

DIFFERENT CLASSES, DIFFERENT STUDENTS?

A comparative study of different Chemistry classes.

by

Bradley M. Pederson

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STATEMENT OF PERMISSION TO USE

In presenting this professional paper in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the MSSE Program shall make it available to borrowers under rules of the program.

Bradley M. Pederson

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## ABSTRACT

Differences in student motivation or why they take the classes that they do is difficult to measure, with out more probing questions. Differences in student learning have required classes that cover the same subject to be taught differently. Observations of which students are taking more science than required did not fit the preconceived notions; students in a nontraditional science class would be less likely to take a fourth year of science as opposed to those taking the traditional science class designed for the college bound.

This study looked at how the students' experiences influence their outcomes in different chemistry classes. In Belle Plaine, MN there are two choices of Chemistry offered, traditional verses context-based. Each of these classes provide the student with a different experience in how they learn chemistry. The data collection and analysis revolved around two major themes. These themes answer the sub-questions dealing with the student's motivation and the student's performance. The data collection techniques of surveys, interviews, classroom assessments, and teacher reflection were used, and the results help answer my main research question, "How do students' goals influence their experience and outcomes in chemistry?"

## INTRODUCTION AND BACKGROUND

Students that are different from others is nothing new for the classroom. Attempting to reach each of these students is not a new challenge for teachers, both science and non-science. The differences in students could be measured by race, gender, economical hardships, and learning disabilities. Differences in student motivation or why they take the classes that they do is more difficult to measure, with out more probing questions. Differences in student's motivation along with those measurable differences, on occasion can be concentrated in a particular class that is set up to accommodate difficulties with learning. Differences in student learning have required classes that cover the same subject to be taught differently. Why students take more science than required is not easily measured because it is based on a student's motivation. Observations of which students are taking more science than required did not fit the preconceived notions; students in a nontraditional science class would be less likely to take a fourth year of science as opposed to those taking the traditional science class designed for the college bound. Many schools around the country try to offer classes that will challenge and engage the students to fit their needs as a learner. Belle Plaine school district attempts to offer multiple chemistry classes in an attempt to fit the needs of the students that we educate. Each class teaches the same subject, but how the subject is taught is what separates them from each other.

### The Classes

#### General Chemistry (GenChem)

General Chemistry is the mainstream chemistry class offered at Belle Plaine Senior High. Most students in the class have passed Algebra II, or higher math, and therefore have a strong background in math. Most students in the school take GenChem during junior year; a few students wait until they are seniors. This arrangement usually leads to larger numbers overall (50-75), which requires multiple sections (2-3 section) of the same class with 20-28 students per section. These multiple sections make for less flexibility in the curriculum. The seniors that take GenChem have taken the alternative chemistry class as juniors in preparation for GenChem. Others waited until they had the prerequisite math, but fewer will have taken high school physics before GenChem. The class is taught in a more traditional nature with lecture, labs, and more formal assessment methods being used. An outline of the class is provided in Appendix A. All of the students that took the second class, Chemistry in the Community, before GenChem would have had me in ChemCom.

#### Chemistry in the Community (ChemCom)

Chemistry in the Community is an alternative to the mainstream chemistry class (GenChem) offered at Belle Plaine Senior High. Most of the students in the school take GenChem, which leaves ChemCom with an average number of students. In previous years the average class size has been 22-28 students. The class numbers allow for similar group activities as those found in GenChem, but because there is typically only one section of ChemCom so there is more flexibility. Many of the students, in the class have documented learning disabilities; those students that do not have an Individual Education Plan (IEP) have some difficulties with math in general (most have not taken Algebra II) and do not expect a career in the sciences. Some of the students take ChemCom as a step

on their way to GenChem. This allows the students to have a good grasp of the concepts without having to worry about the math aspect that GenChem has. The class is taught in a more project-based nature with labs, classroom discussion, and small group activity methods being used. An outline of the class is provided in Appendix B.

In recent years, there has been an increased number of students taking GenChem after taking ChemCom. In 2010-2011 ten students moved from ChemCom to GenChem, the previous year saw seven; until then only three to five students would move on. After further investigation, it has become apparent that there has been a larger percentage of students in ChemCom taking a non-required fourth year of science than those students in GenChem. Which raises the question; Are the students in the different chemistries not getting the same experiences? I feel students have a positive experience in my classes and hypothesized this might be due to students taking GenChem after ChemCom. However, there have been an increasing number of students taking ChemCom before GenChem, prior to teach both classes. In addition, my Physics class should then see an increase in the number of students if students' comfort in my teaching was the reason for taking the class, but this has not been observed. The advanced biology course offered has not had an increase in its numbers beyond the normal influx of one to two students. Because the other alternatives for students to take a fourth year of science have not increased, I believe that some other differences might be the reason for this observation.

### The School

Belle Plaine Public High School has between 450 and 500 students grades 9-12. The school is located in southern Minnesota in between the Minneapolis-St. Paul area and Mankato. The town itself is considered a commuter community with a strong rural

background. The ethnic culture in the school is primarily Caucasian (93.8%), with a handful of students from other ethnic backgrounds (6.2%). Of the students currently enrolled in the high school, 235 are males and 213 are female. The different ethnicities have a similar split of male to female students as seen in the school totals. Table 1 gives a breakdown for each grade along with the number of students that are eligible for free and reduced meals.

Table 1  
*Compensatory Revenue Student Count*

Grade	Ineligible for Free & Reduced Meals	Free & Reduced Meals	Total
9	89	22	111
10	99	17	116
11	101	11	112
12	99	10	109
High School Total	86.6%	13.4%	

The number of students currently receiving services from an IEP or other related services is found in Table 2. In Table 2, each student that is receiving services is also broken down by ethnicity. Unfortunately, one can only speculate those receiving services are similar to those eligible to receiving free and reduced meals.

Table 2  
*IEP or Related Services per Ethnic Group*

				American Indian		Asian/Pacific		Hispanic		Black		White	
	Male	Female	Student Total	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
No IEP	197	196	393	1	1	2	2	3	4	6	3	185	186
Has IEP or related service	38	17	55							3	3	35	14

The class periods during the school day are separated into seven 48-minute periods. Many (97.5%) of the students in GenChem and ChemCom will have been in my physical science class as ninth graders. There should be a level of comfort knowing my routines, procedures, and expectations for these students. This familiarity was made possible by my new teaching assignment starting in the 2009-2010 school year. All of the students that took ChemCom before GenChem would have had me in ChemCom.

### The Question

My research questions are as follows:

- How do the students' experiences influence their outcomes in different chemistry classes?
- What are the motivational differences between different chemistry classes?
- What is the performance difference between the chemistry classes according to state standards set by the state of Minnesota?
- What are the differences for students in GenChem who have taken ChemCom prior to those students taking GenChem only?
- How do the results affect me as an educator?

The support team that I have chosen is comprised of traditional and non-traditional educators. Each of these choices brought a unique talent to my project, and they were all willing to challenge me and support me through the capstone research project.

John Wellner is a Social Studies teacher in my building and he has a room not far from mine. Wellner is currently working on his Masters from another school. John and I have had numerous discussions on our philosophies on education and specifically how to motivate students in the classroom. Wellner's use of the different assessment methods in his classroom separates him from many of the other educators in my building. His assessment methods attempt to have the students understand the material and gain an appreciation for the subject matter, not just memorize the subject. Because we both have currently gone through the process of developing a research project I had full confidence that Wellner was able to question my results and potentially spot trends that I might not have seen. Wellner is a teacher that pushes and helps motivate me to be a better educator by questioning my methods in a professional manner.

Deb O'Malley is an English teacher in my building. O'Malley has edited many of my papers throughout my venture in pursuing a Masters. O'Malley has a way of being able make comments on papers that force me as a writer to use language that makes the paper flow from subject to subject. The benefit of using O'Malley on the research project is that she had time both before and after school to discuss the comments made on the sections that I submitted to her. O'Malley's subject matter expertise forced me as a writer not to become too technical in my discussion of the information, making me write so that this project is readable and flows effortlessly.

Lowell Hoffman is the principal for Belle Plaine Senior High. Lowell Hoffman acts as more than just a principal, he is also a mentor to me. Hoffman has pushed me to be a better educator since I started teaching in Belle Plaine, which has been my only teaching job. Hoffman often seeks my opinion on science curriculum matters; I, in turn,

will run different curriculum ideas by him as well. When I was trying to solidify my main question, I turned to Hoffman for some guidance. He was able to ask the right questions that allowed me to take ownership of this project. Hoffman has a tradition of trying to see the students in his school challenge themselves. Understanding what the motivation differences are for different students will be beneficial to both of us.

My support team offered helpful suggestions during the data collection process. Their ideas made the process more manageable and timely. I appreciated meeting with them and hearing their suggestions.

## CONCEPTUAL FRAMEWORK

In designing any project it is important to read and reflect on the research that has come before yours. One of the earliest works that asked a similar question to mine was Nelson (1988). In this study, the major differences between ChemCom and GenChem were discussed. The benefit of using ChemCom was the major focus along with pointing out the similarities and differences between the chemistries. According to Nelson (1988), “ChemCom strives to enhance scientific literacy in a high school curriculum by emphasizing the impact of chemistry on society”(p.45). In addition to that, Nelson also describes GenChem “a chemistry course concentrated on educating the student for success in college courses, implemented through a lecture, laboratory, and problem solving strategy” (p.71). ChemCom courses are normally structured around a less math intensive path than that found in GenChem (Nelson, 1988). ChemCom, however, covers the same topics, basic vocabulary, and laboratory skills that would be commonplace in

GenChem (Nelson, 1988). The topics and laboratory skills taught in ChemCom are similar in many ways, but taught with a purpose for knowing why the information is taught.

Nelson (1988) pointed out many of the early differences between ChemCom and GenChem. Many of these differences and similarities were pointed out in Smith and Bitner (1993). The difference in this study is that it looked at actual reasoning differences between the two chemistry classes. Smith and Bitner (1993) described ChemCom “as Science-Technology-Society or STS curricula which the major goal of science education is to develop scientifically literate individuals who understand how science, technology, and society interrelate” (p.3). It has always been my goal as a science teacher to do this very same thing; the difference that I see in the chemistries is how this is accomplished. The Smith and Bitner study looked at a similar sample number ( $n=123$ ) as I did ( $n=100+$ ). The sample sizes of my study and the one done by Smith and Bitner should produce some common limitations. Students already having a knowledge base and laboratory skills at the beginning of the study may see no change (Smith and Bitner, 1993). I was interested to see if the students that would fall into this category, students having taken ChemCom prior to GenChem, perform at a higher level than those in either chemistry class. In the Smith and Bitner study, different teachers were used to teach the different chemistry classes so “teachers whose classes were used may have varying degrees of effectiveness in promoting student learning” (p.4). In my study, there was only one teacher meaning effectiveness limitation was the same for all of the classes. Therefore, my own personal limitation to promote student learning was not seen as a limitation but as a fact of the matter, because my limitations would be seen in all my

classes. Some of the issues encountered in the Smith and Bitner study various individual problems, learning disabilities, unforeseen disruptions, students not understanding specific items (Smith and Bitner, 1993). Interruptions, disruptions, and individual problems are items that teachers deal with in the best way they know how, and some are able to deal with them better than others. Again, since I was the only teacher performing this study, the effectiveness limitation as was seen in Smith and Bitner as to how I deal with the interruptions, disruptions, and individual problems will be similar in all cases. According to Smith and Bitner, “students with a learning disability” (p.5) were seen as a limitation. This is where many of the similarities end. My experience has shown more students with learning disabilities register and take ChemCom over GenChem for the very reasons outlined in Nelson (1988) and Smith and Bitner. It has also been my experience that many of these students are successful in ChemCom because it is taught in a fashion that, for many, suits their needs as learners.

Motivation is the state of mind that acts as a students’ base or framework for achieving certain goals that they set for themselves (Glynn et al., 2007). In Glynn, S. M., Taasobshirazi, G., & Brickman, P. (2007), a theoretical model for motivating non-science majors was tested. This was accomplished by surveying 369 students enrolled in an introductory biology class the grade point average (GPA) was tracked, it was investigated if a connection to motivation, gender, and GPA existed. Glynn et al. (2007) found no connection to gender and motivation. Though my study did not look at college students or gender differences these students will become the college students at some time and in many ways show similar motivations to learn science. A student in ChemCom would potentially show the same tendencies for learning science as non-

science majors would. In addition, not every student that takes GenChem is going to be a science major. There are a greater number of students overall that will potentially going into a science-based career in GenChem, but some would also fit in the definition of a non-science major. Therefore, motivating the non-science major in GenChem versus those in ChemCom is different as GenChem student have different underlining motivation to learn science.

Glynn et al. (2007) pointed out that there are five constructs within one's self that contribute to overall motivation to learn science and ultimately achieve the goal that was set forth by themselves.

- 1) There is intrinsic and extrinsic motivation. Motivation to do something for its own sake is mainly intrinsic whereas motivation to do something as a means to the end is mainly extrinsic.
- 2) Second, there is goal orientation. Students with learning goals tend to be intrinsically motivated, seeking understanding and a mastery of science content and skills, whereas students with performance goals tend to be extrinsically motivated, seeking to earn the highest grades and impress their instructors.
- 3) Third, there is self-determination. When students believe they have some degree of control over their learning, such as selecting some of their lab topics, motivation is increased.
- 4) Fourth, there is self-efficacy, defined by Bandura (1997) as "beliefs in one's capabilities to organize and execute the courses of action required to

produce given attainments” (p.1090). Students’ self-efficacy has been found to predict grades in college science courses.

- 5) Fifth, there is assessment anxiety. A high level of assessment anxiety has been found to hinder students’ motivation and achievement (p.1090).

These are pointed out as key factors for motivation of a non-science major to learn science; it is my belief that all five motivational factors are even seen in science majors.

What is the motivation of a student to learn science? Unfortunately, according to Glynn et al. (2007), “the answer is not clear, because previous research has focused on the motivation of science majors” (p.1090). The motivation for students to learn science, even though they are not directly doing science, does need to be looked at, because science is playing an ever increasing role in careers that have traditionally been non-science fields (Glynn et al. 2007). This is where ChemCom comes in; ChemCom is designed to give the students the motivation needed to learn the science by showing the student why they are learning the science and how it relates to their lives. Relating the science to a student’s life, according to Glynn et al. (2007), “has a very strong influence on their science achievement” (p.1102). Glynn et al.(2007) goes on to state, “Student’s motivation was influenced by their belief in the relevance of science to their careers” (p.1102). According to this model, a ChemCom student should be more motivated than a student in GenChem because in ChemCom they are given a reason to learn the information. However, not every non-science major takes ChemCom, and in some cases, students that plan on a science career take ChemCom and then take GenChem. The motivations of each student need to be looked at, a better understanding of the type of student that takes ChemCom versus GenChem and vice-versa.

Surveys that have the students rank on a Likert scale of 1-5 their feelings or motivation based on a statement, gives insight to the type of student and what motivates them for taking the chemistry they enrolled. In Glynn et al. (2007) a survey of 30 questions was used as means to understand student motivation based on the concepts described previously by this study. The information retrieved from this survey provided me with some groundwork in better understanding who is in each class and why they are in that chemistry class. Additional information could be obtained from this initial survey, such as possible interview questions and classroom issues I might not foresee.

Interviews can prove very valuable in doing action research. Interviews can serve as means to hear and understand the student's viewpoints about certain concepts. In King (2007), teachers who were implementing context-based learning in their classrooms were investigated. Though this study does not look at student's ideas directly by interviewing the teachers who are implementing a context-based curriculum similar to ChemCom, one might be able to ascertain underlining feelings towards this type of learning. The methods that were used in King, in many ways, can be implemented in my own interview process. First, King used "a snowball method" to obtain a sample of teachers. Snowball sampling is a sampling technique where existing study subjects recruit future subjects from their acquaintances. Therefore the sample group appears to grow like a rolling snowball. These sample members are not selected from a sampling frame, snowball samples are subject to numerous biases. For example, people might recruit friends that are likely to be recruited into the sample. As the sample builds up, enough data is gathered to be useful for research. This sampling method obviously has its downside. In previous assignments I had established a sampling method; from each group I attempted to get a representative

number of students that I interviewed. I attempted to interview a minimum of ten percent of the sub-group's population.

One of the key points that King (2007) makes about the interview process is that “five key questions were asked of the teachers and questions relating to the general implementation of the context-based approach. The remainder of the interviews elaborated on points that had been raised in the conversation” (p.15). This is different from the way many of my interviews have gone in the past; most follow the path that the conversation takes. Attempting a process similar to King might make the process to the point, and then after the questions have been answered other questions could be asked. Also in King “all interviews were transcribed for analysis so that the researcher could code the responses to search for common themes” (p.15). The practice of completely transcribing the interviews is a good idea, but for many researchers I think that it comes down to a time factor. My research idea is not directly attached to the interview that would be conducted, but used as a way to get reactions and a deeper understanding of the reason for the responses on surveys.

A method of assessments used was a pre-test and post-test for the evaluation of the chemistry concepts. This type of assessment is very common when evaluating concepts in science. In the Polanco (2004) study and in Smith and Bitner, this type of assessment was used to evaluate student performances. Smith and Bitner only used the pre-test and post-test method of evaluating student's performance and concluded, “No significant difference in reasoning gained in ChemCom verses GenChem” (p.23). This is significant because I should see the same conclusion, but again a pre-test and post-test assessment is not a good method for evaluating students. In Polanco, R., Calderon, P., &

Delgado, F. (2004) the pre-test and post-test was not the only method of collecting data. Three samples of data were used to triangulate the data. In Polanco et al. (2004) student's grade point average (GPA), and course performance were used in conjunction with the pre-test and post-test. According to Polanco et al. "students that were in problem based learning (PBL) showed a higher improvement in the understanding of physical concepts than those not in the PBL classes" (p.151). Though Polanco et al. looked at physics and my focus will be on chemistry, there are still things that I can take from this study. First, using just a pre-test and post-test for evaluation is not an ideal measurement of student achievement as seen in Smith and Bitner. Second, using different methods to correlate data better evaluates a student's understanding of the concepts that are covered throughout the course of the study.

After looking at what has been done, one must look at what can be done. One of my early thoughts for a potential research question was: Does ChemCom give enough information to prepare students for a college level chemistry class? A study by Mason (1996) looked at exactly this. Mason mentions a number of the studies mentioned previously by Nelson (1988), Smith and Bitner (1993) as studies that "have addressed the appropriateness and effectiveness of ChemCom curriculum during its development and have followed its implementation at the high school level" (p.4). The results of Mason found that there are some differences between ChemCom and GenChem. According to Mason, "ChemCom students exhibited no significant difference from the overall mean, 75%" (p.6). The majority of the ChemCom students did succeed; only four students that were identified as ChemCom students earned a failing grade ( $4/34 = 11\%$ ) (Mason 1996). In addition, it should be noted that only one student that was identified as a ChemCom

student earned an “A” (Mason, 1996). The students that were identified as having taken a traditional chemistry class before totaled 561 in all; only 39 failed (7%) (Mason, 1996). This shows there is a significant difference between the preparations of students that are in ChemCom versus GenChem. Though Mason only looked at student’s grades as means of success, a couple of assumptions can be made about the structure of the class. First, the university class is structured as a traditional chemistry class based on a lecture, laboratory, and problem solving strategy. Therefore, a number of different assessments were used and figured into the students overall grades.

An opinion article by Sanger and Greenbowe confirms some of the findings found by Mason. “Chemistry faculty members are reporting mixed success of STS and ChemCom students in their courses- some ChemCom students are successful while others are not” (p.532). Much of the article by Sanger and Greenbowe looks at the advantages and disadvantages of ChemCom. Many of these advantages and disadvantages are those that I see in my own classroom. For instance, one of the advantages of ChemCom is that the students are given information as they need it. A disadvantage is that “ChemCom covers a fraction of the content covered in traditional chemistry” (p.534). This probably is because ChemCom is traditionally taught with less attention to mathematical analysis. As stated earlier this is the reason why many of the students choose ChemCom over GenChem. The conclusions from Sanger and Greenbowe state “that more information is needed to help college chemistry faculty make decisions regarding whether or not to accept STS and ChemCom course as acceptable prerequisites for general chemistry” (p.535). Madison, along with Sanger and Greenbowe, discusses the need for more studies that involve ChemCom to see if there is

a greater separation or if the differences that were seen in both cases are anomalies. These studies also focused on how successful ChemCom students would be in college chemistry classes. Since I will not be able to obtain information on ChemCom and GenChem students after they leave high school it is important that I focus on the students that could help me collect data.

## METHODOLOGY

The research methodology for my AR project required the use of different forms of data collection methods and assessments given throughout the school year. To be sure that the results of these assessments are controlled, both classes of chemistry received the assessments. Neither of these classes required any major curriculum changes, so my study is a descriptive study comparing two chemistry classes. Student motivation and performance between the classes were investigated. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

The data collection methods used revolves around two major themes of collection. These themes revolve around two of the sub-questions the student's motivation and the student's performance. The data collection techniques for my research are surveys, interviews, classroom assessments, and teacher reflection. I used the results of the sub questions surveys, interviews, classroom assessments outlined in my matrix (Table 3) to help answer my main research question, "How do students' goals influence their experience and outcomes in chemistry?"

Table 3  
Data Collection Matrix

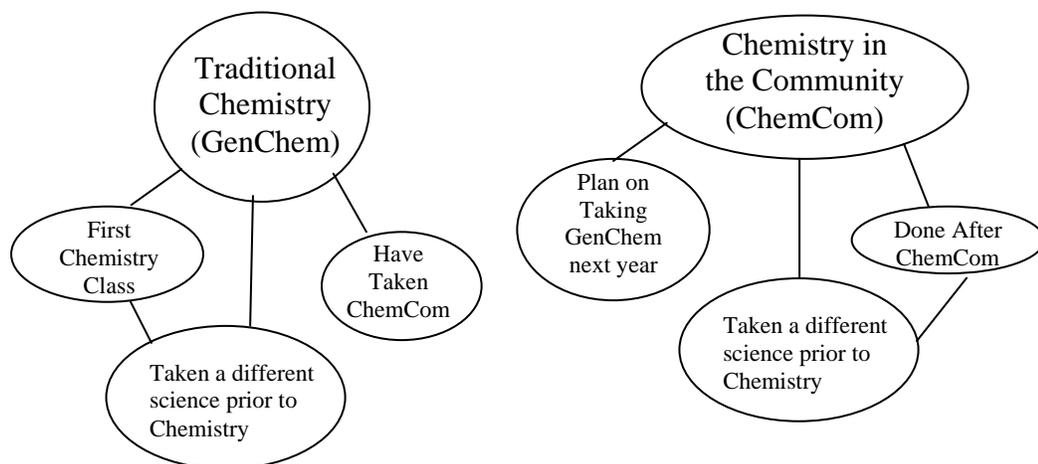
RESEARCH QUESTIONS	DATA COLLECTION METHODOLOGIES						
	BEGINNING SURVEY/ INTERVIEW	PRE-TEST	SPATIAL ASSESSMENTS	MID TERM SURVEY	UNIT/CHAPTER TEST	POST-TEST	FINAL SURVEY/ INTERVIEW
<b>Main Topic</b> How do the students' experiences influence their outcomes in different chemistry classes?	1, 2, 5	3, 5	4, 5	1, 2, 4, 5	4, 5	5, 6	1, 2, 5, 6
<b>Sub-question #1</b> What is the motivational difference between different chemistry classes?	1, 2, 5			1, 2, 4, 5			1, 2, 5, 6
<b>Sub-question #2</b> What is the performance difference between the chemistry classes on the state standards set by the state of Minnesota?		3	4, 5		4	5, 6	1, 6
<b>Sub-question #3</b> What are the differences for students in GenChem that have taken ChemCom prior to those students taking GenChem only?	1, 2	3, 5	1, 2	1, 2, 4	4, 5	5, 6	1, 6
<b>Sub-question #4</b> How do the results affect me as an educator?	1, 2	3	1, 2	1, 2, 4	4, 5	5, 6	1, 6

**Key** used to identify the reasons why the data method selected is suited to gather data for the question it is matched to.

- 1) Will give qualitative data. This will include student opinions about Chemistry.
- 2) Data will show detailed student opinions about specific questions.
- 3) Data will show baseline of the students' information (prior to the treatment).
- 4) Data will show progress during the treatment.
- 5) Data reflects potential differences during treatment.

Data will reflect the knowledge gained after the treatment.

Initially surveys were used to gain some data from every student to see if there are any large trends for each group (Appendix C). The survey itself had the students rank their responses, according to a Likert Scale (1-5), to statements that covered a wide range of topics such as learning styles, past science experience, why chemistry and overall class motivation. The questions used on this survey were used in past studies (Bryant 2008, Davis, 2009, Tenenbaum, 2009) that looked at some of the same themes that I did. I utilized Google forms to administer the surveys planned throughout the year. By utilizing this survey method, I was able to analyze the data in a timely fashion so that interviews were setup and conducted. By conducting the interviews with in a reasonable amount of time, 2-5 days, the student responses in the interviews are more likely to reflect the opinions expressed in the surveys. The students opinion could change as time between the survey and interview are conducted giving less validity to the interviews to correlate and clarify the information retrieved from the surveys. Interview questions (Appendix D) gave structure and allowed more probing question to be asked based on the results of the initial survey. From each group I attempted to get a representative number of students to interview. A 10% minimum of a sub group's population was used as a sampling standard. If a sub group's population was less than two students a minimum of three students were interviewed. A stratified random method was used to choose the students that were included in the sample in addition to the sample, students that were outside the two standard deviations for their groups on the pre-test were also included in the interviews throughout the year.



*Figure 1.* The different student groups that make up the classes in which interviews are conducted.

To keep the identity of the students involved safe in the data collection process each student was given a code that would allow me to know who the student is but will keep their identity safe from the reader. The method used has the student's initials, hour the class meets, class enrolled in, and years in chemistry (XX#GC# or XX#CC#).

The midterm surveys (Appendix E) were given in the middle of the school year using the Google forms survey tool. The survey itself had the students rank their responses, according to a Likert Scale (1-4), to statements that covered more focused questions such as why chemistry and overall class motivation. This survey had some similar questions to the beginning of the year survey that were tracked for changes in student responses while asking more probing questions requiring a typewritten response. A change in the Likert Scale forced students to give a more opinionated response. By forcing the student to chose a more definite answer the student's responses are more representative of their actual feelings. One major difference in this survey is that the juniors were asked questions that dealt with their plans for next year. The results from

this survey resulted in another round of interviews and questions based on the results of the interview (Appendix F).

The end of term surveys (Appendix G) were given before the end of the school year due to time constraints. This survey had some similar questions to the beginning of the year and midterm surveys that were tracked for changes in student responses while asking more probing questions requiring a typewritten response. The juniors were again asked questions that dealt with their plans for next year. The seniors were asked questions that dealt with what science classes they have taken and their motivation behind taking more than required. The results from this survey resulted in another round of interviews and questions based on the results of the interview (Appendix H). The interviews were all conducted with the same students that had been interviewed previously.

Different collection methods were required to answer the other sub-questions, I developed simple classroom assessment (Appendix I) required the students to spatially separate the different forms of matter (substance, mixture) into their subdivisions (element, compound, homogeneous and heterogeneous mixtures) and give examples of each. This assessment helped in triangulating the student responses to a pre-test and post-test (Appendix J) for the evaluation of the chemistry concepts that would have questions of varying difficulty measuring the standards set forth by the State of Minnesota. The test was developed using the program Exam View Pro (2008). Exam View Pro is a computer based test generator which gives the user the ability to pick the questions that are on a particular test. The ability to choose the questions that only dealt with standards set by the state of Minnesota, so the questions themselves are the

standards that I as a teacher should be teaching and therefore the standards that the students are expected to know when leaving my classroom.

## DATA AND ANALYSIS

How to motivate students to learn science that do not see a science field as an option is a problem that many science teachers face in their classes. Some of these students can have learning disabilities or a lack of motivation due to preconceived notions about science. However, is there a difference in motivation between students planning on a science career and those that do not plan on a science career? By the time most students are in their junior or senior year they have an idea of what profession they would likely potentially study. Not every student that takes ChemCom is a student that has a learning disability or is unmotivated. Some of these student are as motivated to learn chemistry as those considering science-based professions.

Student motivation for enrolling in the class they did has many different themes. The two major themes of student performance and motivation are the driving force behind the development of the methods of data. These themes were used to focus the analysis of the data that was collected during the study. The results of GenChem do not include those students that have already taken ChemCom (FChemCom). The number of students in the analysis does not represent the full population of the classes. Through the course of the year, the number of students that participated in this study fluctuated. The main cause for fluctuation is due to students being absent on a day in which the data collection took place. The other reason for this fluctuation is the unfortunate side of

education and that is students who drop classes for a number of reasons which include: dropping out of school, only needing a semester of credit, and moving out of the school district. The results in this study only reflect those students that were present when data collection took place.

Data collection started in September 2010, along with the analysis of the initial survey. This initial survey, along with the interviews, gives insight into a student's motivation for taking the Chemistry class that they did. This survey helped set the baseline for the surveys that came later. Results from the initial surveys, Table 4 indicate there were motivational differences and still some similarities between the groups within the study. Those students that responded with a Likert score of three, claiming neutrality, were not included in Table 4 as this option was not present in later surveys.

Table 4  
*Results for Student Motivation Enrollment By Percent*

GenChem <i>n</i> =58	Beginning 2010		Middle 2011		End 2011	
	Agree	Disagree	Agree	Disagree	Agree	Disagree
Fulfill a science credit	36.2	51.7	44.8	55.2	37.9	62.1
It would be interesting	53.4	29.3	77.6	22.4	72.4	27.6
Colleges look for it.	60.3	12.1	75.9	24.1	77.6	22.4
Help my career	32.8	32.8	63.8	36.2	67.2	32.8
FChemCom <i>n</i> =8	Beginning 2010		Middle 2011		End 2011	
	Agree	Disagree	Agree	Disagree	Agree	Disagree
Fulfill a science credit	12.5	75.0	37.5	62.5	25.0	75.0
It would be interesting	62.5	0.0	75.0	25.0	75.0	25.0
Colleges look for it.	62.5	25.0	87.5	12.5	62.5	37.5

Help my career	37.5	25.0	75.0	25.0	50.0	50.0
ChemCom <i>n</i> =15	Beginning 2010		Middle 2011		End 2011	
	Agree	Disagree	Agree	Disagree	Agree	Disagree
Fulfill a science credit	46.7	33.3	80.0	20.0	60.0	40.0
It would be interesting	40.0	33.3	60.0	40.0	80.0	20.0
Colleges look for it.	46.7	20.0	73.3	26.7	53.3	46.7
Help my career	40.0	33.3	60.0	40.0	46.7	53.3

A few questions had a significant number of neutral responses, more prominent in those students in ChemCom who had a significant number for all four questions (20-33%). In the other groups the neutrality was not as widespread. GenChem students were more neutral in only two questions: Colleges look for it (26.7%) and help my career (34.5%). Former ChemCom students had two questions that also showed significant responses of neutral: thought it would be interesting (37.5%) and help my career (37.5%). The students giving a neutral response that Chemistry might help their career did so because they had not thought about that before. In the initial interviews all but six GenChem students responded similarly, "I just have not thought about that before (yet)." Some of the noticeable trends are that many of the ChemCom students are in the class to receive the credit (46.7%), while the GenChem students (36.2%) overall seem not to agree and find other reasons to take chemistry. GenChem students tended to think about how colleges look for chemistry (60.3%); this is not surprising being that this class has traditionally been taken by those students planning on attending college. This was confirmed through interviews, students in GenChem (80%) and those students having taken ChemCom (100%) that preparation for school beyond high school is the main

reason for taking GenChem. Students in ChemCom who were interviewed and plan on attending college (45%) took ChemCom “as a way to see what Chemistry is all about and become comfortable with the topics because I am not real good at math (BB5CC1).” The results from the initial survey also show that many students do not see the connection between Chemistry and the careers that they are thinking about taking. Many students elected to take the neutral choice of three on the initial survey, but were forced to have an opinion in the later surveys. By forcing students to choose one way or another on the middle-of-the-year survey explains the large fluctuation from the initial survey to the middle of the year survey.

The middle-of-the-year survey forced the student to take a more opinionated stance on the questions dealing with enrollment motivation. This was done by omitting the neutral response option. The values that are found in the middle of the year do not vary from the beginning of the year whether or not the students agreed or disagreed with the statement. The values changed as the neutral response was omitted. Omitting the neutral response one would expect to find increases in both categories, however this was not the case. In the beginning of the year more GenChem students disagreed (29.3%) with the statement, “I thought Chemistry would be interesting”, than the middle of the year where 22.4% of the students disagreed with that statement. This difference was equivalent to four students changing their responses to agree with this statement. These differences were not just found in GenChem; ChemCom also saw a decrease in a category. For ChemCom students the difference was that fewer students disagreed that they took Chemistry just to fulfill their science credit from the beginning (33.3%) to the middle (20%). This difference of about 13% was the equivalent of just two students.

However, in interviews one of those students (RN5CC1) gave insight as to why the difference was seen. In the interview, RN5CC1 stated, “It (Chemistry) was just really hard right now.” When asked for more specifics RN5CC1 expanded, “Well the whole balancing thing seems confusing, I just don’t see why this is needed.” At the time of the interview this response was of concern, why we are learning a particular subject was not made clear. A benefit of the ChemCom curriculum learning chemistry has a purpose to learning the subject. The decrease in students disagreeing that they are taking Chemistry just for credit was not just confined to ChemCom students; former ChemCom students also saw a decrease (12.5%) in this statement. However, this decrease is paired with a decrease in the number of students that disagree that colleges look for Chemistry (12.5%). It might be concluded that this change came from students changing his/her views, why they were taking Chemistry to more of a college prep class and therefore more of a credit need. However, interviews concluded no such indication and further investigation of the surveys showed that the same student did not make a change in his/her response and therefore it was a random switch of attitude. The change in feelings why students registered for the class that they did the greatest correlations are seen between the middle-of-the-year-survey and the end-of-the-year-survey.

The end-of-the-year survey has more of a direct correlation to the middle-of-the-year-survey. The overlying trend from the beginning of the year to the end of the year gives the big picture changes in students’ thoughts as to why they signed up for the Chemistry class that they did. In GenChem, three of the questions that deal with student motivation beyond credit (colleges, career, interesting), two saw increases in students agreeing with those statements. The only question that saw a decrease (5.2%) in students

agreeing was the number of students that thought that it (Chemistry) would be interesting; this equates to about three students that changed their value. From the beginning of the year to the end the year the increases were seen in all three questions. As for students in GenChem taking Chemistry just for credit, the number of students disagreeing with this statement increased as the year progressed (51.7%, 55.2%, 62.1%). In the interviews it was evident that a change in student motivation had occurred. The change was not necessarily found in student quotations, but in the excitement and even the passion with which they conveyed their reasons. Many of the students gave the same responses, citing college and career as the major influences for choosing the class that they did. These responses came faster at the end of the year (within one second of asking) when compared to the beginning of the year (five or more seconds of asking). The students in ChemCom, however, did not see the same trends as those in GenChem did.

In the same three questions, college, career, interesting, ChemCom students showed no significant difference (3.3%) in agreeing or disagreeing that college or career as a reason for taking the class they did. This did not change from the beginning-of-the-year. However, the changes from the middle of the year were interesting as these variances were only seen in the surveys. The ChemCom students did not show this variation from survey to survey when interviewed post survey. Only one question saw a significant difference between those that agree (80%) to those that disagree (20%) they enrolled because they thought Chemistry was interesting. In ChemCom students also seem to agree (60%) that they are in their class to fulfill credit. In the interviews RN5CC1 said, "I just don't see myself needing Chemistry beyond high school." When

probed as to why, “I just don’t see myself going to school after high school; I will most likely work construction or something. I liked the class and all but I just don’t see needing this later on.” These responses were completely opposite from AD5CC1, “I am totally taking Chemistry (GenChem) next year, I know I am going to need it for college and all.” When asked why they took ChemCom first as opposed to GenChem, student AD5CC1 responded, “I was not sure if I could have handled it, but I think I should be okay next year, after having ChemCom first.” These differences in student attitude and motivation are common for students near the end of the year. Former ChemCom students changed the least from the beginning of the year to the end of the year. None of these students need the science credit, but a few (25%) still feel that they are in the class for credit. There is an equal split (50%) in how chemistry will benefit their future careers. This was confirmed in the interviews where there was an equal 50% split; students TD4GC2 and MK4GC2 are pursuing degrees in the fine arts. Both stated, “Though I will not need this class (Chemistry) directly it will help me in my generals in college.” On the other side, CB4GC2 and CM4GC2 are pursuing different careers and they both stated, “I know I will need this stuff (Chemistry) for my job and even in school on my way to my degree.” When asked why they did not take their current Chemistry the year before they both stated, “My math skills are not the best and I figured that it would be best to see if Chemistry is something I liked before taking this class.” One common thread among all of the groups was that the majority in all three groups in this study, at the end of the year took Chemistry because they thought it would be interesting. Interest got them in to the class; what motivated them once in the class was the next step.

Once the students are in the class what is their motivation; is it a grade or is it the information learned? Table 5 suggests that the grade which the student receives is more important than the chemistry that is learned. Initially ChemCom students seem slightly less motivated by grades (60%) than their GenChem (69%) counterparts or the former ChemCom students (75%). It does not come as a surprise that students' are motivated by the grade they receive. According to Glynn et al. (2006), the grade point average (GPA) has a large direct motivation to learn science. The students responses in this study fall in line with the claims made by Glynn et al., at the beginning of the year with grades being the major motivation between the classes as opposed to the science.

Table 5  
*Students Rankings of Their Motivation.*

GenChem $n=58$	Beginning 2010		Middle 2011		End 2011	
	Agree	Disagree	Agree	Disagree	Agree	Disagree
Chemistry learned is more important than the grade received.	22.4	50.0	48.3	51.7	48.3	51.7
I think how my chemistry grade has affected my overall GPA.	69.0	10.3	70.7	29.3	81.0	19.0

FChemCom $n=8$	Beginning 2010		Middle 2011		End 2011	
	Agree	Disagree	Agree	Disagree	Agree	Disagree
Chemistry learned is more important than the grade received.	12.5	37.5	62.5	37.5	50.0	50.0
I think how my chemistry grade has affected my overall GPA.	75.0	12.5	87.5	12.5	100.0	0.0

ChemCom n=15	Beginning 2010		Middle 2011		End 2011	
	Agree	Disagree	Agree	Disagree	Agree	Disagree
Chemistry learned is more important than the grade received.	6.7	53.3	20.0	80.0	40.0	60.0
I think how my chemistry grade has affected my overall GPA.	60.0	26.7	60.0	40.0	60.0	40.0

Throughout the year GenChem and former ChemCom students increased their feelings on how their grade has affected their overall GPA. ChemCom students did not change their responses as the year went on when asked about their overall GPA being affected; only those that claimed neutrality changed their responses from neutral to disagree. All students in this study tended to agree with Glynn et al., throughout the year with only increases of the number that agree that grades are a great motivating factor.

As a science teacher the subject matter is a passion, learning and teaching the content is a part of that passion. Initially students in all the classes entering Chemistry feel that the grade is more important than the subject matter. A significant number of students responded neutrally to initial survey. In the interviews that followed it was shown that the students did not know how to respond, "I never thought of learning that way before (NZ2GC1)." As the year went on, towards the middle-of-the-year survey, there was a shift in their motivation based on their experiences in the chemistry classroom. Former ChemCom students had the greatest increase in the percentage of responses of students that felt the Chemistry learned is more important than the grade received. Students that have taken ChemCom before have learned the information in a manner that gives reason as to why they are learning the information. This method might enable students to see that learning chemistry has a value to them. This increase was

coupled with the majority of the students feeling that the class had affected their GPA. Which indicates that though they understand that learning chemistry is important they are still motivated by the grade they receive? The increase of students that agree that the Chemistry learned is more important was not just seen in the former ChemCom students; both GenChem and ChemCom students began to see an increase in those that agreed. The interviews showed the same increase of students that switch their thinking, OK4GC1 stated, "My view did not change. I can see that I will need this in college so learning this stuff (chemistry) now is important, the grade is important too, but I need to know this for later classes." The students in ChemCom did not have the same thoughts as GenChem students but were similar, "I will most likely be taking Chemistry again next year (GenChem) so learning it now is important for next year. (AD5CC1)" Though the comments are different, they both point to a common trend that the students are more aware of the need to learn not just for the grade but also for the future.

In the final survey the students' perception of learning Chemistry being more important than the grade did not change. This no change was coupled with an increase of students thinking how their GPA has affected their grade. There was a slight decrease in former ChemCom students agreement (-12.5%) which was the equivalent of one student. Leaving the former ChemCom group evenly split if the Chemistry learned is more important than the grade, but 100% agree that their grade has affected their GPA. The only group that saw an increase in students that agree that learning Chemistry was more important than the grade was ChemCom. The odd thing about this group's gain is the number of students worried about the grade affecting their GPA was opposite from those that agree that Chemistry learned is more important. This contradicts Glynn et al., in that

students find that the grade is the most important thing. However, a trend might have continued to increase if there was more time.

Overall, from the beginning to the end of the year, each of the groups saw an increase towards the two motivational factors: learning chemistry and grade received. Many of these motivational factors coincide with the three factors that put the student in the class for which they registered. Student motivation to learn based on GPA is a documented reason (Glynn et al.) for students to learn the information, but is the information learned just for that test or is knowledge actually gained as suggested by learning Chemistry being more important than the grade? To show that the student has actually learned some information one must test to see what the student knows before they enter the classroom and then when they leave the classroom

To test the students on what they know entering and also know when they leave the classroom, another piece of data was collected at both the beginning and the end in the form of pre-tests and post-test. This test was developed under the standards set by the state of Minnesota. The pre-test (Table 6) results indicate that GenChem students scored higher than those students did in ChemCom. The students that have taken ChemCom prior scored higher than those students that are in GenChem for the first time. Of those that took the pre-test, four students did not score within two standard deviations: three from GenChem (all on the high end of the scale), one from ChemCom (below the scale).

Table 6  
*Average Percent Results on the Pre-Test*

GenChem		Former ChemCom		ChemCom	
<i>n</i> =58	pre-test	<i>n</i> =8	Pre-test	<i>n</i> =15	pre-test
AVG	29.98	AVG	32.88	AVG	25.47
STD DEV	7.9	STD DEV	6.4	STD DEV	3.7

Finding that students formerly in ChemCom scored higher on average than those taking GenChem and ChemCom for the first time is not significant. Since these students have covered many of the topics in some fashion in the previous year, the results, if anything, show some level of retention from one year to the next. The three students from GenChem that scored above two standard deviations from the average within their group also scored higher than any other that took the pre-test. These students have a reputation as intelligent students that normally score well in their respective classes. Guessing the correct answer or being test-wise, having the ability to take test and find the correct answer with little knowledge of the correct answer, would not explain why these students scored the way they did. The pre-test is a valuable tool in that it gives us an idea of what the students know entering the class. To find if the students really do understand the information in the pre-test, another means of testing their knowledge is done to validate the scores on the pre-test. In this study, a classroom assessment (Appendix I) required the students to spatially separate the different forms of matter (substance, mixture) into their subdivisions (element, compound, homogeneous and heterogeneous mixtures) and give examples of each. In addition to the separating of matter, students were required to understand the properties of the three states of matter: solid, liquid, and gas. These

questions on the classroom assessment related directly to some of the questions on the pre-test (Appendix J). Questions 13, 45, and 67 dealt with the student being able to understand properties of different states of matter. These responses correspond to question 2 in Appendix I; there the students needed to identify the property that overlaps with another state of matter. Questions 16, 32, and 82 required the students to understand the difference between homogeneous and heterogeneous mixtures by the examples given. These responses correspond to question 1 in Appendix I. There the students needed to identify the different types of sub-divisions of matter and give examples. The questions in Appendix I were graded as a quiz score but not used to calculate the students' grade.

According to the scores from the pre-test there is no overlying trend that would indicate that students overall had prior understanding of the concepts investigated. When the results from the spatial assessment are compared to the scores for the same concepts, Table 7. Spatial assessment required the students to place the correct answers within a diagram format. It can be seen that there is a small difference in the pre-test and the spatial assessment, indicating that the pre-test was a practical assessment of the students' knowledge prior and after the class.

Table 7  
*Pre-test and Post –test questions that pertain to the Spatial Assessment*

Assessment Method	GenChem	FChemCom	ChemCom
Pre-test %	42.0	23.3	41.7
Spatial %	51.2	27.5	30.7
post-test	77.3	50.0	50.0

There are some notable results; student AL4GC1 was the only student correctly answering all of the questions identified in this comparison on the pre-test and scoring a ten on the spatial assessment. This student goes beyond many of his/her peers in attempting to challenge his/her self, by taking courses online that are not offered in the classroom by the district. One student, DB5CC1, scored outside two standard deviations on the low end of the scale for their particular group and was the only student to incorrectly answer all of the questions on the pre-test. This student has no documented learning disability but has shown to have difficulties conveying his/her thoughts through speech. One student, CG6GC1, did not correctly answer questions for a particular section, identifying examples of mixtures. This particular student did have Physics the previous year in which states of matter is covered, but scored a ten on the spatial assessment. Many of the other students did not improve by any great deal and in some cases did worse. There can be many different reasons for this; this was, for some, the first time in which they were asked to answer questions in this manner. For some students, seeing a different format on a quiz can lead to a heightened anxiety when taking the quiz and result in poor scores. However, this was not seen in those students that were the outliers from the GenChem class. These students were, for the most part, able to answer the questions correctly and give examples. Only student JK4GC1F did not give examples on the spatial assessment, resulting in a deduction of points. Though the students formerly in ChemCom scored higher on the pre-test over all, they did not, however, score better than many of the GenChem students. These students did not score better than those in GenChem in this particular section of the pre-test; the scores on the spatial assessment did not improve either.

The scores from the spatial assessment for the former ChemCom students was somewhat of a surprise as these students worked with these types of diagrams the previous year. Many of these diagrams are used to help students spatially separate information given to them, one of the strengths of ChemCom. Even students in ChemCom class did not score particularly well (30.7%) having done and used these types of diagrams in the class as a part of notes. The one student that did see the most success in the spatial assessment was KM5CC1; this student did not do well on the pre-test for this section but did have one of the highest scores overall on the spatial assessment. This student was able to make and see improvements from the information given between assessments.

The results from the pre-test showed that the students did not have a great deal of prior knowledge. When compared to a spatial assessment that was given to the students, during the time in which those topics were covered there was an increase in scores among GenChem and former ChemCom students. Only the ChemCom students saw a decrease in their scores. This does not mean that there is a decrease in understanding. When the same questions are looked at in the post-test this is evident, as can be seen with all groups increasing their percentage in Table 7. Student AL4GC1 was the only student correctly answering all of the questions in the pre-test and scored a ten on the spatial assessment. However, this student was not the only one to do so on the post-test. Students MK6GC1 and OK4GC1 also answered all of the questions that correlated to the spatial assessment. There were a number of students (18) that missed one question in this set. There does not seem to be a direct relationship between questions answered correctly on the pre-test and those on the post-test. Some students correctly answered questions on the pre-test and not

on the post-test. Many of the other students had minimal improvements, one to two questions, and in some cases did worse. Five students decreased their score 1-2 points on this particular section. Though the students formerly in ChemCom scored higher on the pre-test, they did not score better than the GenChem students in the spatial assessment and on the post-test questions that pertain to the same subject matter.

The student DB5CC1 who scored outside two standard deviations on the low end of the scale for his/her group increased his/her scores on the post-test for these questions from 0% to 50%, and this helps to show that the cyclic nature of the ChemCom curriculum can help students increase understanding. This was odd, as 41.7% to 50% of the students did not improve their scores on this particular set of questions. The one student who saw the most success in the spatial assessment was KM5CC1; this student did not do well on the pre-test (33%) for this section, but did have one of the highest scores overall on the spatial assessment, and kept the success on the post-test where he/she scored the best in the class with 83%. Looking at just this set of questions does not give a big enough picture on what the students learned over the course of a school year.

To see if the students increased their knowledge under the standards that the state of Minnesota has set for Chemistry classes, the best comparison would be to compare the pre-test scores to the post-test scores. Table 8 looks at the class averages on both the pre-test and post-test, in addition to showing the average normalized gain ( $g$ ) for each class. The average normalized gain is a calculation used to determine meaningful comparison between groups that have a wide range of pre-test and post-test scores by defining  $g$ , as the actual gain divided by the maximum possible gain (Francis, G.E., Adams, J.P., &

Noonan, E.J. (1998), Hake, R.R. (1998)). Student 1 having a pre-test score of 25 and a post-test score of 63 would see a normalized gain of about 50%. Student 2 scored double than student 1 on the pre-test (50) would need to score a 75 on the post-test to see the same gain. According to Francis et al. “normalized gain tends to be remarkably consistent for classes taught using similar strategies despite a wide range in the pre-test scores” (p.488).

$$g = \frac{(\% \text{ post} - \% \text{ pre})}{(100 - \% \text{ pre})}$$

Table 8  
*Average Percent Results on the Pre-Test verses Post-Test with Average Normalized Gain*

GenChem <i>n</i> =58	Pre-test	Post-test	Normalized Gain
AVG	29.98	54.36	45.53
STD DEV	7.9	11.9	17.0
FChemCom <i>n</i> =8	Pre-test	Post-test	Normalized Gain
AVG	32.88	44.25	21.77
STD DEV	6.4	7.7	11.9
ChemCom <i>n</i> =15	Pre-test	Post-test	Normalized Gain
AVG	25.47	39.53	23.91
STD DEV	3.7	8.6	12.0

The post-test saw a change in the students that are seen as outliers. The students that were originally outliers on the high end of two standard deviation on the pre-test were no longer outliers on the post-test when that test’s standard deviation was used. The scores on the post-test varied larger (standard deviation of 11.9) with no student scoring lower on the post-test than they scored on the pre-test. There were only two outliers amongst

all three groups and these two outliers were on the low end of two standard deviation. These students were not outliers in the pre-test because their scores were like many in the GenChem group, low but still close together. These students saw the smallest normalized gain from the beginning of the class to the end, which was less than 10. Those students that were outliers in the pre-test, did not score low gains and actually saw gains 20 points higher than the average for the group. This is not surprising as these students are near or at the top of their class. So grades are important to these students. Learning the information is something that these students take seriously.

The ChemCom students saw gains but not the same as those seen in the GenChem group. The ChemCom students also saw a larger variation in the test score as seen from the increase in the standard deviation. The one student that was seen as an outlier on the low end of the spectrum was not an outlier for the post-test. This student did score one of the lowest scores on the post-test but did, however, see a normalized gain only slightly less than the class average (16.18); this gain is most likely do to the low pre-test. This group did not see the gains that the GenChem students saw. Some of the questions on the post-test did pertain to subject matter that had not been covered at the time the post-test was given. This would explain, to some degree, the lower scores that were seen on the post-test.

The former ChemCom students saw the least gain when compared to the other groups. This was a surprise as these students have had both sections of Chemistry. It is understandable that they scored higher on the pre-test than the other groups. The interesting result from the post-test is that these students did not score as high on the post-test as would be expected. These students have had all the topics on the test, but they still

did not see the continued scores that they saw in the beginning of the year. There was a only a slight change in the standard deviation meaning the scores of the students were still close to each other but just not as high of gains as the other groups ended up having over the course of the year. One student had a very low gain (4.4) and only improved his/her score by two points. Even with this low score he/she was within the two standard deviations used to determine outliers. The results from these students give very mixed results and not what was expected.

Through the process of setting up the questions, gathering, analyzing and interpreting the data I was able to get a better understanding of what motivates my students in the classroom. It is these motivations that though similar from group to group, still differ from student to student. Each student has a certain level of motivation for getting the grade he/she wants and learning the Chemistry needed to accomplish these goals. It is why they want to learn and earn the grade that makes them individuals and makes each experience different.

Through the analysis process it was important to keep an open mind. Letting the classes be taught as they are designed to be taught, teach with no prejudice as to what method is the best, and making sure that each of the students has an experience that would give them opportunities to obtain their goals what ever they might be. The data collection process was a new aspect of the classroom experience for the students in the Chemistry classes this year. At times the students were reluctant to participate in the process, while others were very inquisitive. Throughout the collection process it was difficult to try and not sway the data one way or another. In previous studies in which I was a researcher, the process was different; samples were prepared, collected and

analyzed by myself. The end result was not influenced by how the sample was feeling on that day. The samples did not have lives that influence how it might do on a test. This study had these potential pitfalls. To make sure that the students were not stressed by the pre-test and post-test results two weeks of warning. Describing of how the test would be given, where to meet, where to sit, format, what will be given as aids (calculators, periodic tables), and overall expectations for behavior, before, during and after the tests. The surveys did not require this preparation; this part of the data collection process required that I create a survey that would encourage the students to give their honest responses. This was done by not having the questions of the highest data value at the beginning or at the end of the survey. Instead, these questions were placed in the middle so that the student was thinking freely and responding in a way that was honest. This honesty was the most important aspect of the data. If the data was not a true indicator of how the students felt, the data would not have been consistent and reliable. The interviews would have pointed to the potential of this happening. The interviews fell in line with what the survey's data was revealing. It is these snap shots the interviews give of the surveys that give confidence the data from the surveys is reliable.

Through the process of preparation, collection and analyzing is different from previous research experiences. This process has forced me to look at what I teach and why I teach certain lessons in the classroom. Certain lessons give the students an experience that they need for their success in meeting their goals. Not all of the students' goals are achieved in every lesson. At times different students are more engaged than others, as the lesson being taught might have more meaning or personal value to learn them. Even though the curriculum in GenChem does not go into the connections to

society that ChemCom does, I find it important to inject the connections to society when appropriate. It is these connections that make the class valuable to the student, MK6GC1 stated, "I liked the connections that you made to the real world. It made the information worth it (to learn)." Even students that have had ChemCom prior to GenChem agreed but felt that the connections should be more frequent. Students in ChemCom all appreciated the connections, "It gave me a reason to learn the information (RN5CC1)."

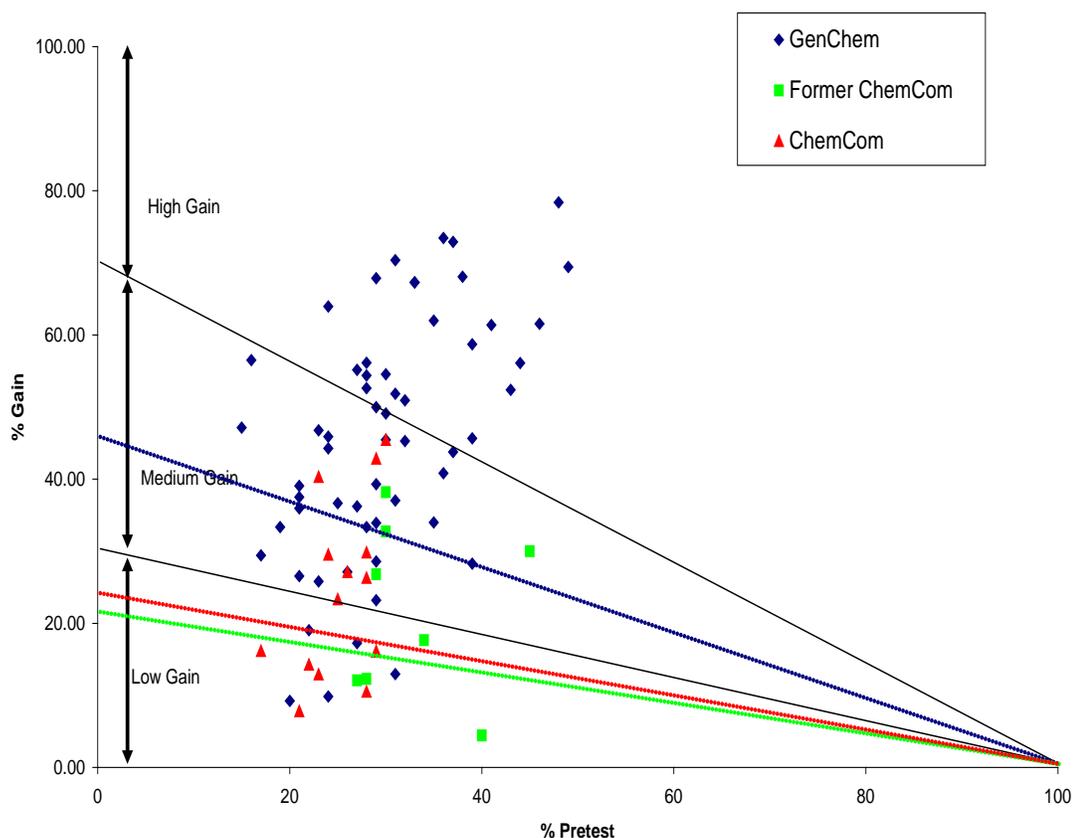
The depth of content taught so students are able to be successful in their goals is a difficult task as well. Each student's goals and motivation illustrates the amount of depth that is required for the students to achieve the highest level that they seek. These differences make the planning process difficult. In an ideal world, each student would have an individual curriculum that would allow the student to learn only what he or she needs to achieve the goals the students have for themselves. However, in teaching to the masses from a loosely structured curriculum, students can choose what they want out of the class based on their motivations. This can change as time moves forward. Ultimately, it is not about me teaching what I want, but giving the experiences that give the student opportunities to see the outcomes that drive them to perform and succeed.

## INTERPRETATION AND CONCLUSION

The data collection methods used revolve around two major themes of collection, the students' motivation and the students' performance. The data collection techniques included surveys, interviews, classroom assessments, and teacher reflections. I used the results of the sub-questions, surveys, interviews, and classroom assessments to help

answer my main research question, “How do students’ goals influence their experience and outcomes in chemistry?”

The information obtained from the surveys clearly showed that that students in all groups have some of the same motivations to take Chemistry. The GenChem students stated that college and career are some of the major reasons for taking Chemistry. It is not surprising that these students would cite these two reasons as major factors for taking GenChem as opposed to the alternative ChemCom. The other result that ties these two reasons together is that the students find the grade received is a motivating factor (Table 5). This agrees with the Glynn et al., study that found that for college students the grade that they earn, and how it might affect their GPA was a large motivating factor for doing well. The GenChem class is designed for those students that plan on attending a college. It is this motivation to learn the information for a grade so they can get into a college and therefore enhance their careers. These motivations, grade and attending college, are the most likely cause of the gains seen in Figure 2 by this group and why their gains were so much greater than the other two groups.



*Figure 2.* Hake plot showing of high, medium, and low gain. Dotted lines represent the average gain for that group. ( $n=81$ )

It was not surprising that GenChem students are motivated by grades; their ChemCom counterparts claimed to be motivated by grades; the results were just not seen to the same degree. These students do not see the connection between their class choice, and how it pertains to the next step in the education process such as college and career. Again this is not surprising given the demographics in this class. But, an early study by Nelson (1988) stated that ChemCom was an alternative to how Chemistry is taught, not what is taught. I can agree with Nelson that the subject matter is there, but it has become common practice (Smith, L.A., Bitner, B.L. (1993), Sanger, M. J., & Greenbowe, T. J. (1996), Mason, D. (1996)) to teach ChemCom as it is taught in my school district. The

push for students to take more sciences and giving students choices to choose the class that best serves them makes ChemCom a great alternative to the mainstream GenChem class, but the gains that were seen in this study do not give any overlying benefit to taking ChemCom versus GenChem. This study is unable to obtain information on students to determine if students that only take GenChem are successful at the next level. However, a study by Mason (1996) showed that students that have taken any chemistry, ChemCom or a traditionally taught chemistry are more successful in a college level chemistry class than those that have taken no chemistry. In Figure 2, the ChemCom students did not have the gains that the GenChem students had. A few students in ChemCom saw gains close to and even above the GenChem average. These three students have expressed interest in continuing to take an optional fourth year of science.

Unfortunately, there does not also seem to be any real advantage for those students in ChemCom to take GenChem. Those that have taken ChemCom previously scored higher on the pre-test as a whole but did not see the same gains as the GenChem students did. Even the highest pre-test in GenChem (48) saw a larger gain (78.4) than the highest gain from a former ChemCom student (38.2). Having had all the information prior to taking GenChem it would be expected that these students would have high pre-test scores and then see less gain because of the high pre-test scores. This was not the case as these students saw low gains, but it was not because the scores were too high. These students might have, in some way, topped out in their ability level. The other explanation could be the students in this group did not see the same gains as their motivation to learn the information was not the same as those students also in the GenChem class. At the end of the year the students that took ChemCom previously

claimed that interest (75%) was the biggest motivation for taking the class which is unlike the other students in GenChem who are taking the class not only for interest but for their future. The grade motivation was there as well, but these students are closer to graduation so the effect of a grade might be minimal. Also, they might not see the immediate connection to the claimed major of choice. Two of the students interviewed actually claimed to be entering college as a fine arts major (music therapist, artist) and the need for Chemistry would only be to fulfill the general education credits.

How do the students' experiences influence their outcomes in different chemistry classes? The Glynn et al., study suggests that the motivation to do well comes from the grade that would be earned in the class. This is confirmed from the results in the surveys given throughout the year. The motivation based on earning a grade is seen for all groups identified in this project. However, the learning that is suggested by the motivation to get a good grade was not seen in all groups as can be seen from the gain that Figure 2 illustrates. Even though the grade motivation is there, I feel that there is another factor that helps explain the results and differences seen.

The other factor that helps explain why the GenChem students saw higher gains was that these students are not only motivated by grades, but they see the connection to the grade and the information learned and how it will affect their future. In the interviews throughout the year it was evident that these students wanted to know the information not just for the grade that can help get them into a college, but what they learn now will help deepen their understanding of Chemistry when taken after high school. ChemCom students that had the highest gains did not start with the same motivation for learning for the future as those in GenChem did, but in the end their motivations were aligned to be

the same. The gains for these students might not have been as great as they could have been because of the cumulative way that Chemistry is taught, in that information learned in the beginning of the year is important to the information that is learned at the end. By ultimately recognizing the need for Chemistry later in the year students might see lower gains than have been seen if these students recognize this other motivation factor to not only learn the information but to also receive a good grade.

## VALUE

Very early on in the process of the research, I had some preconceived notions how the results would look. Many of these preconceptions were based on what the previous year of students showed in very informal observations. The observations were that students in GenChem were in class as unavoidable step to the next. The apparent lack of motivation to challenge themselves, I felt necessary to look into and try to uncover the underlying motivations for students taking the science classes that they do. In the process of this study, I was shown that the students were motivated to learn the material. Why they learned or to what depth the material was learned depended on that student's motivation for being in the classroom.

The classes in this study are taught differently to engage the student for different reasons. GenChem would be the easiest for most Chemistry teachers because it is most like the method traditionally taught in high school and college. ChemCom requires the educator to have the same understanding of the content that the GenChem class requires, but the connections to society need to be better understood. The educator needs to be willing to teach the subject matter differently and in a sequence that is different than what

is the traditionally taught. The curriculum ChemCom is taught from allows the teacher to change the depth that is required to fit district and state standards. This flexibility of the curriculum gives teachers the opportunity to change as motivations change.

As an educator it is nice to see students motivated by learning the content and not just grades. Nolen (2003) states that “students in science classrooms where teachers were perceived to endorse independent scientific thinking and to desire deep understanding of science concepts had higher achievement and greater satisfaction with their science learning” (p. 363). By just focusing on the grades that these students receive, they will not have an appreciation for the subject matter. I think that as a secondary teacher we have a great passion for the subject matter that we teach. We would like others to have or gain an appreciation for the subjects that we teach. For many teachers, grades are a necessary evil. It is my feeling that grading students and the stress ensued from them is cause many teachers to lose their passion for the subject matter. Through the course of this project I have learned that my passion for my subject matter and preparing students for their futures is for me the motivation that I need to try and improve myself as teacher. It is this motivation to improve myself that Munro and Elsom (2000) found that “Science teachers have the major influence on pupils motivations towards and enjoyment of science, through the pupils experience of science in the classroom” (p.4). To improve myself as a teacher I need to constantly push myself to engage the students’ interests, so their motivation for being in the classroom and learning is steady.

This project seemed, at times, too big to accomplish in the time constraints placed on the data collection process and me. Next year I would like to continue collecting data on the students in the groups that I have identified through the process. The data

collected next year would be as close to methods the data was collected in this study but given at times that are more appropriate. Next year would not have the time constraints seen with this study. Allowing for the post-test given at the end of the year after all material was covered. Students in ChemCom during this study that take GenChem can be looked at closer as to see if the results from this study are consistent. These students' motivations can be compared to the previous year's responses to see if any likenesses or differences are present. The collection of the data does not need to stop after next year either; the collection process can be improved as technologies improve and other questions present themselves. Each year the data is collected will give a better understanding to how the students' experiences influence their outcomes and how these experiences affect me to improve for the next year.

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APPENDICES

APPENDIX A

CHEMISTRY YEAR PLAN

# Chemistry

Mr. Pederson  
Year Plan

## Course Outline

- i. Lab Safety**
  - a. What's in the Lab
  
- I. Matter and Measurement**
  - a. What is Chemistry
  - b. Matter & Change
  - c. Scientific Measurement
  
- II. The Atom and the Periodic Table**
  - a. Atomic Structure
  - b. Electrons in Atoms
  - c. The Periodic Table
  
- III. Chemical Names and Bonding**
  - a. Ionic & Metallic Bonding
  - b. Covalent Bonding
  - c. Chemical Names & Formulas
  
- IV. Chemical Reactions and Quantities**
  - a. Chemical Quantities
  - b. Chemical Reactions
  - c. Stoichiometry
  
- V. Gas Laws & Thermochemistry**
  - a. Liquids and Gases
  - b. The Behavior of Gases
  - c. Thermochemistry
  
- VI. Aqueous Chemistry**
  - a. Water & Aqueous Systems
  - b. Solutions
  - c. Reaction Rates & Equilibrium
  
- VII. Electrochemistry**
  - a. Acids, Bases, and Salts
  - b. Oxidation-Reduction Reactions
  - c. Electrochemistry

APPENDIX B

CHEMCOM YEAR PLAN

# Chemistry in the Community: ChemCom

Mr. Pederson  
Year Plan

## Course Outline

### **i. Lab Safety**

- a. What's in the Lab

### **I. Water: Exploring Solutions**

- a. What is Chemistry and its Measurements
- b. Sources and Uses of Water
- c. Looking at Water and Its Contaminates
- d. Investigating the Cause of the Fish Kill
- e. Water Purification and Treatment

### **II. Materials: Structure and Uses**

- a. Why We Use What We Do
- b. Earth's Mineral Resources
- c. Conserving Matter
- d. Designing for Desired Properties

### **III. Petroleum: Breaking and Making Bonds**

- a. Petroleum What is It
- b. Petroleum: An Energy Source
- c. Petroleum: A Building Material Source
- d. Energy Alternative to Petroleum

### **IV. Atoms, and Air: Chemistry Interactions and The Atmosphere**

- a. The Nature of Atoms
- b. Gases in the Atmosphere
- c. Electromagnetic Spectrum and Radiation

APPENDIX C

BEGINNING OF THE YEAR SURVEY

All the questions are taken in whole or in part from the following sources: Bryant 2008, Davis 2009, Tenenbaum 2009

### Beginning of the Year Survey

1. Name (first name, last name)

2. What hour does your class meet?

➤ 2<sup>nd</sup>, 4<sup>th</sup>, 5<sup>th</sup>, 6<sup>th</sup>

3. What Chemistry are you enrolled in?

➤ General Chemistry GenChem,  
➤ Chemistry in the Community (ChemCom)

4. How many chemistry classes have you taken?

➤ 1, 2, 3

5. Not including this class, how many science classes are you currently taking or have you taken after 10th grade Biology?

➤ 0, 1, 2, 3, 4

6. I did well in my other high school science classes.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

7. I found physical science (9th grade) interesting.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

8. I found biology interesting.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

9. I found biology related to my life.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

10. Overall I enjoy science classes.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

11. The science classes I have taken have value to me

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

12. I am taking chemistry just to fulfill a science credit

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

13. I took chemistry because I thought it would be interesting

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

14. I took chemistry because colleges look for it.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

15. I think about how learning Chemistry can help my career

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

16. I think about how I will use the chemistry I learn.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

17. The chemistry I learn is more important to me than the grade I receive.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

18. Earning a good chemistry grade is important to me.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

19. I think about how my chemistry grade will affect my overall grade point average.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

20. I am nervous about how I will do on the chemistry test.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

21. I understand why labs are important in understanding chemical concepts.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

22. I am confident I will do well on the chemistry labs and projects.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

23. I feel comfortable using and identifying lab equipment

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

24. I feel comfortable working with hazardous chemicals.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

25. The chemistry that I am in is based on my math experience.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

26. How the subject matter that is presented is an important factor in enjoying a science class.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

27. The activities done in class are an important factor in enjoying a science class.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

28. I learn best when concepts, examples, etc., are repeated consistently

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

29. I learn best with hands-on activities such as labs.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

30. I learn best by listening to lecture and taking notes in class.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

31. I completely read the experiment before entering the lab.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

32. I become anxious when it is time to take a test.

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

33. I like courses that challenge me

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

34. What is the likely hood that you would take a science class beyond the three that are required?

➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly

APPENDIX D

INITIAL INTERVIEW QUESTIONS

Name \_\_\_\_\_

Enrolled in \_\_\_\_\_

Taken ChemCom Before \_Y/N\_

Will be Taking Chemistry \_Y/N\_

1. What do you plan on doing after you graduate?
  - How does this class fit in?
2. Of the science classes you have taken which, did you enjoy the most?
  - Why?
  - Was it because it related to your life?
    - i. How was this accomplished or could have been better?
3. What is the reason for taking the chemistry class in which you are in?
  - Interesting, college look for it, career, just need the credit.
    - i. Expand
  - Did you consult anyone before hand
    - i. Who and Why?
4. What are your fears of taking Chemistry
  - Test, Labs, Projects
  - Where do these fears come from?
    - i. Previous students?
    - ii. What do you hear about chemistry from other students? What do you hear about GenChem as compared to ChemCom?
5. What are your favorite classes in general?
  - If science why?
  - If not science
    - i. Are you challenged in these classes?
    - ii. Are you worried about your grade when you are challenged?
6. What is your motivation for taking the classes you do?
  - Do you consult anyone before hand?
    - i. Who and Why
7. How could your experienced in chemistry be enhanced?

APPENDIX E

MIDDLE OF THE YEAR SURVEY

### Middle of the year survey

1. Name (first name, last name) \_\_\_\_\_
2. What hour does your class meet?  
➤ 2<sup>nd</sup>, 4<sup>th</sup>, 5<sup>th</sup>, 6<sup>th</sup>
3. What Chemistry are you enrolled in?  
➤ General Chemistry GenChem,  
➤ Chemistry in the Community (ChemCom)
4. I am taking chemistry just to fulfill a science credit  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
5. I took chemistry because I thought it would be interesting  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
6. I took chemistry because colleges look for it.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
7. I think about how learning Chemistry can help my career  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
8. I think about how I will use the chemistry I learn.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
9. I am doing well in my Chemistry class thus far.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
10. Overall I am enjoying Chemistry.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
11. Provide some examples of what you have enjoyed about chemistry thus far
12. Provide some examples of what you have not enjoyed about chemistry thus far

13. Chemistry has shown to have value to me  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
14. The chemistry I have learned is more important to me than the grade I received.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
15. I think about how my chemistry grade has affected my overall grade point average.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
16. I understand why labs are important in understanding chemical concepts.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
17. I feel comfortable using and identifying lab equipment  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
18. I feel comfortable working with hazardous chemicals.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
19. My math experience as helped me in chemistry  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
20. I am a junior  
➤ Yes No  
➤ If yes go on to questions 21, 22, 23
21. What is the likely hood that you would take a science class beyond the three that are required?  
➤ Not Likely 1 – 2 – 3 – 4 Very Likely
22. What is the class that you would most likely take as a forth year?
23. What is your reasoning for this choice?

APPENDIX F

MID TERM INTERVIEWS

Name \_\_\_\_\_

Enrolled in \_\_\_\_\_

Taken ChemCom Before \_Y/N\_

Will be Taking Chemistry \_Y/N\_

1. How is chemistry going for you thus far?
2. What has been your biggest challenge?
3. What is the reason for taking the chemistry class in which you are in?
  - Interesting, college look for it, career, just need the credit.
    - i. Expand
4. What are your current fears of taking Chemistry
  - a. Test, Labs, Projects, grades
  - b. Where do these fears come from?
5. Overall are you enjoying Chemistry.
  - Provide some examples of what you have enjoyed about chemistry thus far
  - Provide some examples of what you have not enjoyed about chemistry thus far
6. What are your favorite classes (not chemistry)?
  - Has it changed?
    - i. Why
  - Are you challenged in these classes?
  - Are you worried about your grade when you are challenged?
7. What is the likely hood that you would take a science class beyond the three that are required?
  - What is your motivation for doing so/or not so?
  - What is the class that you would most likely take as a fourth year?
  - What is your reasoning for this choice?
8. How could your experienced in chemistry be enhanced?

APPENDIX G

END OF THE YEAR SURVEY

## End of Term Survey

1. Name (first name, last name)  
\_\_\_\_\_
2. What hour does your class meet?  
➤ 2<sup>nd</sup>, 4<sup>th</sup>, 5<sup>th</sup>, 6<sup>th</sup>
3. What Chemistry are you enrolled in?  
➤ General Chemistry GenChem,  
➤ Chemistry in the Community (ChemCom)
4. Overall I enjoyed Chemistry.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
5. The Chemistry I have taken have value to me  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
6. I am took chemistry just to fulfill a science credit  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
7. I took chemistry because I thought it would be interesting  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
8. I took chemistry because colleges look for it.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
9. I think about how learning Chemistry can help my career  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
10. I think about how I will use the chemistry I learned.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
11. The chemistry I learned is more important to me than the grade I received.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
12. Earning a good chemistry grade is important to me.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
13. I think about how my chemistry grades have affected my overall grade point average.  
➤ Disagree Strongly 1 – 2 – 3 – 4 – 5 Agree Strongly
14. I understand why labs are important in understanding chemical concepts.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
15. I feel comfortable using and identifying lab equipment  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
16. I feel comfortable working with hazardous chemicals.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
17. The chemistry that I am in was based on my math experience.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
18. How the subject matter was presented was an important factor in enjoying Chemistry class.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
19. The activities done in class were an important factor in enjoying Chemistry class.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
20. I learned best when concepts, examples, etc., were repeated consistently  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
21. I learned best with the hands-on activities such as labs.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
22. I learned best by listening to lecture and taking notes in class.  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
23. I like courses that challenge me  
➤ Disagree Strongly 1 – 2 – 3 – 4 Agree Strongly
24. I am a junior going to be a senior  
➤ If yes go on to questions 25, 26, 27  
➤ If no go onto question 28, 29
25. What is the likely hood that you would take a science class beyond the three that are required?  
➤ Not Likely 1 – 2 – 3 – 4 Very Likely
26. What is the class that you would most likely take as a forth year?
27. What is your reasoning for this choice?
28. How many other science classes have you taken
29. What was our reasoning for taking the science classes that you did?

APPENDIX H

END OF TERM INTERVIEWS

Name \_\_\_\_\_

Enrolled in \_\_\_\_\_

Taken ChemCom Before \_Y/N\_

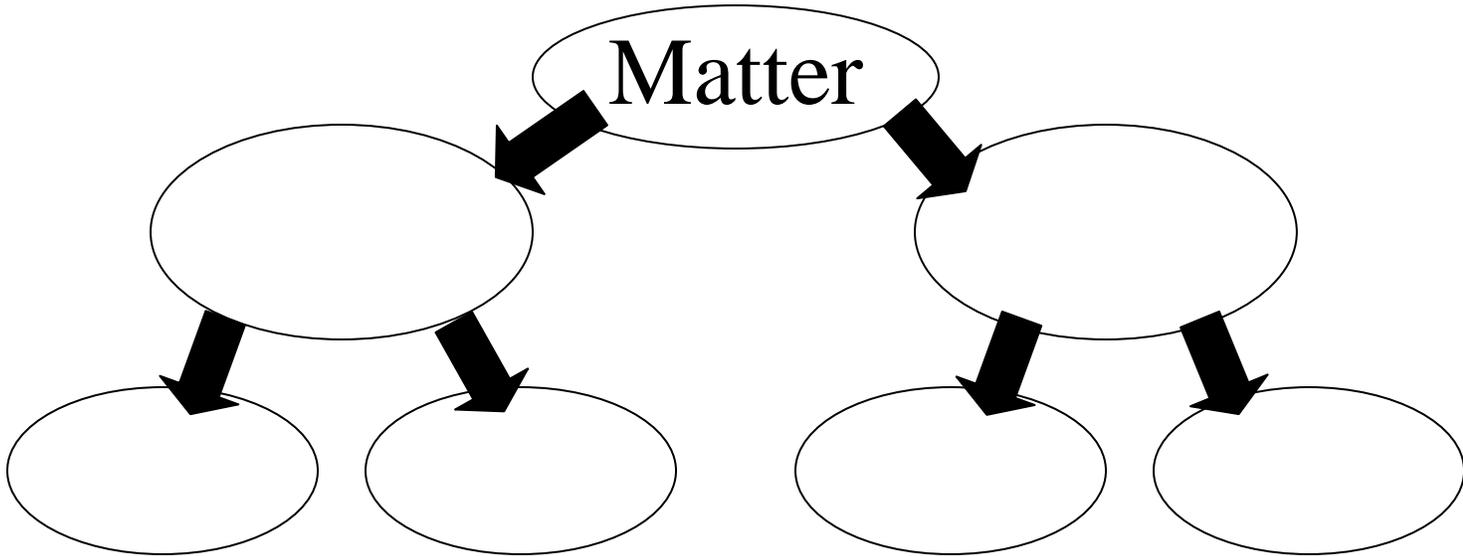
Will be Taking Chemistry \_Y/N\_

1. How is chemistry going for you thus far?
2. What has been your biggest challenge?
3. What was the reason for taking the chemistry class in which you are in?
  - Interesting, college look for it, career, just need the credit.
    - i. Expand
4. Overall have you enjoyed Chemistry.
  - Provide some examples of what you have enjoyed about chemistry
  - Provide some examples of what you have not enjoyed about chemistry
5. What is the likely hood that you would take a science class beyond the three that are required?
  - What is your motivation for doing so/or not so?
  - What is the class that you would most likely take as a forth year?
  - What is your reasoning for this choice?
6. What was you favorite class this year (not chemistry)?
  - Has it changed?
    - i. Why
  - Are you challenged in this class?
  - Are you worried about your grade when you are challenged?
7. How could your experienced in chemistry have been enhanced?
8. Are there other comments you might have for helping me improve chemistry?

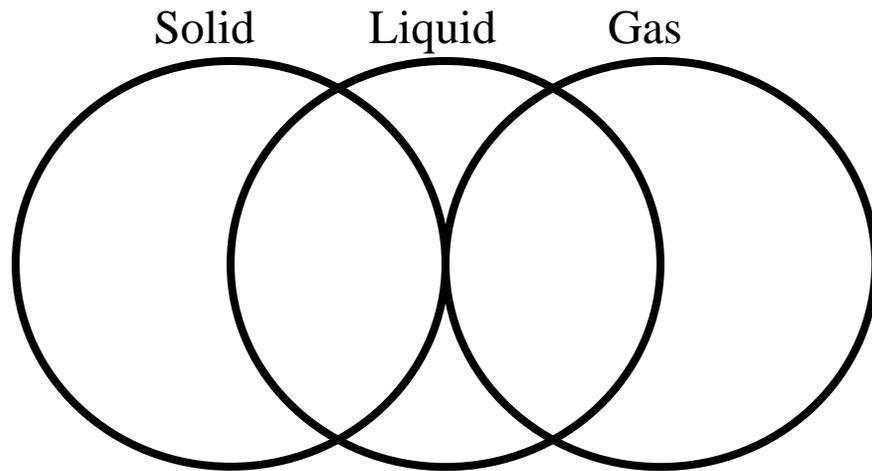
APPENDIX I

SPATIAL PERFORMANCE ASSESSMENT

1. Fill in the spaces with correct subdivision of matter and give an example.



2. Fill in the space with the properties that would best fit in the spaces.



APPENDIX J

PRE-TEST, POST-TEST

**Pre Test/Post Test**

Name: \_\_\_\_\_ Hour \_\_\_\_\_

**Multiple Choice***Identify the choice that best completes the statement or answers the question.*

- \_\_\_\_\_ 1. Isotopes of the same element have different \_\_\_\_\_.  
a. numbers of neutrons  
b. numbers of protons  
c. numbers of electrons  
d. atomic numbers
- \_\_\_\_\_ 2. Which of the following is the correct skeleton equation for the reaction that takes place when solid phosphorus combines with oxygen gas to form diphosphorus pentoxide?  
a.  $P(s) + O_2(g) \rightarrow PO_2(g)$   
b.  $P(s) + O(g) \rightarrow P_5O_2(g)$   
c.  $P(s) + O_2(g) \rightarrow P_2O_5(s)$   
d.  $P_2O_5(s) \rightarrow P_2 + O_2(g)$
- \_\_\_\_\_ 3. What is the charge of a cation?  
a. a positive charge  
b. no charge  
c. a negative charge  
d. The charge depends on the size of the nucleus.
- \_\_\_\_\_ 4. When an acid reacts with a base, what compounds are formed?  
a. a salt only  
b. water only  
c. metal oxides only  
d. a salt and water
- \_\_\_\_\_ 5. If heat is released by a chemical system, an equal amount of heat will be \_\_\_\_\_.  
a. absorbed by the surroundings  
b. absorbed by the universe  
c. released by the surroundings  
d. released by the universe
- \_\_\_\_\_ 6. Which of the following categories includes the majority of the elements?  
a. Metalloids  
b. Liquids

- c. Metals
- d. Nonmetals

- \_\_\_\_\_ 7. Which of the following is a physical change?
- a. Corrosion
  - b. Explosion
  - c. Evaporation
  - d. rotting of food
- \_\_\_\_\_ 8. How many valence electrons are in an atom of magnesium?
- a. 2
  - b. 3
  - c. 4
  - d. 5
- \_\_\_\_\_ 9. Which of the following is NOT a physical property of water?
- a. It has a boiling point of 100°C.
  - b. It is a colorless liquid.
  - c. It is composed of hydrogen and oxygen.
  - d. Sugar dissolves in it.
- \_\_\_\_\_ 10. What is one difference between a mixture and a compound?
- a. A compound consists of more than one phase.
  - b. A compound can only be separated into its components by chemical means.
  - c. A mixture can only be separated into its components by chemical means.
  - d. A mixture must be uniform in composition.
- \_\_\_\_\_ 11. What are the coefficients that will balance the skeleton equation below?
- $$\text{N}_2 + \text{H}_2 \rightarrow \text{NH}_3$$
- a. 1, 1, 2
  - b. 1, 3, 3
  - c. 3, 1, 2
  - d. 1, 3, 2
- \_\_\_\_\_ 12. Which of the following is a chemical property?
- a. Color
  - b. Hardness
  - c. freezing point
  - d. ability to react with oxygen

- \_\_\_ 13. Which state of matter has a definite volume and takes the shape of its container?
- Solid
  - Liquid
  - Gas
  - both b and c
- \_\_\_ 14. The reaction  $2\text{Fe} + 3\text{Cl}_2 \rightarrow 2\text{FeCl}_3$  is an example of which type of reaction?
- combustion reaction
  - single-replacement reaction
  - combination reaction
  - decomposition reaction
- \_\_\_ 15. How many energy sublevels are in the second principal energy level?
- 1
  - 2
  - 3
  - 4
- \_\_\_ 16. Which of the following is a heterogeneous mixture?
- vinegar in water
  - Milk
  - oil and vinegar
  - Air
- \_\_\_ 17. What is true about the molar mass of chlorine gas?
- The molar mass is 35.5 g.
  - The molar mass is 71.0 g.
  - The molar mass is equal to the mass of one mole of chlorine atoms.
  - none of the above
- \_\_\_ 18. In which of the following sets is the symbol of the element, the number of protons, and the number of electrons given correctly?
- In, 49 protons, 49 electrons
  - Zn, 30 protons, 60 electrons
  - Cs, 55 protons, 132.9 electrons
  - F, 19 protons, 19 electrons
- \_\_\_ 19. What determines that an element is a metal?
- the magnitude of its charge

- b. the molecules that it forms
- c. when it is a Group A element
- d. its position in the periodic table

\_\_\_\_ 20. What is the charge on the cation in the ionic compound sodium sulfide?

- a. 0
- b. 1+
- c. 2+
- d. 3+

\_\_\_\_ 21. How many valence electrons does a helium atom have?

- a. 2
- b. 3
- c. 4
- d. 5

\_\_\_\_ 22. Which of the following elements is in the same period as phosphorus?

- a. Carbon
- b. Magnesium
- c. Nitrogen
- d. Oxygen

\_\_\_\_ 23. What is a property of a base?

- a. bitter taste
- b. watery feel
- c. strong color
- d. Unreactive

\_\_\_\_ 24. The nucleus of an atom is \_\_\_\_.

- a. the central core and is composed of protons and neutrons
- b. positively charged and has more protons than neutrons
- c. negatively charged and has a high density
- d. negatively charged and has a low density

\_\_\_\_ 25. How many protons, electrons, and neutrons does an atom with atomic number 50 and mass number 125 contain?

- a. 50 protons, 50 electrons, 75 neutrons
- b. 75 electrons, 50 protons, 50 neutrons
- c. 120 neutrons, 50 protons, 75 electrons
- d. 70 neutrons, 75 protons, 50 electrons

- \_\_\_ 26. Which of the following was originally a tenet of Dalton's atomic theory, but had to be revised about a century ago?
- Atoms are tiny indivisible particles.
  - Atoms of the same element are identical.
  - Compounds are made by combining atoms.
  - Atoms of different elements can combine with one another in simple whole number ratios.
- \_\_\_ 27. When naming a transition metal ion that can have more than one common ionic charge, the numerical value of the charge is indicated by a \_\_\_\_.
- Prefix
  - Suffix
  - Roman numeral following the name
  - superscript after the name
- \_\_\_ 28. How many electrons does nitrogen gain in order to achieve a noble-gas electron configuration?
- 1
  - 2
  - 3
  - 4
- \_\_\_ 29. The first figure in a properly written chemical symbol always is \_\_\_\_.
- Boldfaced
  - Capitalized
  - Italicized
  - Underlined
- \_\_\_ 30. Emission of light from an atom occurs when an electron \_\_\_\_.
- drops from a higher to a lower energy level
  - jumps from a lower to a higher energy level
  - moves within its atomic orbital
  - falls into the nucleus
- \_\_\_ 31. The equation  $\text{Mg}(s) + 2\text{HCl}(aq) \rightarrow \text{MgCl}_2(aq) + \text{H}_2(g)$  is an example of which type of reaction?
- combination reaction
  - single-replacement reaction
  - decomposition reaction
  - double-replacement reaction

- \_\_\_ 32. Which of the following is a heterogeneous mixture?
- Air
  - salt water
  - Steel
  - Soil
- \_\_\_ 33. Which of the following is a valid unit for specific heat?
- cal / (g°C)
  - Cal
  - Cal/g
  - °C
- \_\_\_ 34. Which of the following elements is a transition metal?
- Cesium
  - Copper
  - Tellurium
  - Tin
- \_\_\_ 35. Which of the following is a property of an acid?
- sour taste
  - Nonelectrolyte
  - strong color
  - Unreactive
- \_\_\_ 36. In a combustion reaction, one of the reactants is \_\_\_\_.
- Hydrogen
  - Nitrogen
  - Oxygen
  - a metal
- \_\_\_ 37. Which of the following was a major contribution to chemistry by Antoine Lavoisier?
- He showed that oxygen is required for material to burn.
  - He demonstrated the presence of phlogiston in air.
  - He encouraged scientists to form explanations based on philosophical arguments.
  - He developed the science of alchemy.
- \_\_\_ 38. How does calcium obey the octet rule when reacting to form compounds?
- It gains electrons.
  - It gives up electrons.

- c. It does not change its number of electrons.
- d. Calcium does not obey the octet rule.

- \_\_\_ 39. A vapor is which state of matter?
- a. Solid
  - b. Liquid
  - c. Gas
  - d. all of the above
- \_\_\_ 40. Chemical equations must be balanced to satisfy \_\_\_\_.
- a. the law of definite proportions
  - b. the law of multiple proportions
  - c. the law of conservation of mass
  - d. Avogadro's principle
- \_\_\_ 41. Which of the following is a chemical property of water at 4°C?
- a. its color
  - b. its state
  - c. its temperature
  - d. its ability to decompose into hydrogen and oxygen
- \_\_\_ 42. Who arranged the elements according to atomic mass and used the arrangement to predict the properties of missing elements?
- a. Henry Moseley
  - b. Antoine Lavoisier
  - c. John Dalton
  - d. Dmitri Mendeleev
- \_\_\_ 43. Chemical equations \_\_\_\_.
- a. describe chemical reactions
  - b. show how to write chemical formulas
  - c. give directions for naming chemical compounds
  - d. describe only biological changes
- \_\_\_ 44. If the spin of one electron in an orbital is clockwise, what is the spin of the other electron in that orbital?
- a. Zero
  - b. Clockwise
  - c. Counterclockwise
  - d. both clockwise and counterclockwise

- \_\_\_ 45. Which state of matter is characterized by having an indefinite shape, but a definite volume?
- Gas
  - Liquid
  - Solid
  - none of the above
- \_\_\_ 46. How many valence electrons are transferred from the calcium atom to iodine in the formation of the compound calcium iodide?
- 0
  - 1
  - 2
  - 3
- \_\_\_ 47. The principal quantum number indicates what property of an electron?
- Position
  - Speed
  - energy level
  - electron cloud shape
- \_\_\_ 48. What type of ions have names ending in *-ide*?
- only cations
  - only anions
  - only metal ions
  - only gaseous ions
- \_\_\_ 49. According to the aufbau principle, \_\_\_\_.
- an orbital may be occupied by only two electrons
  - electrons in the same orbital must have opposite spins
  - electrons enter orbitals of highest energy first
  - electrons enter orbitals of lowest energy first
- \_\_\_ 50. How does atomic radius change from top to bottom in a group in the periodic table?
- It tends to decrease.
  - It tends to increase.
  - It first increases, then decreases.
  - It first decreases, then increases.
- \_\_\_ 51. What causes water molecules to have a bent shape, according to VSEPR theory?

- a. repulsive forces between unshared pairs of electrons
- b. interaction between the fixed orbitals of the unshared pairs of oxygen
- c. ionic attraction and repulsion
- d. the unusual location of the free electrons

- \_\_\_\_\_ 52. In a double-replacement reaction, the \_\_\_\_\_.
- a. products are always molecular
  - b. reactants are two ionic compounds
  - c. reactants are two elements
  - d. products are a new element and a new compound
- \_\_\_\_\_ 53. In which of the following sets are the charges given correctly for all the ions?
- a.  $\text{Na}^+$ ,  $\text{Mg}^+$ ,  $\text{Al}^+$
  - b.  $\text{K}^+$ ,  $\text{Sr}^{2+}$ ,  $\text{O}^{2-}$
  - c.  $\text{Rb}^-$ ,  $\text{Ba}^{2-}$ ,  $\text{P}^{3+}$
  - d.  $\text{N}^-$ ,  $\text{O}^{2-}$ ,  $\text{F}^{3-}$
- \_\_\_\_\_ 54. All of the following changes to a metal are physical changes EXCEPT \_\_\_\_\_.
- a. Bending
  - b. Melting
  - c. Rusting
  - d. Polishing
- \_\_\_\_\_ 55. If three electrons are available to fill three empty  $2p$  atomic orbitals, how will the electrons be distributed in the three orbitals?
- a. one electron in each orbital
  - b. two electrons in one orbital, one in another, none in the third
  - c. three in one orbital, none in the other two
  - d. Three electrons cannot fill three empty  $2p$  atomic orbitals.
- \_\_\_\_\_ 56. Of the elements Pt, V, Li, and Kr, which is a nonmetal?
- a. Pt
  - b. V
  - c. Li
  - d. Kr
- \_\_\_\_\_ 57. The first step in most stoichiometry problems is to \_\_\_\_\_.
- a. add the coefficients of the reagents
  - b. convert given quantities to moles
  - c. convert given quantities to volumes

d. convert given quantities to masses

- \_\_\_ 58. Which of the following are considered physical properties of a substance?
- color and odor
  - melting and boiling points
  - malleability and hardness
  - all of the above
- \_\_\_ 59. Which subatomic particle plays the greatest part in determining the properties of an element?
- Proton
  - Electron
  - Neutron
  - none of the above
- \_\_\_ 60. An *-ate* or *-ite* at the end of a compound name usually indicates that the compound contains \_\_\_\_.
- fewer electrons than protons
  - neutral molecules
  - only two elements
  - a polyatomic anion
- \_\_\_ 61. What is the correct name for the  $\text{N}^{3-}$  ion?
- nitrate ion
  - nitrogen ion
  - nitride ion
  - nitrite ion
- \_\_\_ 62. According to the kinetic theory, collisions between molecules in a gas \_\_\_\_.
- are perfectly elastic
  - are inelastic
  - never occur
  - cause a loss of total kinetic energy
- \_\_\_ 63. An example of an extensive property of matter is \_\_\_\_.
- Temperature
  - Pressure
  - Mass
  - Hardness

- \_\_\_ 64. In which of the following types of reaction are electrons gained?
- Decomposition
  - Oxidation
  - Neutralization
  - Reduction
- \_\_\_ 65. In a chemical reaction, the mass of the products \_\_\_\_.
- is less than the mass of the reactants
  - is greater than the mass of the reactants
  - is equal to the mass of the reactants
  - has no relationship to the mass of the reactants
- \_\_\_ 66. Which step in the scientific method requires you to use your senses to obtain information?
- revising a hypothesis
  - designing an experiment
  - making an observation
  - stating a theory
- \_\_\_ 67. Which state of matter takes both the shape and volume of its container?
- Solid
  - Liquid
  - Gas
  - both b and c
- \_\_\_ 68. If you rewrite the following word equation as a balanced chemical equation, what will the coefficient and symbol for fluorine be?  
nitrogen trifluoride  $\rightarrow$  nitrogen + fluorine
- $6F_2$
  - $F_3$
  - $6F$
  - $3F_2$
- \_\_\_ 69. Using the periodic table, determine the number of neutrons in  $^{16}O$ .
- 4
  - 8
  - 16
  - 24
- \_\_\_ 70. Chemical reactions \_\_\_\_.

- a. occur only in living organisms
- b. create and destroy atoms
- c. only occur outside living organisms
- d. produce new substances

\_\_\_ 71. What do chemical symbols and formulas represent, respectively?

- a. elements and compounds
- b. atoms and mixtures
- c. compounds and mixtures
- d. elements and ions

\_\_\_ 72. Who was the man who lived from 460B.C.-370B.C. and was among the first to suggest the idea of atoms?

- a. Atomos
- b. Dalton
- c. Democritus
- d. Thomson

\_\_\_ 73. What are the coefficients that will balance the skeleton equation below?



- a. 1, 3, 1, 3
- b. 3, 1, 3, 1
- c. 1, 1, 1, 3
- d. 1, 3, 3, 1

\_\_\_ 74. Which of these elements does not exist as a diatomic molecule?

- a. Ne
- b. F
- c. H
- d. I

\_\_\_ 75. In the reaction  $2\text{CO}(g) + \text{O}_2(g) \rightarrow 2\text{CO}_2(g)$ , what is the ratio of moles of oxygen used to moles of  $\text{CO}_2$  produced?

- a. 1:1
- b. 2:1
- c. 1:2
- d. 2:2

\_\_\_ 76. What is the electron configuration of potassium?

- a.  $1s^2 2s^2 2p^2 3s^2 3p^2 4s^1$

- b.  $1s^2 2s^2 2p^{10} 3s^2 3p^3$
- c.  $1s^2 2s^2 3s^2 3p^6 3d^1$
- d.  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

- \_\_\_ 77. All atoms are \_\_\_\_.
- a. positively charged, with the number of protons exceeding the number of electrons
  - b. negatively charged, with the number of electrons exceeding the number of protons
  - c. neutral, with the number of protons equaling the number of electrons
  - d. neutral, with the number of protons equaling the number of electrons, which is equal to the number of neutrons
- \_\_\_ 78. How do atoms achieve noble-gas electron configurations in single covalent bonds?
- a. One atom completely loses two electrons to the other atom in the bond.
  - b. Two atoms share two pairs of electrons.
  - c. Two atoms share two electrons.
  - d. Two atoms share one electron.
- \_\_\_ 79. When energy is changed from one form to another, \_\_\_\_.
- a. some of the energy is lost entirely
  - b. all of the energy can be accounted for
  - c. a physical change occurs
  - d. all of the energy is changed to a useful form
- \_\_\_ 80. The atomic number of an element is the total number of which particles in the nucleus?
- a. Neutrons
  - b. Protons
  - c. Electrons
  - d. protons and electrons
- \_\_\_ 81. If an atom is reduced in a redox reaction, what must happen to another atom in the system?
- a. It must be oxidized.
  - b. It must be reduced.
  - c. It must be neutralized.
  - d. Nothing needs to happen to another atom in the system.
- \_\_\_ 82. Which of the following is a homogeneous mixture?
- a. salt water
  - b. beef stew
  - c. sand and water
  - d. Soil

- \_\_\_\_\_ 83. One characteristic of a scientific theory is that \_\_\_\_\_.
- it can never be proved
  - it can be proved
  - it cannot be modified
  - it summarizes a set of observations
- \_\_\_\_\_ 84. Why did J. J. Thomson reason that electrons must be a part of the atoms of all elements?
- Cathode rays are negatively-charged particles.
  - Cathode rays can be deflected by magnets.
  - An electron is 2000 times lighter than a hydrogen atom.
  - Charge-to-mass ratio of electrons was the same, regardless of the gas used.
- \_\_\_\_\_ 85. How does atomic radius change from left to right across a period in the periodic table?
- It tends to decrease.
  - It tends to increase.
  - It first increases, then decreases.
  - It first decreases, then increases.

**Pre Test  
Answer Section**

**MULTIPLE CHOICE**

1. ANS: A	DIF: L1	OBJ: 4.3.1	STA: II.A.3.c
2. ANS: C	DIF: L2	OBJ: 11.1.2	STA: II.B.1.a
3. ANS: A	DIF: L1	OBJ: 6.3.2	STA: II.A.1.a
4. ANS: D	DIF: L1	OBJ: 19.1.1	STA: II.B.5.e
5. ANS: A	DIF: L1	OBJ: 17.1.1	STA: II.C.5.e
6. ANS: C	DIF: L1	OBJ: 6.1.3	STA: II.A.3.c
7. ANS: C	DIF: L2	OBJ: 2.1.4	STA: II.A.7.g
8. ANS: A	DIF: L1	OBJ: 7.1.1	STA: II.A.1.a
9. ANS: C	DIF: L2	OBJ: 2.1.2	STA: II.A.7.g
10. ANS: B	DIF: L2	OBJ: 2.3.2	STA: II.A.9.i
11. ANS: D	DIF: L1	OBJ: 11.1.3	STA: II.B.4.d
12. ANS: D	DIF: L1	OBJ: 2.4.1	STA: II.B.1.a
13. ANS: B	DIF: L1	OBJ: 2.1.3	STA: II.A.7.g
14. ANS: C	DIF: L1	OBJ: 11.2.2	STA: II.B.1.a
15. ANS: B	DIF: L2	OBJ: 5.1.3	STA: II.A.1.a
16. ANS: C	DIF: L1	OBJ: 2.2.2	STA: II.A.7.g
17. ANS: B	DIF: L2	OBJ: 10.1.3	
18. ANS: A	DIF: L2	OBJ: 4.2.1   4.3.1	STA: II.A.1.a
19. ANS: D	DIF: L2	OBJ: 9.1.1	STA: II.A.4.d
20. ANS: B	DIF: L1	OBJ: 7.2.1	STA: II.A.6.f
21. ANS: A	DIF: L1	OBJ: 7.1.1	STA: II.A.1.a
22. ANS: B	DIF: L1	OBJ: 6.1.1	STA: II.A.4.d
23. ANS: A	DIF: L1	OBJ: 19.1.1	STA: II.B.5.e
24. ANS: A	DIF: L2	OBJ: 4.2.2	STA: II.A.1.a
25. ANS: A	DIF: L2	OBJ: 4.3.1	STA: II.A.1.a
26. ANS: A	DIF: L2	OBJ: 4.1.2	STA: II.A.1.a
27. ANS: C	DIF: L1	OBJ: 9.1.1	STA: II.A.4.d   II.A.5.e
28. ANS: C	DIF: L1	OBJ: 7.1.4	STA: II.A.1.a
29. ANS: B	DIF: L1	OBJ: 2.3.3	STA: II.B.1.a
30. ANS: A	DIF: L2	OBJ: 5.3.2	STA: II.A.1.a
31. ANS: B	DIF: L1	OBJ: 11.2.2	STA: II.B.1.a
32. ANS: D	DIF: L1	OBJ: 2.2.2	STA: II.A.7.g
33. ANS: A	DIF: L1	OBJ: 17.1.3	
34. ANS: B	DIF: L1	OBJ: 6.2.3	STA: II.A.3.c
35. ANS: A	DIF: L1	OBJ: 19.1.1	STA: II.B.5.e
36. ANS: C	DIF: L1	OBJ: 11.2.1	STA: II.B.1.a
37. ANS: A	DIF: L2	OBJ: 1.3.1	STA: I.D.1.a
38. ANS: B	DIF: L1	OBJ: 7.1.1	STA: II.A.1.a
39. ANS: C	DIF: L1	OBJ: 2.1.3	STA: II.A.7.g
40. ANS: C	DIF: L1	OBJ: 11.1.3	STA: II.B.4.d
41. ANS: D	DIF: L2	OBJ: 2.4.1	STA: II.A.7.g

42.	ANS: D	DIF: L1	OBJ: 6.1.2	STA: II.A.2.b
43.	ANS: A	DIF: L1	OBJ: 11.1.2	STA: II.B.1.a
44.	ANS: C	DIF: L1	OBJ: 5.2.1	STA: II.A.1.a
45.	ANS: B	DIF: L1	OBJ: 2.1.3	STA: II.A.7.g
46.	ANS: C	DIF: L2	OBJ: 7.2.1	STA: II.A.6.f
47.	ANS: C	DIF: L2	OBJ: 5.1.3	STA: II.A.1.a
48.	ANS: B	DIF: L1	OBJ: 9.1.1	STA: II.A.5.
49.	ANS: D	DIF: L2	OBJ: 5.2.1	STA: II.A.1.a
50.	ANS: B	DIF: L1	OBJ: 6.3.1	STA: II.A.2.b
51.	ANS: A	DIF: L2	OBJ: 8.3.2	
52.	ANS: B	DIF: L1	OBJ: 11.2.1	STA: II.B.1.a
53.	ANS: B	DIF: L3	OBJ: 6.3.2	STA: II.A.1.a
54.	ANS: C	DIF: L2	OBJ: 2.4.1	STA: II.A.7.g
55.	ANS: A	DIF: L3	OBJ: 5.2.1	STA: II.A.1.a
56.	ANS: D	DIF: L2	OBJ: 6.1.3	STA: II.A.3.c
57.	ANS: B	DIF: L1	OBJ: 12.1.2	
58.	ANS: D	DIF: L2	OBJ: 2.1.2	STA: II.A.7.g
59.	ANS: B	DIF: L2	OBJ: 6.2.2	STA: II.A.1.a
60.	ANS: D	DIF: L2	OBJ: 9.1.2	
61.	ANS: C	DIF: L1	OBJ: 9.1.1	STA: II.A.5.e
62.	ANS: A	DIF: L1	OBJ: 13.11	STA: II.A.7.g
63.	ANS: C	DIF: L1	OBJ: 2.1.1	STA: II.A.7.g
64.	ANS: D	DIF: L1	OBJ: 20.1.1	STA: II.B.1.a
65.	ANS: C	DIF: L1	OBJ: 12.1.2	STA: II.B.4.d
66.	ANS: C	DIF: L2	OBJ: 1.3.2	STA: I.B.1.a
67.	ANS: C	DIF: L1	OBJ: 2.1.3	STA: II.A.7.g
68.	ANS: D	DIF: L1	OBJ: 11.1.3	STA: II.B.1.a   II.B.4.d
69.	ANS: B	DIF: L2	OBJ: 4.3.1	STA: II.A.4.d
70.	ANS: D	DIF: L1	OBJ: 11.1.1	STA: II.B.1.a
71.	ANS: A	DIF: L2	OBJ: 2.3.3	STA: II.B.1.a
72.	ANS: C	DIF: L2	OBJ: 4.1.1	STA: II.A.1.a   II.A.2.b
73.	ANS: A	DIF: L1	OBJ: 11.1.3	STA: II.B.4.d
74.	ANS: A	DIF: L1	OBJ: 8.2.1	STA: II.A.6.f
75.	ANS: C	DIF: L1	OBJ: 12.1.2	
76.	ANS: D	DIF: L2	OBJ: 5.2.1	STA: II.A.1.a
77.	ANS: C	DIF: L3	OBJ: 4.2.1	STA: II.A.1.a
78.	ANS: C	DIF: L2	OBJ: 8.2.1	STA: II.A.9.i
79.	ANS: B	DIF: L1	OBJ: 17.1.1	STA: II.C.5.e
80.	ANS: B	DIF: L1	OBJ: 4.3.1	STA: II.A.1.a
81.	ANS: A	DIF: L1	OBJ: 20.1.1	STA: II.B.4.d
82.	ANS: A	DIF: L2	OBJ: 2.2.2	STA: II.A.7.g
83.	ANS: A	DIF: L1	OBJ: 1.3.2	STA: I.A.1.a
84.	ANS: D	DIF: L2	OBJ: 4.2.1	STA: II.A.1.a
85.	ANS: A	DIF: L2	OBJ: 6.3.1	STA: II.A.2.b

APPENDIX K  
EXMPTION REVIEW BOARD APPLICATION

MONTANA STATE UNIVERSITY  
Request for Designation of Research as Exempt from the  
Requirement of Institutional Review Board Review  
(10/01/10)

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THIS AREA IS FOR INSTITUTIONAL REVIEW BOARD USE ONLY. DO NOT WRITE IN THIS AREA.

Confirmation Date:

Application Number:

\*\*\*\*\*

\*\*\*\*

DATE:

I. INVESTIGATOR:

Name: Bradley Pederson

Department/Complete Address: 276 E Orchard St. Belle Plaine, MN 56011

Telephone: (952) 456-2057

E-Mail Address: [bpederson@belleplaine.k12.mn.us](mailto:bpederson@belleplaine.k12.mn.us)

DATE TRAINING COMPLETED: 10/10/2010 [Required training: CITI training; see website  
for link]

Name of Faculty Sponsor: Walt Woolbaugh  
(if above is a student)

Signature 

II. TITLE OF RESEARCH PROJECT: Different Classes Different Students. A comparative study  
of different Chemistry classes

III. BRIEF DESCRIPTION OF RESEARCH METHODS (also see section VII). If using a  
survey/questionnaire,

provide a copy with this application: Surveys will be given to students to determine  
motivational differences of students in different chemistry classes.

IV. RISKS AND INCONVENIENCES TO SUBJECTS (also see section VII):

There is no risks and inconveniences to the subjects as it will be a part of my class.

V. SUBJECTS:

A. Expected numbers of subjects:   100  

B. Will research involve minors (age <18 years)? **Yes** No

(If 'Yes', please specify and justify.) The subjects are students in chemistry classes

- C. Will research involve prisoners? Yes No
- D. Will research involve any specific ethnic, racial, religious, etc. groups of people?  
(If 'Yes', please specify and justify.) Yes No
- E. Will a consent form be used? (Please use accepted format from our website and provide a stand-alone copy. Do not include form here.) None is required as it is with the scope of teaching.

VI. FOR RESEARCH INVOLVING SURVEYS OR QUESTIONNAIRES:

- A. Is information being collected about:
- |                                       |     |    |
|---------------------------------------|-----|----|
| Sexual behavior?                      | Yes | No |
| Criminal behavior?                    | Yes | No |
| Alcohol or substance abuse?           | Yes | No |
| Matters affecting employment?         | Yes | No |
| Matters relating to civil litigation? | Yes | No |
- B. Will the information obtained be completely anonymous, with no identifying information linked to the responding subjects? Yes No I will be the only one with access to the information
- C. If identifying information will be linked to the responding subjects, how will the subjects be identified? (Please circle or bold your answers)
- |                                  |     |  |
|----------------------------------|-----|--|
| By name                          | Yes | No   |
| By code                          | Yes | No I will be the only one with access to the information |
| By other identifying information | Yes | No   |
- D. Does this survey utilize a standardized and/or validated survey tool/questionnaire?  
Yes No  
The survey was created and tested by me.

VII. FOR RESEARCH BEING CONDUCTED IN A CLASSROOM SETTING:

- A. Will research involve blood draws? (If Yes, please follow protocol listed in the "Guidelines for Describing Risks: blood, etc.", section I-VI.)  
No

VIII. FOR RESEARCH INVOLVING PATIENT INFORMATION, MATERIALS, BLOOD OR TISSUE SPECIMENS RECEIVED FROM OTHER INSTITUTIONS: None Being Done

- A. Are these materials linked in any way to the patient (code, identifier, or other link to patient identity)? Yes No

B. Are you involved in the design of the study for which the materials are being collected?  
Yes No

C. Will your name appear on publications resulting from this research?  
Yes No

D. Where are the subjects from whom this material is being collected?

E. Has an IRB at the institution releasing this material reviewed the proposed project?  
(If "Yes", please provide documentation.) Yes No

F. Regarding the above materials or data, will you be:

Collecting them	Yes	No
Receiving them	Yes	No
Sending them	Yes	No

G. Do the materials already exist? Yes No

H. Are the materials being collected for the purpose of this study? Yes No

I. Do the materials come from subjects who are:

Minors	Yes	No
Prisoners	Yes	No
Pregnant women	Yes	No

J. Does this material originate from a patient population that, for religious or other reasons, would prohibit its use in biomedical research?  
Yes No Unknown source

IX. FOR RESEARCH INVOLVING MEDICAL AND/OR INSURANCE RECORDS: None Being Done

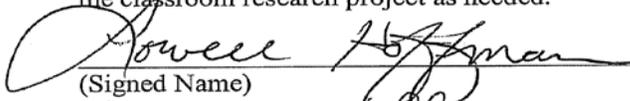
A. Does this research involve the use of:

Medical, psychiatric and/or psychological records	Yes	No
Health insurance records	Yes	No
Any other records containing information regarding personal health and illness	Yes	No

If you answered "Yes" to any of the items in this section, you must complete the HIPAA Worksheet.

## Exemption Regarding Informed Consent

I, *Lowell Hoffman*, Principal of *Belle Plaine*, verify that the classroom research conducted by *Bradley Pederson*, is in accordance with established or commonly accepted educational settings involving normal educational practices. I also verify that parents have received notification of the classroom research project as needed.

 \_\_\_\_\_  
(Signed Name)

*Lowell Hoffman* \_\_\_\_\_  
(Printed Name)

*12-6-10* \_\_\_\_\_  
(Date)