five basic standards: Scientific Methods and Measurement, Atomic Theory and the Periodic Table, Chemical Formulas and Balanced Equations, Molar Relationships, and Kinetic Theory. Each of the eight units contains all five standards. Unit 1 teaches a basic understanding of each standard. Unit 2 adds another level of deeper content on top of the Unit 1 essential knowledge. As an example, the mole is introduced in Unit 1 simply by the relationship of 6.02×10^{23} particles. In Unit 2 atomic mass is added to the calculation and students are expected to solve for the mass of a given number of atoms. In October in Unit 3, they are solving for mass of more complicated molecules, not just atoms. By March, in Unit 6 students are using stoichiometry to solve problems finding mass of a product given a mass of reactant using a balanced equation. This method allows students to continue practicing all content throughout the year. It also means they must have a firm foundation in the earlier units of instruction to be successful in the latter units.

In addition to review of previous material, some of the sessions involved pre-teaching math-related chemistry concepts prior to their introduction in the regular chemistry classroom setting. Pre-teaching has been found to be an effective method to increase achievement (Seery & Donnelly, 2012). Whenever possible, concrete methods were used to teach more complex mathematical concepts. As an example, balancing equations can be very difficult for many students. This concept was pre-taught in one of the sessions. Students were given building brick models of compounds in the equation.

Each element in the compound was a different colored building brick. Students manipulated the number of model compounds until they could get equal numbers of colored bricks for both the reactants and products in a chemical reaction. By presenting this hands-on activity prior to normal classroom instruction it was hoped that students could become more confident in their own abilities when taught in the large group setting. Even the use of rhymes was employed for various mathematical manipulations. For example, to solve for an empirical formula when given percentage composition, the following rhyme (created by the CLT) was used: Percent to mass, mass to mole, divide by small, multiply 'til whole.

The treatment phase lasted from the end of September until the end of May. Students spent on average about three to four sessions per instructional unit. There were two units per grading period. To measure the success of the treatments outlined above, various instruments were used and analyzed. These instruments are discussed in the following section.

Instruments

The instruments used for my action research are shown on a research matrix which is found on the following page (see Table 1). The matrix shows how multiple data sources will be used to insure reliability of the data from each instrument. Also of note, is that the methodology for this project was given an exemption from review by the Montana State University's Institutional Review Board (Appendix A). Approval was also granted by my administrator on behalf of Fairfax County Public Schools.

During the first week of the school year in early September, all students in my chemistry classes took a practice SOL test made available by the Virginia Department of

Education (VDOE) (Appendix B). I am required by the county to administer a pre-, mid- and post-assessment as part of my professional evaluation so this data was useful in my research as well. The assessment covers all of the standards required by the VDOE for every chemistry class. Because it has been standardized for the state, it is a considered a valid measure of content knowledge which is related to passing the course as outlined in my overall research question.

Table 1
Research Matrix

Research Matrix	Survey	Group Interview	Individual Interview	Formative Assessments	Final Survey and	Practice SOL results	Summative Assessments	Reflective Journal
Primary Question: What is the impact of using a weekly math review session on reducing the failure rates of underachieving math students in chemistry?		X	X		X	X	X	X
Sub-question #1: What effect does a weekly review session have on students' grades in chemistry?				X		X	X	X
Sub-question #2: What effect does a weekly review session have on the student-teacher relationship and associated attitudes?	X	X	X	X	X			X
Sub-question #3: What are the challenges to the teacher(s) who has to plan and prepare materials for a weekly review session?		X	X					X

After completion of the pre-assessment and the Unit 1 test at the end of September, I began meeting with my target group once a week. By the second week in

October, these students completed a pre-treatment survey (Appendix C) consisting of eighteen Likert-style responses to general statements about school, science, and in particular, about their experience in Algebra 1. Four of the questions gave students a chance to respond in a free-response format. Not every student came to every session so this process took two weeks to complete, but in the end all twelve students completed the survey.

Every student was given a bound notebook in which they kept a reflective journal. At the beginning of each session, short formative assessments were completed in the journal. At the end of each session students were encouraged to write their opinions of the lesson and their own knowledge gained for the day. To further back up the opinions students wrote about in their journals, I also conducted individual interviews with three randomly selected girls and three randomly boys participating in the study (Appendix D). The interviews were completed by the end of October.

The treatment period continued throughout the entire school year. Summative unit assessments were given in addition to two more administrations of the practice SOL test in January and April. A post-treatment interview (Appendix E) and survey (Appendix F) were also used to give multiple data sources for all of my research questions. The large amount of data collected is presented and discussed in the following section.

DATA AND ANALYSIS

My primary research question and my first sub-question rely heavily on assessment data which is generated by all students in my classes, not just the treatment group. This gave me a unique opportunity to compare three separate groups of students. First is the entire group of students who took the assessment which included the target

group ($N=78$). Second is my target group who participated in the review sessions ($N=12$), and third is the target group who chose not to participate in the review sessions ($N=9$). Their results on the practice SOL pre-assessment are shown on the next page (see Figure 1). The same assessment was given again in April and these results are shown below (see Figure 2). Red boxes represent the second quartile range (25th to 50th percentile) and green boxes represent the third quartile range (50th to 75th percentile). The statistical median is represented where the red and green boxes meet. Whiskers represent the minimum and maximum values.

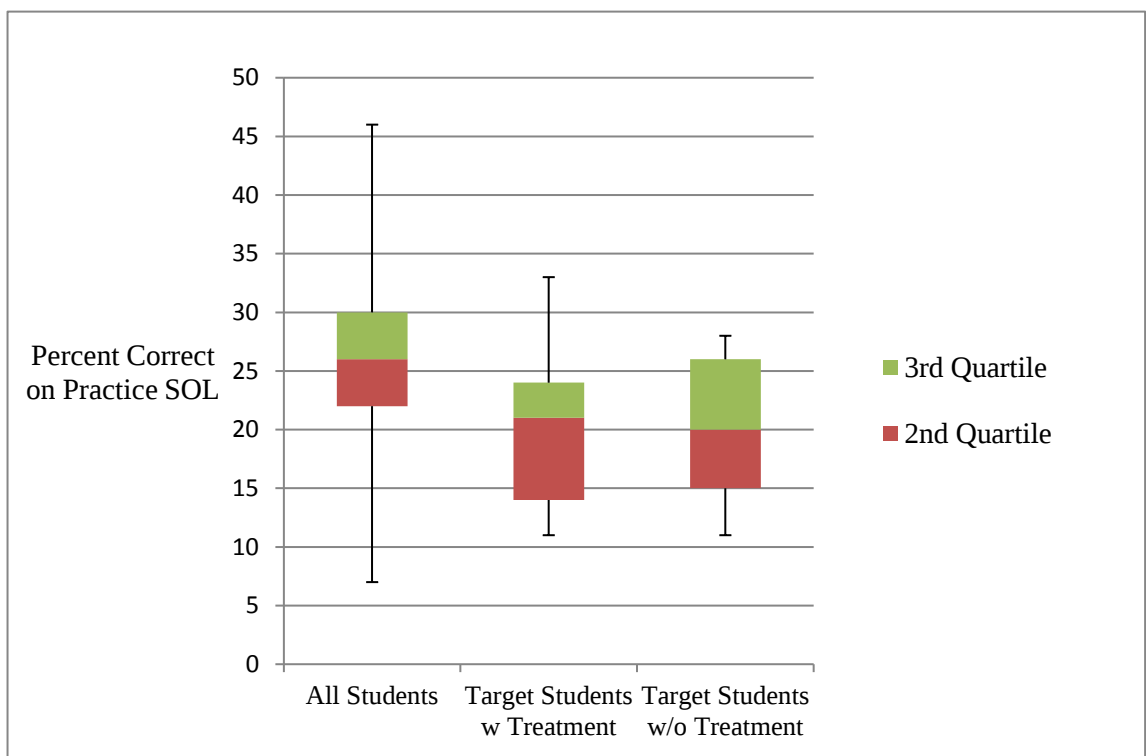


Figure 1. Box and whisker plot of student scores on SOL pre-assessment showing results for all students ($N=78$), for the target population with treatment ($N=12$), and the target population without treatment, ($N=9$).

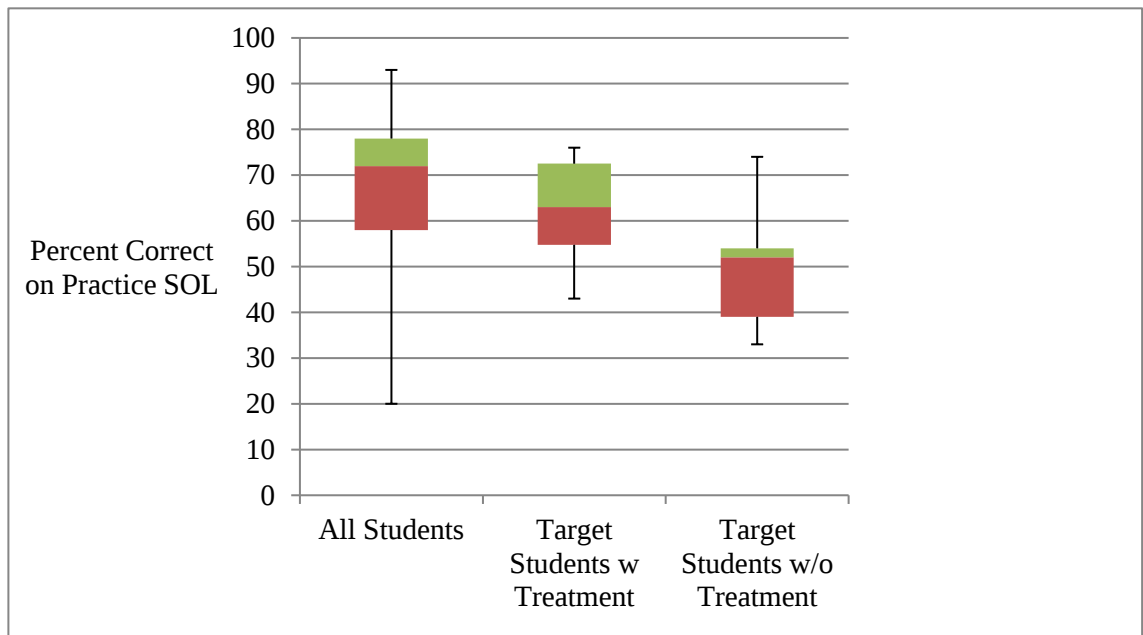


Figure 2. Box and whisker plot of student scores on SOL post-assessment showing results for all students ($N=78$), for the target population with treatment ($N=12$), and the target population without treatment, ($N=9$).

The data shows gains by all students in all three groups. The median score of the treatment group (63%) did not reach the median score of all students (72%), but it was higher than the target group of students who did not participate in the treatment study (52%). Since the target group was identified as having weaknesses in math, the results are not surprising when compared to the overall population. What is most notable is that the treatment group significantly outperformed the non-treatment group. The median value was over 10% higher in the treatment group as compared to the non-treatment group which represents one full letter grade. The range of the treatment group was also noticeably smaller than both the overall group and for the non-treatment group, particularly in the lower end of the values. The median and range data both support the treatment's effectiveness.

Another way to support this analysis is through the use of normalized gains (see Table 2). The treatment group had normalized gains very close to those of all students. The non-treatment target group had a statistically lower normalized gain. This further supports the success of the program.

Table 2
Normalized Gains on Practice SOL Assessment

	Number of Students (N)	Mean Pre-Assessment Score (percent)	Mean Post-Assessment Score (percent)	Average Normalized Gain
All Students	78	25.5	67.7	0.577
Target Students with Treatment	12	19.8	61.8	0.528
Target Students without Treatment	9	19.8	49.1	0.372

Similar results were found in summative unit assessments throughout the year. Statistics for three unit assessments given in October, January and March for the three groups were compared (see Figure 3). Data shows that the treatment group had a higher median test score on each unit test when compared to the non-treatment group.

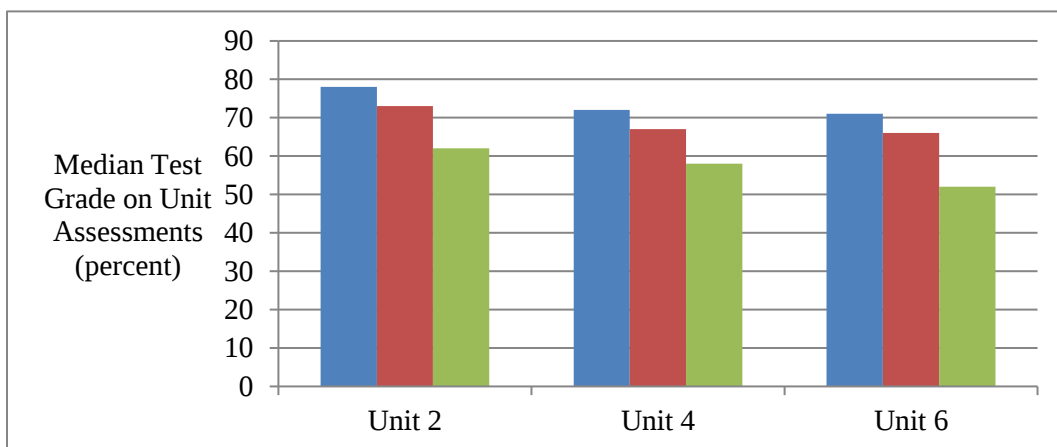


Figure 3. Summative unit assessment median scores showing results for all students in blue ($N=78$), for the target population with treatment in red ($N=12$), and the target population without treatment in green, ($N=9$).

My second sub-question dealt with the effect of the program on teacher-student relationships. This was measured with interview data, survey data and information taken from reflective journals. After completing the pre-treatment survey and interviews I discovered that many of the students' troubles in algebra were due, in some part, to a lack of a relationship with their teacher. Questions 14 and 16 on the Pre-Treatment Student Survey deal directly with this relationship and the responses to these questions are shown below (see Figure 4).

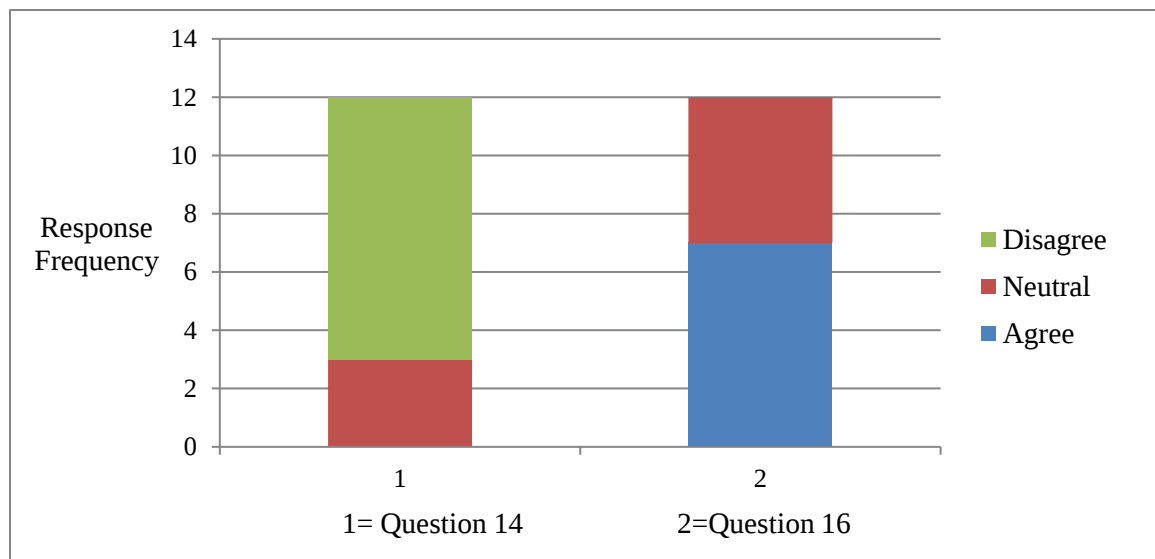


Figure 4. Frequency response for Pre-Treatment Survey question numbers 14 and 16 ($N=12$) dealing with teacher-based issues.

In survey question 14 almost all of the students responded that they disagreed to some degree with the statement, “My algebra teacher made me feel like I could succeed in class.” These same students nearly all agreed in question 16 with the statement that, “If I like my teacher I am motivated to do my best.” These students were all underachievers in algebra and did not feel supported by their teacher. In the pre-

treatment individual interviews one student mentioned, “I tried to stay after for help, but my teacher was never there.” Another said that the teacher “was always too busy to help me so I just stopped trying.”

Post-treatment interviews and surveys further addressed the relationship formed between myself and the students in the treatment group and showed some amazing results. When asked the question, “What do you feel was the most helpful part of the Major Time review sessions?” one student’s response was, “Being able to ask questions without everyone judging me.” Another stated that, “I got to practice before the test so I didn’t worry about it as much as I do in other classes.”

Students kept a reflective journal all year. On March 19, we had just finished a unit assessment that previous week and I asked students to reflect on how the review session had helped them prepare for the test. One student who had been showing tremendous progress in his grades wrote in his journal as quoted below.

I just wanted to thank you for taking the time to help me. My grades have really gone up this year and I was really scared of chemistry. Everybody said it was crazy hard but you have really helped me get through it. It’s nice to have a teacher that really cares about me.

At several points during the program, many students were forced to miss review sessions. Reasons ranged from missed days of school due to snow and changes to the school schedule for testing. Other students missed random days. When asked why they missed a session, one student wrote in his journal that, “I feel pretty good about your class right now, but I really needed more help in geometry so I went to Ms. (name removed) for extra help instead.” By coming to my class during Major Time, students were giving up the chance to attend other teacher’s classrooms. Some students decided on

their own that they did not need chemistry review that week. The fact that they chose to do this because they felt confident in chemistry was a good sign that they were changing their attitudes about the class and school as a whole.

Both the Pre-Treatment and Post-Treatment Surveys asked students to evaluate the statement “I like school” using a Likert scale response. The difference of these responses from late September to mid-April can be seen below (see Figure 5). Green represents responses that either agreed or strongly agreed with the statement. Although most students still did not agree with the statement “I like school” there were dramatically fewer disagree responses. Many factors go into the response to this statement so it is not possible to relate this solely to their participation in the review sessions but it does provide context for students’ overall attitude toward school.

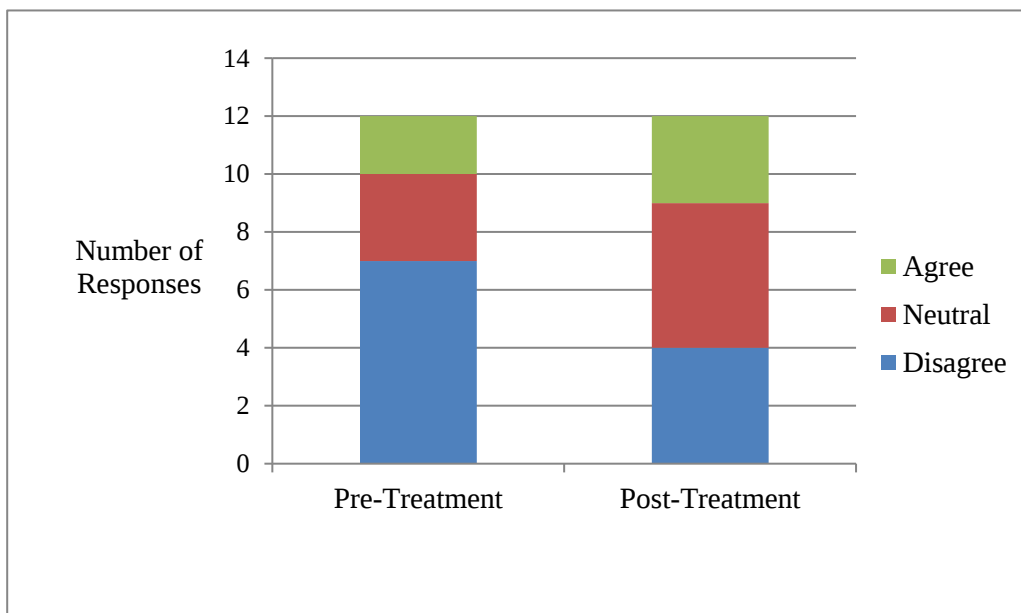


Figure 5. Survey data for question 1, “I like school”. ($N=12$) Green represents responses that agree with the statement, red represents a neutral response and blue represents responses that disagree with the statement.

The final portion of data deals with my third sub-question on the challenges to the teacher participating in the project. I spent approximately two hours per week preparing and creating extra materials for the students. Members of the CLT collectively put in an additional hour of preparation time each week. The time was used to analyze individual needs and make individualized practice sheets. I also had to create new lesson plans and manipulatives for many of the mathematical concepts. If the program is to continue in future years, materials are now already prepared and the time required will be far less than recorded in my journal for this year. It is also necessary to dedicate an additional hour each week during Major Time. This has a positive effect on the students participating but means that others students will not have access to me during that time. A post-treatment interview with my CLT indicated that a group approach made this a manageable task. Personally the relationships I built with the students made the program worth the time invested.

INTERPRETATION AND CONCLUSION

The overall question of this action-research project was to determine the impact of a weekly review session on reducing the failure rates of underachieving math students in chemistry. By forging personal relationships with at-risk students, creating individualized review programs, and giving pre-instruction to a small group of students, measurable success was achieved. The treatment group came very close to the levels of achievement seen in the overall group of students and significantly higher than the non-treatment group as shown by the normalized gains in assessment scores. The real power of the data lies in the comparison between the two different target groups. Both groups were deemed to be at risk of failing chemistry based on their algebra grades. As shown

by normalized gains, the group that participated in the treatment scored statistically higher on all assessments including summative unit assessments and the practice SOL. The true SOL will be given in May so results are not available at the time of this writing, but the practice SOL results should be a good predictor of future results. Actual SOL testing data was gathered in June (Appendix G).

The first of my sub-questions dealt with the effect of the review sessions on students' grades in chemistry. As seen in the data gathered from Unit Assessment data, the target group with treatment scored around ten percent higher than the target group without treatment (see Figure 3). Data from the SOL practice assessment mirrored these findings as well. The review sessions had a significant impact on student grades.

The second sub-question looked at the student-teacher relationship and associated student attitudes. This question in particular is the one that stands out the most for me. Student interviews detailed unfavorable relationships with previous teachers, especially with algebra teachers where the students struggled. After the completion of the program it was shown that many of the students felt personally connected to me as a teacher. The relationships formed were important to both me as a teacher and to the students. Students gained a comfort level that instilled confidence as evidenced by their journal entries, surveys and interviews. It was hoped that this would carry over into their other classrooms as their view of school improved as a whole. Even if the pass rates and test scores had not improved, an improved attitude towards school can be counted as a success. The improved engagement of the involved students carried over into the regular classroom.

The third sub-question deals with the challenges to the teacher in developing and implementing the review session and supporting materials. The teacher must be willing to put in the two hours a week of necessary planning. Having a supportive CLT was invaluable and made this classroom project a less daunting task. Unfortunately when using one Major Time block a week for only a small selected group of students, other students don't have as much access to the extra help that Major Time can provide to all students. With two to three Major Time sessions a week, this issue was kept to a minimum and other students came on different days. The extra time and effort put into this project by me and my CLT was well worth the effort if even a few of the treatment group students are successful in passing both the class and the SOL exam. The minimum state requirement on the SOL exam is a 70% pass rate among all students taking the exam. Last school year the percentage was 69%. Therefore even a small increase in the number of students passing will take MVHS over the threshold for minimum requirements of adequate yearly progress. Success of the program can have a deeply felt impact on the school as a whole in addition to the individual student.

As a teacher I gained valuable insight into the importance of a personal relationship. So often a student only needs to know that someone cares. Watching a student smile after mastering a concept is worth extra planning and preparation time. Working within a highly functioning CLT, the burden to the teacher with extra planning time can easily be offset with the difference it can make in even a small number of students. The project was considered a success on all levels for both the students and the teacher.

VALUE

With the success of the project within my own classroom, the implications for expanding the program are noteworthy. There are six chemistry teachers in my building and all have agreed to implement the program with their own student populations starting the next school year. The planning load should be much smaller for the individual teacher next year due to the materials already created and the additional teachers creating new materials. Within our school we have the potential to reach over 100 students who fall into the at-risk category based on their algebra grades. My school is one of 22 high schools in the county district. If our school-wide launch of the program meets with success, it could, potentially, be implemented in the future in other schools that have a significant population of at-risk students.

The school administration has been very supportive of my efforts this year and is considering making it a mandatory program for all qualified students next year. This presents a unique dilemma. It would mean that more students could participate in the remediation sessions. At first glance, this sounds like a good proposal. However not all students wanted to participate this year. Many students stated that it detracted from their ability to see whichever teacher they felt they needed most at any given time. Others simply were not interested at all. If these students were forced to attend the sessions, it might interfere with the positive atmosphere that was generated by the students who volunteered to be there. The positive nature of the sessions is one of the main reasons I feel the program was so successful. This is to be a debate within the CLT and with administration at a later date. The students who participated in the treatment this year overwhelmingly felt that it should remain a voluntary program.

After completion of the treatment, a few questions still remain for me. Did this have a noticeable impact on students' grades and attitudes in other classes beyond chemistry? If I were to repeat the project I would expand the data to include data points from other courses. In particular it would be important to forge working relationships with the algebra and geometry teachers. Also, how many other students would benefit from such a program? I only looked at students who earned a grade of D in their algebra class. What about other students who are motivated to work hard but just need a teacher to take a personal interest in them? This question has made me decide to give a survey at the beginning of the next school year to every student looking at their attitudes towards teachers and school. Based on the results, perhaps I can find a few more students who just need that extra push from a caring teacher to make them more successful.

As a teacher I have been driven by testing data for years. I have always worked hard to make sure that students were presented with all of the content knowledge necessary to do well on state testing. This project reminded me that success is based on much more than content knowledge. Being available to my students for extra help and encouragement is just as important, and I will strive to make better relationships with all of my students in the future.

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APPENDICES

APPENDIX A
IRB EXEMPTION FORM



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

960 Technology Blvd. Room 127
 c/o Immunology & Infectious Diseases
 Montana State University
 Bozeman, MT 59718
 Telephone: 406-994-6783
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Chair: Mark Quinn
 406-994-5721
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Administrator:
 Cheryl Johnson
 406-994-6783
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MEMORANDUM

TO: Linda Townley and Walter Woolbaugh

FROM: Mark Quinn, Chair *Mark Quinn CJ*

DATE: November 16, 2015

RE: "Improving Chemistry Pass Rates of Weaker Algebra Students Using Review Sessions" [LT111615-EX]

The above research, described in your submission of November 12, 2015, 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
PRE-ASSESSMENT (PRACTICE SOL)

Question 1 :

A student measures the mass of a 1.00 g aluminum rod as 0.99 g. The best estimate of the percent error associated with this measurement is -

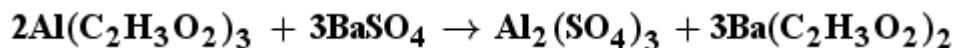
- A: 0.01%
- B: 0.1%
- C: 1%
- D: 10%

Question 2 :

The most efficient way to determine whether a reaction is an exothermic chemical reaction is to use -

- A: an oxygen probe
- B: a temperature probe
- C: a pressure probe
- D: a pH probe

Question 3 :



Which type of chemical reaction does this equation represent?

- A: Synthesis
- B: Neutralization
- C: Oxidation-reduction
- D: Double-replacement

Question 4 :

Directions: Type your answer in the box. Use "+" or "-" for the electrical charge.

What is the oxidation number of an oxide ion? _____

Question 5 :

What is the molarity of a solution with 0.2 moles of potassium permanganate (KMnO_4) dissolved in enough water to make a 500.0 mL solution?

- A: 0.0004 M
- B: 0.1 M
- C: 0.4 M
- D: 100 M

Question 6 :

When 92.0 g of ethanol ($\text{C}_2\text{H}_5\text{OH}$) are vaporized at its boiling point of 78.3°C , it requires 78.6 kJ of energy. What is the approximate molar heat of vaporization of ethanol in kJ/mol?

- A: 0.854
- B: 1.17
- C: 39.3
- D: 78.3

Question 7 :

Directions: Type your answer in the box. Your answer must use significant digits.

What is the density of an aqueous solution that has a mass of 10.081 g and 12.5 mL?

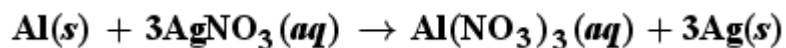
_____ g/mL

Question 8 :

Which element has 16 neutrons, 15 protons, and 15 electrons?

- A: Sulfur (S)
- B: Phosphorus (P)
- C: Gallium (Ga)
- D: Zinc (Zn)

Question 9 :



This equation represents which type of chemical reaction?

- A: Single-replacement
- B: Double-replacement
- C: Decomposition
- D: Synthesis

Question 10 :

In the formula for barium chloride (BaCl_2), barium (Ba) is written first because it is -

- A: a single atom
- B: a larger atom
- C: the positive ion
- D: the negative ion

Question 11 :

Which of these laboratory techniques is best to separate a solid from a liquid to recover the liquid?

- A: Titration
- B: Chromatography
- C: Filtering
- D: Vaporization

Question 12 :

Which of these is NOT required to ensure that stock solutions are free of contamination?

- A: Store all solutions in brown bottles
- B: Do not place dropping pipettes in stock solution bottles
- C: Never return excess chemicals to stock bottles
- D: Replace tops of reagent bottles after use

Question 13 :

Which of these values is most responsible for changing the boiling and freezing points of a solvent?

- A: Molar mass of the solvent
- B: Electronegativity of the solvent
- C: Weight of the solute particles
- D: Number of the solute particles

Question 14 :

What is the name of the compound with the formula NH_4NO_3 ?

- A: Ammonium nitrate
- B: Nitrogen nitrate
- C: Nitrogen hydrogen oxide
- D: Ammonium nitrogen trioxide

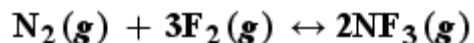
Question 15 :

Directions: Type your answer in the box.

Calculate the number of moles of Li_3PO_4 in 2.2 L of a 0.60 M Li_3PO_4 solution.

_____ moles

Question 16 :



Equilibrium has been reached for the reaction shown. Which conclusion is correct?

- A: The N_2 and F_2 together will form at a faster rate than the NF_3 .
- B: The partial pressures of N_2 , F_2 , and NF_3 will stay constant.
- C: The NF_3 will form at a faster rate than the N_2 and F_2 together.
- D: The partial pressure of NF_3 will keep changing.

Question 17 :

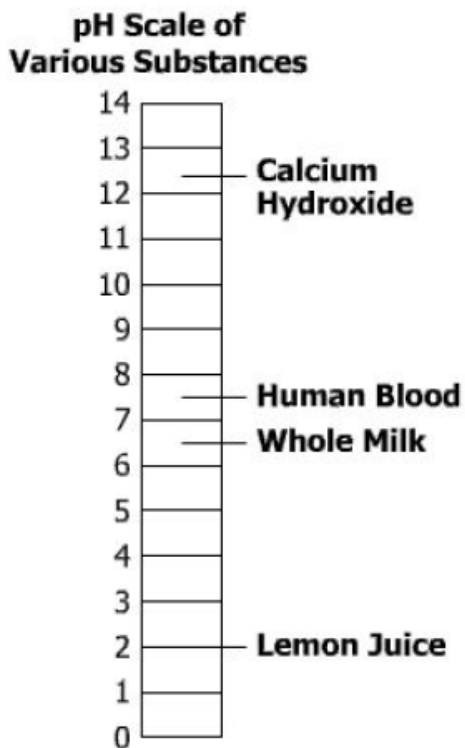
If 89.6 joules of heat are needed to heat 20.0 grams of iron from 30.0°C to 40.0°C, what is the specific heat of the iron in $\frac{\text{J}}{\text{g} \cdot ^\circ\text{C}}$?

- A: .448
- B: 2.23
- C: 8.96
- D: 896

Question 18 :

Which of the four basic substances on this pH scale is slightly basic?

- A: Calcium hydroxide
- B: Human blood
- C: Whole milk
- D: Lemon juice



Question 19 :

Which element will most likely form covalent bonds with fluorine?

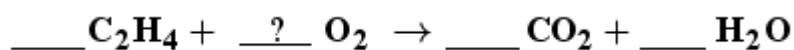
- A: Carbon
- B: Potassium
- C: Neon
- D: Tin

Question 20 :

The physical process of evaporation involves -

- A: ion formation
- B: electron sharing
- C: transferring valence electrons
- D: overcoming intermolecular forces

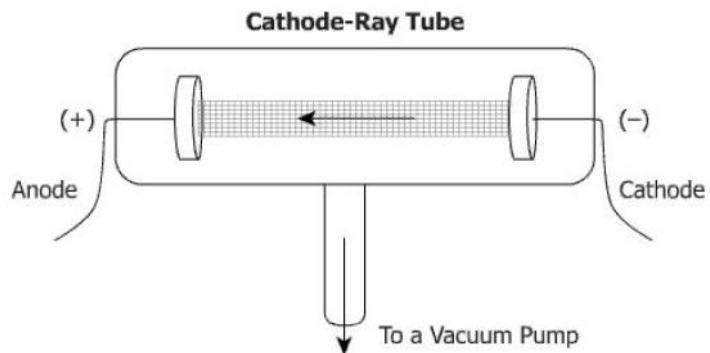
Question 21 :



How many moles of O_2 are in the chemical equation when balanced using the lowest whole numbers?

- A: 5
- B: 4
- C: 3
- D: 2

Question 22 :



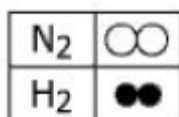
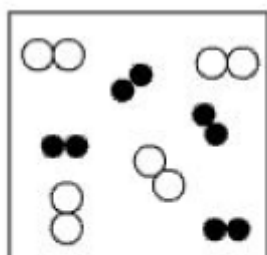
While English physicist was able to
determine that the rays consisted of particles he called "corpuscles." These particles were later named -

- A: protons
- B: electrons
- C: gamma rays
- D: neutrons

Question 23 :

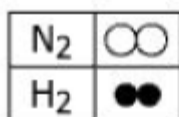
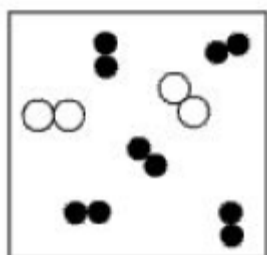
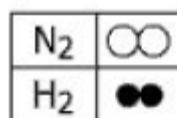
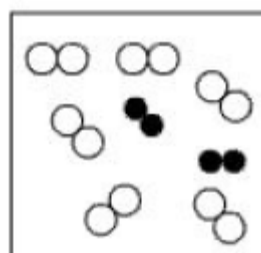
In the Haber process, nitrogen (N_2) and hydrogen (H_2) are directly combined to form ammonia (NH_3). Which illustration contains the stoichiometric quantities of the reactants for this reaction?

A



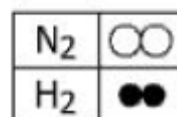
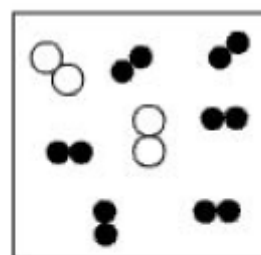
:

C:

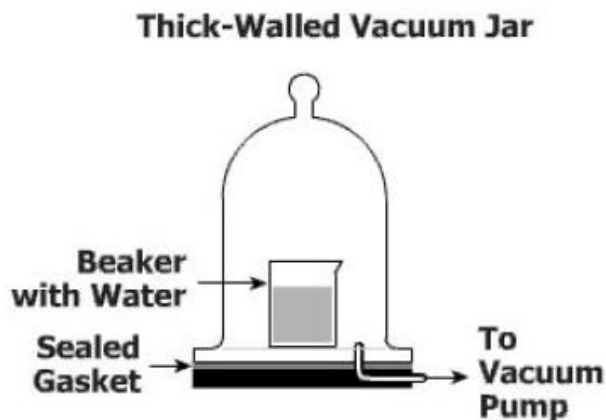


B:

D:



Question 24 :



A beaker of water is placed in a large sealed jar that is attached to a vacuum pump. As air is pumped out of the jar, the water begins to boil because -

- A: the temperature of the water decreases as the surrounding pressure decreases
- B: the lower pressure inside the jar causes the water to contract
- C: the air pressure in the jar has been lowered until it is equal to the vapor pressure of the water
- D: the pressure on the water is insufficient to hold the hydrogen and oxygen atoms together, resulting in a decomposition reaction

Question 25 :

Directions: Click the box to select each correct answer. You must select all correct answers.

According to the periodic table of the elements, which elements belong to the same period?

- A: Aluminum
- B: Germanium
- C: Antimony
- D: Arsenic
- E: Gallium

Question 26 :

How many moles are in 2.04×10^{24} molecules of H_2O ?

- A: 0.295 mol
- B: 3.39 mol
- C: 1.13×10^{24} mol
- D: 1.44×10^{48} mol

Question 27 :

What is the name for FeCl_3 using the IUPAC nomenclature rules?

- A: Iron chloride
- B: Iron(II) chloride
- C: Iron trichloride
- D: Iron(III) chloride

Question 28 :

Directions: Type your answer in the box.

An expandable container of oxygen gas has a volume of 125 mL at a temperature of 25.0°C . What volume will the gas occupy at 55.0°C ?

_____ mL

Question 29 :

Which of these correctly describes how organic catalysts operate in biological reactions?

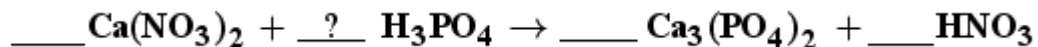
- A: They are used up in the reactions.
- B: They lower the overall energy of the reactions.
- C: They lower the activation energy of the reactions.
- D: They keep the temperature of the reactions constant.

Question 30 :

What volume will 35.9 g of hydrogen gas (H_2) occupy at STP?

- A: 399 L
- B: 798 L
- C: 804 L
- D: 1,620 L

Question 31 :



When this equation is balanced, the coefficient in front of H_3PO_4 is -

- A: 1
- B: 2
- C: 3
- D: 4

Question 32 :

Increasing the volume of a sealed container will cause the gas particles within the container to -

- A: form a liquid
- B: collide more frequently
- C: increase in molecular attraction
- D: exhibit lower pressure

Question 33 :

Melting Point Results (°C)

Trial	Group 1	Group 2	Group 3	Group 4
1	113	114	116	110
2	111	115	113	111
3	110	111	114	111
4	110	110	113	110

Each of four groups of students determined and recorded the melting point of a solid compound. If the actual melting point is 113°C, which group had the best precision?

- A: Group 1
- B: Group 2
- C: Group 3
- D: Group 4

Question 34 :

Consider any set of three adjacent elements in the same period on the periodic table. For which characteristic is the average for the three elements always equal to the value of the middle element?

- A: Atomic number
- B: Atomic mass
- C: Number of neutrons
- D: Number of isotopes

Question 35 :

A substance has a molecular formula of $C_8H_{10}N_4O_2$. The empirical formula is -

- A: $C_2H_6N_2O$
- B: $C_4H_5N_2O$
- C: $C_9H_7N_3O$
- D: $CHNO$

Question 36 :

Create the formula for diboron trioxide using the symbols provided.

Symbols

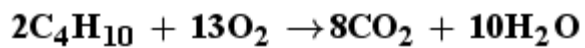
B	b
O	o
1	2
3	4

Question 37 :

What is the name for the compound AlI_3 ?

- A: Aluminum(I) iodide
- B: Aluminum triiodide
- C: Aluminum(III) iodide
- D: Aluminum iodide

Question 38 :



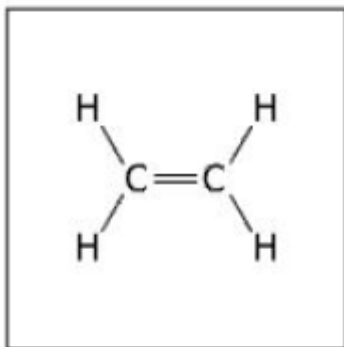
How many moles of carbon dioxide (CO_2) are produced when reacting 6.00 moles of butane (C_4H_{10}) in excess oxygen (O_2)?

- A: 1.50 mol
- B: 24.0 mol
- C: 66.0 mol
- D: 1,060 mol

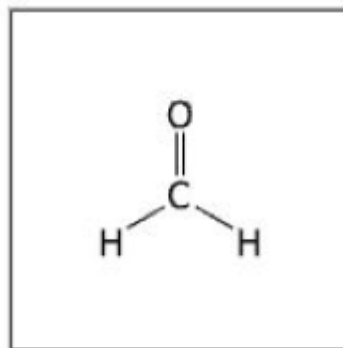
Question 39 :

Which structure represents a nonpolar molecule?

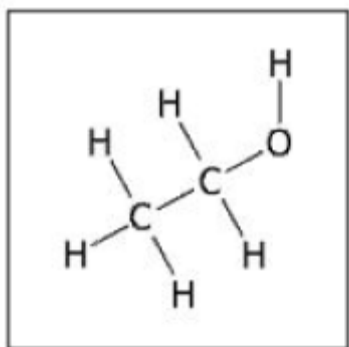
A:



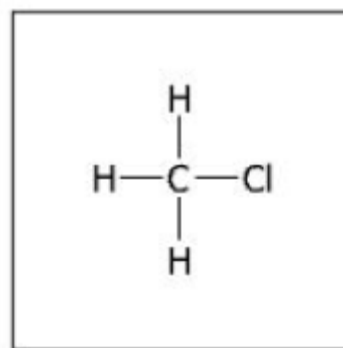
C:



B:



D:



Question 40 :

Using only one trial to collect data in an experiment -

- A: makes it easier to determine a valid conclusion
- B: reduces the percent error in the results
- C: causes the conclusion to be less reliable
- D: requires data with more significant figures

Question 41 :

A common product of acid-base neutralization reactions is -

- A: hydrogen
- B: water
- C: carbon dioxide
- D: oxygen

Question 42 :

Data Table

Solution	Brightness of Light Bulb	pH
NaHCO ₃	Bright	8.4
HClO	Dim	3.7
NaNO ₃	Bright	7.0
CH ₃ NH ₂	Dim	8.0

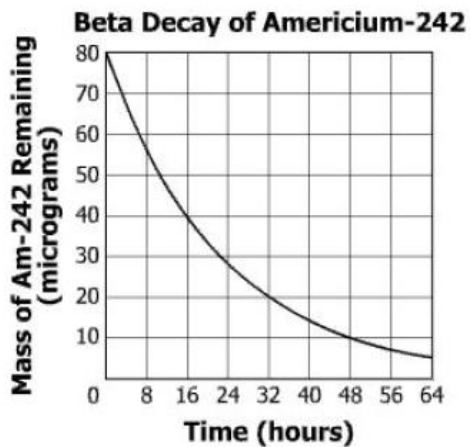
Based on the information provided, which solution is a base and a weak electrolyte?

- A: NaHCO₃
- B: HClO
- C: NaNO₃
- D: CH₃NH₂

Question 43 :

What is the half-life of Americium-22?

- A: 11 hours
- B: 16 hours
- C: 32 hours
- D: 64 hours



Question 44 :



Two electrons are shared equally in bromine (Br₂). What type of bond is represented between the bromine atoms in this Lewis structure?

- A: Nonpolar covalent bond
- B: Polar covalent bond
- C: Metallic bond
- D: Ionic bond

Question 45 :

A student is studying the effects of several solutions on the prevention of the browning of apples. The student used solutions having different pH values and immersed three apple slices in equal volumes of each of the solutions. Which of these is the independent variable in this investigation?

- A: pH of solution
- B: Shade of brown
- C: Number of apple slices
- D: Volume of solutions

Question 46 :

An experiment produced 0.10 g CO₂ with a volume of 0.056 L at STP. If the accepted density of CO₂ at STP is 1.96 g/L, what is the approximate percent error?

- A: 110%
- B: 92%
- C: 71%
- D: 8.2%

APPENDIX C

PRE-TREATMENT STUDENT SURVEY

Pre-Treatment Survey

The following survey is voluntary and participation will not affect your grade or class standing in any way.

Instructions: Read each statement and select the appropriate response showing how much you agree or disagree with the statement using the following choices:

5-strongly agree 4- agree 3-neutral 2-disagree 1-strongly disagree

1. I like school.

5 4 3 2 1

Tell me the reason you selected your answer for this statement.

2. My grades are determined by how hard I work.

5 4 3 2 1

3. I like science.

5 4 3 2 1

4. I will get good grades in my chemistry class.

5 4 3 2 1

--What is your academic goal in chemistry?

5. The subject of chemistry is interesting to me.

5 4 3 2 1

6. Chemistry will be useful to me as an adult.

5 4 3 2 1

7. I have someone at home who will help me with my chemistry homework.

5 4 3 2 1

8. I ask questions when I don't understand something in class.

5 4 3 2 1

9. I like math.

5 4 3 2 1

10. I put in as much effort as possible in my algebra class.

5 4 3 2 1

Tell me the reason you selected your answer for this statement.

11. Algebra will be useful to me as an adult.

5 4 3 2 1

12. Math facts come easily to me.

5 4 3 2 1

13. My algebra teacher used real-world examples of algebra during instruction.

5 4 3 2 1

14. My algebra teacher made me feel like I could succeed in class.

5 4 3 2 1

15. If I like the material I am motivated to do my best.

5 4 3 2 1

16. If I like my teacher I am motivated to do my best.

5 4 3 2 1

17. Having extra practice outside of class helps me learn.

5 4 3 2 1

18. I like asking questions in front of the whole class.

5 4 3 2 1

Tell me the reason you selected your answer for this statement.

--

APPENDIX D

PRE-TREATMENT STUDENT INTERVIEW QUESTIONS

Interview Questions and Probes

Question: Without using any names, tell me about your favorite teacher.

Question: What do you feel are the most important traits in a good teacher?

Question: What has been your favorite class in school?

-Probe: What are the reasons you liked it so much?

Question: What has been your least favorite class in school?

-Probe: What are the reasons you didn't enjoy it?

Question: Of your core subjects, what class do you find easiest?

-Probe: What does the teacher do to make it easy for you?

-Probe: What methods do you use to make it easy for you?

Question: Of your core subjects, what class do you find hardest?

-Probe: What are some things that the teacher could do to make it easier for you?

-Probe: What methods do you use to do your best in that class?

Question: You had some trouble when you took algebra. What stands out for you as you remember your challenges in the class?

Question: What steps did and your teacher take to improve your performance in algebra?

-Probe: Which steps were most helpful to you?

-Probe: Which steps were least helpful?

Question: How do you think you will do in chemistry?

-Probe: Why do you think that?

Question: What methods will you use to be successful?

APPENDIX E
POST-TREATMENT STUDENT SURVEY

Post-Treatment Survey

The following survey is voluntary and participation will not affect your grade or class standing in any way.

Instructions: Read each statement and select the appropriate response showing how much you agree or disagree with the statement using the following choices:

5-strongly agree 4- agree 3-neutral 2-disagree 1-strongly disagree

1. I like school.

5 4 3 2 1

Tell me the reason you selected your answer for this statement.

2. My grades are determined by how hard I work.

5 4 3 2 1

3. I like science.

5 4 3 2 1

4. I am satisfied with my grades in my chemistry class.

5 4 3 2 1

--Have you met your academic goal in chemistry? Explain.

5. The subject of chemistry is interesting to me.

5 4 3 2 1

6. Chemistry will be useful to me as an adult.

5 4 3 2 1

7. I had someone at home who helped me with my chemistry homework.

5 4 3 2 1

8. I asked questions when I didn't understand something in class.

5 4 3 2 1

9. I like math.

5 4 3 2 1

10. I put in as much effort as possible in my geometry class.

5 4 3 2 1

Tell me the reason you selected your answer for this statement.

11. Geometry will be useful to me as an adult.

5 4 3 2 1

12. Math facts come easily to me.

5 4 3 2 1

13. My geometry teacher used real-world examples of geometry during instruction.

5 4 3 2 1

14. My geometry teacher made me feel like I could succeed in class.

5 4 3 2 1

15. If I like the material I am motivated to do my best.

5 4 3 2 1

16. If I like my teacher I am motivated to do my best.

5 4 3 2 1

17. Having extra practice outside of class helps me learn.

5 4 3 2 1

18. I like asking questions in front of the whole class.

5 4 3 2 1

Tell me the reason you selected your answer for this statement.

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APPENDIX F

PRE-TREATMENT STUDENT INTERVIEW QUESTIONS

Interview Questions and Probes- Post Treatment

Question: Of your core subjects, which class do you find easiest?

-Probe: What does the teacher do to make it easy for you?

-Probe: What methods do you use to make it easy for you?

Question: Of your core subjects, what class do you find hardest?

-Probe: What are some things that the teacher could do to make it easier for you?

-Probe: What methods do you use to do your best in that class?

Question: You had some trouble when you took algebra. You are now almost finished with geometry. What have been your challenges in geometry class?

Question: What steps did and your teacher take to improve your performance in geometry?

-Probe: Which steps were most helpful to you?

-Probe: Which steps were least helpful?

Question: How would you evaluate your own performance in chemistry?

-Probe: Why do you think that?

Question: What strategies did you learn that you can use in other classes as you move forward?

Question: What do you feel was the most helpful part of the Major Time review sessions?

-Probe: Why do you think that?

Question: What do you feel was the least helpful part of the Major Time review sessions?

-Probe: Why do you think that?

APPENDIX G
FINAL SOL DATA

June 2016 Results

	<i>N</i>	Number of students passing SOL	Percentage of students passing SOL
All Students	78	64	82%
Treatment Group	12	11	92%
Non-treatment Group	9	3	33%