Student Centered Learning in the Chemistry Classroom

Christopher Amesbury

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Student Centered Learning in the Chemistry Classroom

By

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A thesis submitted to the
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Student Centered Learning in the Chemistry Classroom

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Abstract

Students in a chemistry classroom do not always perform to the level they are capable of. One variable that may play a part in this performance is the method the teacher uses to deliver the content. Typically a lecture format is used and students are very passive in this environment. This research focuses on investigating the effectiveness of different strategies that require students to be more active. These strategies included group work, partner work, demonstrations, inquiry lab activities and guided notes. The teacher collected students’ opinions on these strategies by using a survey. Further data was collected by recording teacher observations to provide insight as to what strategies should be incorporated into the chemistry classroom to give students the best formula for success. As a result of this research, it was concluded that students do not study on their own to prepare for chapter tests and teachers should deliver the content in a variety of methods. These instructional methods include guided notes, demonstrations, group work, visual aids and laboratory investigations.
Chapter One: Introduction

*Problem Statement*

In my chemistry classroom all of the students do not achieve to the best of their ability. One reason may be how the content is delivered. Typically I use a teacher centered lecture format. This is a passive approach for students and is not active and engaging for students to learn the content.

*Significance of Problem*

I believe that my role in the chemistry classroom is to facilitate student learning. This is to ensure that my students have practical knowledge that can be applied to the real world. In teaching my chemistry class, I understand that most students will not go on to become chemists. In fact, most will not even use chemistry directly in his or her career. Typically my classroom teaching is teacher centered with a lecture format. This is not the case all of the time, but lecturing does take place most of the time. If students were pursuing a higher level of education in the sciences, this may be an effective way of teaching. However, this is not the case for my students and I am looking for other techniques and ways to make teaching chemistry more effective. Stereotyping students and the methods in which they learn would not be beneficial because each of my students is unique. Also, I know that they all have the potential to go on in life and be very successful. I have been able to make many observations of students in my classroom. Students lack the motivation and enthusiasm needed to learn the content and excel. They are satisfied with just passing the course. Students often have a hard time learning a concept and applying the information. Reading a question and deciphering what the question is asking is often a challenge (e.g. students learn the basic concepts,
but when asked in test format, students can’t understand or decipher the test question). Students do not take the time to do homework independently and thoroughly. If the assignment is complete, the answers are sometimes copied or randomly filled in. Students struggle when reading a textbook, pulling out information that is important, and then applying that information to test questions. They do not study or review notes outside of class, and finally, Students enjoy being engaged during the lesson.

**Purpose**

The purpose of this action research is to look at ways to improve student learning in the chemistry classroom. This will be done by building on the strengths of the students and working to help students overcome and conquer the challenges that they face. This can be done by looking at different ways of delivering the chemistry content to make student learning engaging and exciting. There are numerous pathways that chemistry education research can take. One method is to look at the content and standards that are covered. The other pathway is to look at how the information is delivered. This paper examines the delivery of the chemistry content.

**Rationale**

This research examines the need to improve student learning in the chemistry classroom and in science education overall. In the upcoming literature review, researchers have pointed out that lecturing may not be the best way of delivering content in the chemistry classroom. There are several reasons for this. One is that students are not motivated and excited about learning the content if their only method of receiving instruction is to be talked to by a teacher. The other reason is that many of the concepts in chemistry are abstract. The ideas are not easily described. Therefore if a
teacher employs other alternatives to deliver the content students may be able to better visualize and retain the concepts. This can be especially beneficial if the teacher can relate and build upon previous knowledge.

Summary

In focusing on the problems I have encountered based upon my stereotypical observation, I have narrowed the broad path into three specific areas. It is anticipated that if these questions are researched and the results implemented into the chemistry classroom, then the learning will be more engaging, motivating, and effective. I have attempted to answer the following questions:

I. How can technology be effectively and efficiently implemented into the chemistry classroom? Will students perform better? Will their motivation increase?

II. What can be done in the chemistry classroom to improve student achievement? What are effective literacy strategies that can be implemented into the chemistry classroom?

III. What can the teacher do to make learning for the student more active instead of passive? In other words, what can be done in the classroom to engage students and increase motivation? What can replace or reduce the “lecture” that takes place in the classroom while still holding the rigor and relevance?

Motivation, achievement and effectiveness of technology will be measured in several ways. The teacher will ask students to complete surveys stating their opinions about topics such as group work, laboratory work, taking notes, lecturing and about the class in general. The teacher will also keep a journal to record observations of students in the classroom. These observations will include student reactions to certain activities,
changes that should be made to make the lesson more effective and anything else the teacher sees as being relevant.
Chapter Two: Literature Review

What can be done in the classroom to engage students and increase motivation? What can replace or reduce the "lecture" that takes place in the classroom while still holding the rigor and relevance? According to Herron and Nurrenbern (1999), "chemical education research is the exploration of learning based on a theoretical foundation with the focus on the understanding and learning of chemistry" (p. 1353). In looking at the chemical education research there are two avenues that can be pursued. We can look at the chemistry content or focus on what the teacher and students do in the classroom. There are two different view points that have shaped chemical education research. The two perspectives are the behaviorist and constructivist perspectives. The behaviorist-based research puts learning under the microscope and tries to identify specific variables that guarantee to improve student performance in the classroom. The constructivist-based research has the opposite focus by using a broader view of learning (Herron & Nurrenbern, 1999).

Science is one of the major subjects currently taught in high schools around the globe. Science has also been around for an extended period of time. According to Cobern (1999), teachers should be sensitive to the culture of their students. Teachers need to be aware of the fact that science concepts are often quite abstract and foreign to students. Science concepts need to be presented to students in a manner that makes sense to students (Cobern, 1999).

Conceptual v. Factual Knowledge in the Chemistry Classroom

Chemistry is the study of matter. This is often a very challenging subject for students. There have been multiple studies that have demonstrated the concepts in
chemistry are very difficult for students to grasp. The studies suggest that students cannot join together the scientific explanation of chemistry and the initial conceptions. According to a study conducted by Saul and Kikas (2003) verbal, mathematical, spatial and reasoning abilities was significantly better in older grades. (Saul & Kikas, 2003) Chemistry involves abstract thinking and research shows that older students perform better and exhibit higher levels of understanding. Therefore, schools should set students up for success by teaching chemistry in the later years of high school rather than earlier. Saul and Kikas (2003) reported that seniors in high school scored significantly higher on chemistry concepts tested in class than underclassmen. In order to explain these findings, Saul and Kikas compared factual knowledge to conceptual knowledge. At all ages students had a better knowledge base when it came to studying the facts instead of the conceptual ideas (Saul & Kikas, 2003).

The difference between factual and conceptual knowledge is immense. For a student to have conceptual understanding of chemistry, one must be able to comprehend a variety of concepts, and then be able to apply them to a new and unfamiliar problem. The conceptual understanding should incorporate metacognitive aspects; in other words the student should be able to think about the problem. By applying knowledge to a situation, students turn abstract ideas and knowledge into more concrete knowledge, and therefore gain a deeper understanding. The ability of a student to do this takes time. The opposite of this would be factual or algorithmic knowledge which incorporates the memorization of facts or a preset procedure to follow. (Saul & Kikas, 2003).

Students are successful with factual knowledge but have a hard time grasping the abstract thoughts. Typically, chemistry classes work on enhancing the factual knowledge
but do not focus as much on the understanding of concepts. Saul and Kikas (2003) provide the following example of the difference between the factual and conceptual knowledge in the chemistry classroom:

To illustrate the distinction, on the level of factual knowledge \( \text{H}_2\text{SO}_4 \) signifies sulphur oxide, a certain substance (this formula, when understood on factual level, i.e. macroscopically, is not different from, say, the word “butter”). Conceptual understanding, on the contrary, allows one to deduce from the formula its molecular-atomic structure and predict its possible reactions with other substances (p.110).

From the study of students’ knowledge in the chemistry classroom Saul and Kikas (2003) came up with several conclusions. The first conclusion was that students do not understand the basic theoretical concepts to an acceptable level in high school. Also students focus on learning and understanding factual and algorithmic knowledge giving students a false sense of understanding of certain topics. Saul and Kikas also concluded that chemical education has two parts. The first part is the ability of a student to understand the general theory and framework of the subject. The second part is for a student to be able to apply the knowledge of these theories. It is here in the second part that factual knowledge is crucial. Without knowing the theory and fully comprehending the meaning of a concept the factual knowledge has little meaning and value (Saul and Kikas, 2003).

So what can be done to correct this problem? Saul and Kikas (2003) suggest turning the traditional teaching into more constructive learning. For instance when a teacher has traditionally taught a concept there has been a great emphasis on the
memorization of facts and procedures with little time put into discussions. By having students relate to previous experiences or discover the solution to a problem by talking to other students, they may be able to develop a deeper understanding of the theory instead of just the facts (Saul & Kikas, 2003). This will break up the lecturing of the teacher and increase students achievement by limiting the lecturing done in the classroom.

Motivation of Chemistry Students in the Classroom

By altering the method of teaching, students may or may not learn better because of personal motivation levels. A teacher can teach any way he or she wants, deliver the content in a variety of ways and use a variety of methods. Some students may be unmotivated and not willing to learn. If this is the case, teachers need to hone in on problems with the student’s motivational level. In a study done by Santos and Mortimer (2003) they found that chemistry is not a very popular subject among high school students in Brazil. In the 1980s, there was even a song that came out that was titled I hate chemistry. Two recent works tend to confirm that attitudes have not changed. Leal, Fonesca, Alves, Malta and Carneiro (1990), in a study with 42 students from four different schools in different cities of Minas Gerais, Brazil, found that the students were not happy with their chemistry classes that were considered to be very theoretical, boring and monotonous. Cardoso and Colinvaux (2000) interviewed 157 high school students about their motivation toward school chemistry and found that the great majority did not like chemistry and were not motivated to learn it in schools. The students related this lack of motivation to the absence of a relationship between the chemistry concepts presented in schools and the events of their everyday life (Cardoso and Colinvaux, 2000).
In the study conducted by Santos and Mortimer (2003) they tried to fix and modify the delivery of content to make the subject more motivational for students:

Generally, the chemistry lesson involved, initially, observing a phenomenon, doing an experiment or talking about an everyday experience, followed by a discussion by each group of students around issues proposed in the activities of the teaching material. During the discussions, the teacher followed the groups, proposing other issues, providing new elements and guiding the discussion. In the end, the teacher conducted a discussion with the whole class, during which she tried to hear the conclusions form the groups, taking up some points that seemed important to the development of the content. This general approach can be characterized as student-centered and includes larger varieties of activities. The teacher also tried to relate chemistry concepts to phenomena and application from everyday life as much as possible (p. 1199).

From this study, there were many students who still did not like chemistry any better than before the study occurred (Santos & Mortimer, 2003). The significant contribution of this occurred because of the teacher student relationship.

The data presented provided evidence that the competence of the teacher in installing and maintaining a student-centered approach in the classroom and her skillfulness in relating chemical knowledge to everyday phenomena were not enough to guarantee
an affective proximity between students and school chemistry
(Santos & Mortimer, 2003, p.1109).

Another study was conducted by Aalsvoort and Huygenwaard (2004) that looked at the relevance in secondary school chemical education and student motivation in the Netherlands. There are three types of relevance that chemistry students can find meaning of. According to Aalsvoort and Huygenwaard (2004), these include: (a) personal relevance – chemical education out to make connection to pupils’ lives, (b) professional relevance – chemical education ought to offer pupils a picture of possible professions, and (c) social relevance – chemical education ought to clarify chemistry’s purpose in human and social issues (Aalsvoort & Huygenwaard, 2004).

Thus, students need to see relevance in order to motivate them to learn. Students need to change their way of thinking so instead of seeing science as school work or a school subject they need to think of learning the subject manner as a way that relates to students own day to day experiences. (Aalsvoort & Huygenwaard, 2004). According to Campbell (1994), too many students end their chemical education in school with a dull view of chemistry. This is because it is viewed as being irrelevant. Chemistry at this level largely failed to make links with the lives and interests of young people. Courses were impersonal and did not sufficiently involve people or viewed (Campbell, 1994).

According to Aalsvoort and Huygenwaard (2004) “pupils see science as school work or a school subject, not as a way of making sense of their own experiences” (p. 1152). Two other researchers, Young and Glanfield (1998) note:

At present students drop science for a number of reasons. The most frequently referred to are that studying science no longer leads to a
clear range of future careers and that the sciences are not
sufficiently concerned with human and social issues.... The
problem is that in the subject form in which they make up the
existing curriculum, their original sense of human purpose is often
list, at any rate from the point of view of students (p.16).

Another excuse from students about their poor performance may be to blame the teacher.
The student may feel that the teacher is not qualified to teach the course. In 2000, the
National Survey of Science and Mathematics Education in the United States concluded
virtually all chemistry teachers have had college course work equivalent to and beyond
the topics they would be likely to teach in a high school chemistry class. Eighty-five
percent or more responded that they felt "very well qualified" to teach each of these
topics, and less than 1 percent felt "not well qualified" (Smith, 2000, p.5).

How to Change Chemical Education

So what needs to be changed with chemical education? According to Gardner
(1999) science education has been too abstract. There is too much of a concern with high-
level concepts and too little concern with making connections to 'the real world'. Schools
and universities should have their science curricula more relevant to technology and
meaningful to the students’ day to day lives (Gardner, 1999).

What is the role of the teacher? According to Pierce (2005) teachers must engage
students in the classroom instead of trying fight their social tendencies with academic
tasks. For instance, some collaborative learning models accommodate the teachers’ and
students’ social and academic agendas. We must consider the people our students are and
the learning we mean to sponsor in rearranging our classrooms. We can not escape the
political nature of our work as teachers any more than we can deny that students are
telling us that classrooms can be intensely uncomfortable, boring, and rarely the sites of
engagement or learning.

From this information and these cases there are obviously many different
situations that can affect a student’s ability to perform in the classroom. This action
research project is focusing on alternatives to the teacher centered lecture. The thought of
sitting through a lecture is often unpleasant for most students, no matter how old a person
is. Abrami (2004) describes the advice that a faculty member gave him on teaching:

When I went to graduate school, a faculty member known as a
good undergraduate teacher told his secret of success. Order the
second best textbook for the students and use the best one to read
to the class from. The first class I taught as a lecturer was to 150
students. For weeks they would ask me to slow down because they
could not write verbatim as quickly as I could talk (p.290)
The art of lecturing has always seemed to be mastered by the college professors. As high
school teachers we want to prepare students to be successful in a lectured class. Abrami
(2004) remembers his unhappy early days as an undergraduate student:

I remember spending too many hours engaged in the process of
transcription as my instructors, usually senior graduate students,
wrote notes on the blackboard as quickly as they and most of the
class members could write. When I did pause in my labors to look
up, I seldom saw more than the back of the instructor’s head as the
instructor was usually too busy and focused to do more than write (p.289).

According to what the research shows students in high school need to be engaged to be successful. This contradicts the traditional teaching style of the teacher standing in front of the class and lecturing. There needs to be more interaction between students and between the teacher and students. Several approaches have been researched including the addition of visual aids to the lecture, the use of the internet and technology into the classroom lecture and the use of cooperative learning or small group work. There are positives and negatives to each one and each strategy has instances that seem to increase the knowledge of students in the chemistry classroom.

A study conducted by Thompson and Soyibo (2002) investigated the comparison of two classroom settings. The first combined lecture, demonstrations, class discussion and practical work in small groups versus a second group that looked at combining lecture, demonstrations and class discussion without the use of practical work in small groups. From the assessment of attitudes after the study students in the experimental group had a better attitude towards chemistry. This is only one sample and a definite conclusion can not be drawn but the preliminary test group appears to benefit the combination of lecture, demonstrations, class discussion and practical work in small groups. The potential for success needs to be further investigated.

To supplement the lecture teachers can often conduct demonstrations. According to Bodner (2001) there are many reasons for doing demonstrations within the lecture:

They are fun to do. Students like them. They grab the students’ attention. They provide breaks that help students recover from
the deluge of information in a typical class. They provide concrete examples of abstract concepts. Most importantly, they can teach chemistry (p.32).

Bodner (2001) suggests demonstrations should be done with a purpose. He gives us some guidelines of what demonstrations should accomplish:

There is no evidence that students learn from demonstrations by themselves. There is some evidence that students remember the visual images of a demonstration long after they forget the words. Good demonstrations provide a basis on which learning can be built. Demonstrations don’t have to be spectacular- or dangerous – to be useful. Demonstrations that contain an element of surprise, which don’t behave the way students might expect are often the most charming. Demonstrations that are the most charming can therefore facilitate both the learning of chemistry and the retention of this knowledge. Demonstrations that students find ‘exoharmic’ might therefore be those that best teach chemistry (p.33).

For some concepts in the chemistry classroom demonstrations can be a very effective method of visualizing a concept. Teachers should carefully choose the demonstrations and not just do the spectacular ones. Bodner (2001) supports this because the spectacular and dangerous demonstrations that attract some students to chemistry might be driving others away by giving students a false impression of what chemists really do (Bodner, 2001). Sometimes a demonstration cannot adequately teach a concept
and students struggle with the conceptual understanding of chemical concepts. The teacher can address this issue by using three-dimensional objects to help students visualize what is happening. With the advancement in technology this can be done on the computer in a virtual environment. According to Trindade (2002) a virtual environment, based on 3-D graphics, may assist students in learning conceptual knowledge because the technology requires students to develop higher skills. There are three main factors to consider. They are immersion, interaction, and engagement.

When a student is immersed in virtual environments students can take a concept that is intangible in the real world and turn it to a visible and manipulative form. This allows the student to experience the phenomena hands on by them self rather than through the eyes of a teacher or textbook. The second factor is interaction. By having a student interact they learn from their environment. Students become active learners and thinkers instead of passive observers. When this is done in a virtual environment the students’ interaction becomes effective and meaningful. The third factor to consider is engagement. In a virtual environment, students experience very unique situations. Learners can control the computer to do their bidding in sophisticated ways, and may be intrigued by well designed virtual environments (Trindade, 2002). Through the research that Trindade (2002) conducted the major strength to the virtual reality technology is the ability of students to visualize what is taking place. This can be done with the assistance of technology and can increase student motivation (Trindade, 2002).

Another method for teaching chemistry as an alternative to the lecture is through inquiry based laboratory investigations. The chemistry class has used laboratory activities for a substantial amount of time to assist in teaching the curriculum. The major benefit to
laboratory techniques is the ability of the investigation to engage a student. The inquiry
based lab may take it a step further and contains the potential to enhance students’
conceptual learning. The use of the inquiry-type experiences in the science laboratory
seem to be most effective when conducted with in the lesson when a specific objective is
being taught. This allows students to learn through class and through the hands on
laboratory experiment. From the study that was conducted Hofstein (2004) it was
concluded that students’ involvement in inquiry-type experiments improved their ability
to ask better scientific questions. More specifically, there was a significant change in the
type of questions being asked by the students (Hofstein, 2004).

There are other studies that investigate inquiry where students are discovering and
learning through activities. Forster (2002) looks at ways to encourage students to actively
participate in classroom activities. Forster (2002) defines student participation as,

Action and sharing. It is evidenced in language and gesture, and
involves taking part with others. Working together; one speaking,
another listening, taking turns and waiting; putting up a hand and
turning around to join in. Input might be mainly from one party or
it might be co-participatory, with contributions spread evenly
across a group....It can also center on concrete objects. However,
not understanding the language or assumed prior knowledge can be
barriers to an individual participating; as can difficulties with
visualization (p.127).

Another supplement or addition to the lecture is with the use and implementation
of small groups within the class. Many teachers are finding that large classes can be
broken down into small groups. Within the lesson the teacher presents opportunities for short discussions in these small groups. Students work with a neighbor on a question or problem and then report back to the entire class (Cooper & Robinson, 2000).

The question then becomes how much additional work is it for teachers to use these small groups? According to Cooper & Robinson the small groups are very easy to implement because teachers should not spend an enormous amount of time creating the groups. Instead the teacher should develop and coach the group to become more effective over a period of time. They believe that when the teacher turns a small percentage of instructional time into informal small group work a major benefit can be seen. This can produce a large “bang for the buck” in making conventional lecture-centered formats more engaging for students and more productive for their learning (Cooper & Robinson, 2000). Each teacher in the study commented that an increase in learning for students occurred after a brief adjustment period in the beginning. The adjustment period occurred because most students are not used to engaging in activities in class. Most are used to sitting quietly through a lecture. Teachers need to be aware of this adjustment period and push students to work effectively.
Chapter Three: Applications and Evaluation

Introduction

In this chapter participants of the community and the classroom environment will be outlined. In addition, the procedural steps of the study and all instruments used to gauge motivation, achievement and effectiveness of technology within the classroom and among students will be discussed in detail.

Participants

I am currently teaching three sections of chemistry with class sizes of 18, 19 and 20. Only the chemistry students that I was currently teaching were invited to participate in this research. There were a total of 57 students. From these students, 90% were in their junior year of high school and 10% were high school seniors in a suburban school of Rochester, NY.

The school district covers 26 square miles situated between Lake Ontario and the Finger Lakes. As a community next to the City of Rochester, the district offers easy access to a variety of sporting events, cultural events, several colleges and universities, and employers. The school district operates seven schools - five elementary buildings housing grades K-5, a middle school for grades 6-8, and a high school for grades 9-12.

Facts and Figures

- District Population: 35,000
- Number of students (2005-2006): 5,001
- Cost per student (2005-2006): $13,722
- Budget (2005-2006): $68,622,424
- True Tax Rate (2005-2006): $24.28
- Number of professional staff: 466
- Number of support staff: 399
- Average teacher salary: $52,249
- Average elementary class size: 21
- Average years of experience of teachers: 12.2
Classroom Environment

The classroom is equipped for both class and laboratory. The desks are arranged in five rows with five desks in each row. There is a white board in the front of the classroom with a projection screen that can be pulled down. There is also an overhead projector and a television that is equipped with a VCR and DVD player. There is a demonstration bench between the white board and the student desks. This bench is equipped with a sink, electricity, and natural gas hook ups for the Bunsen burner. Around the perimeter of the classroom are six laboratory benches where four students can comfortably work. In the middle of each lab bench are sinks and natural gas hook ups for the Bunsen burners. On the side of the lab bench there are electrical outlets. On the side of the classroom there is also a fume hood for volatile chemicals. All safety materials such as emergency eye wash, shower, fire extinguisher, and fire blanket are present.

Procedures of Study

During the time frame of April 10th to May 15th 2006, I conducted research to see if a student centered learning environment promotes more success in the chemistry classroom instead of the traditional teacher centered lecture. I investigated students’ opinions about the chemistry class and how different strategies seemed to work from their prospective. Students were given a pre- and post questionnaire. The teacher conducted observations and recorded them in a journal throughout the time frame. The teacher also incorporated student centered activities and learning.
Student surveys and teacher observations were used to gain a general view of the students' opinions about the different implemented strategies. The surveys along with the permission forms were distributed to students on a Friday to be completed over the weekend. The teacher explained the objective and read the letter to the students in class. The students were not allowed any class time to complete the survey. A signed permission form from both the student and the parent/guardian was submitted so that obtained data could be analyzed. The teacher incorporated guided note taking. This strategy had students fill in the blanks instead of copying down notes word for word. The teacher also varied instruction by conducting demonstrations in small groups and with partners. Data collection was obtained in two ways. Students were asked to take part in the research by completing the questionnaire twice (see Appendix C). The exact same questionnaire was distributed at the beginning and the end of the research. The survey targeted certain areas of the course and asked students for their opinion about student centered techniques employed in the classroom. The questions in the survey asked students for a general profile such as gender, current course average, year in high school, and career goals. Only the data for those students who returned permission forms were analyzed. Students did not receive extra credit or other rewards for participation.

The second form of data collection came from my observations in the classroom. I recorded these remarks in a journal. These informal observations were acquired through listening to student-student conversations, making general observations of lesson plans, noting specific comments students made about the lessons and my overall impression of how smoothly a lesson plan was carried out. Data was collected for six weeks.

_Instruments for Study_
In this research there were two methods of data collection used. The first was a survey given to students (see Appendix C). The survey asks students their general background including age, desires after high school and current grade point average. The remaining portion of the survey was a 5-point Likert scale. One indicated that students strongly disagreed with the statement and five indicated that the students strongly agreed with the statement.

The second method of data collection was a journal that was used to record student observations. During the lesson the teacher made observations as to how smoothly the lesson ran, considering a new technique was used daily. The teacher took notes commenting on students views of the utilized instructional techniques. The teacher also recorded student suggestions to improve delivery of the technique for the future.
Chapter Four: Results

From the 57 students that received the first questionnaire only 16 turned it in with their parent or guardian permission form. Of the 16 students, five were male and 11 were female. Their current averages in chemistry class ranged across the spectrum. Four students had an average less than a 70%. There were five students that had an average between 70 and 80% and seven of them had an average higher than an 80%. Of these students, eight were satisfied with their current average and eight were not. Of the 16 students, 15 of them planned on going to college. Of the 15 students, seven of them planned on pursuing a career in chemistry. These jobs included physical therapist, veterinarian technician, cosmetologist, doctor, nurse and a job in the sports medicine field. Some of the other preliminary statistics included having seven students agree or strongly agree that they enjoy chemistry class. There were eight students who sometimes do and sometimes don’t enjoy coming to class. Most of the students enjoyed group work. For example, from the survey 13 students agreed or strongly agreed that they enjoyed working in groups. There were 10 students who agreed or strongly agreed that they liked working in lab and 11 strongly agreed that they always felt more successful when working with others.

After six weeks the questionnaire was distributed a second time to only those students who completed the first survey. Of the 16 questionnaires that were handed out, 11 were returned. Of the 11 students, four were male and seven female. Their grades ranged across the spectrum. Seven students had an average less than a 70%. There were two students that had an average between 70% and 80% and another two students who had an average higher than 80%. Of these students, two were satisfied with their current
average and nine were not. Most of the students enjoyed group work. For example, from
the survey ten students would prefer to work in groups instead of independently at least
some of the time. There were 10 students agreed or strongly agreed that they liked
working in lab and nine always felt more successful when working with others.

In the first survey, 15 of the 16 students study a total of 30 minutes or less for a
chapter test. In the second survey, 11 out of 11 students study between zero and 30
minutes. The students realized they should be studying because all of the students felt
they would be more successful if they studied at least 15 minutes a day. Students
responded to the following questions:

I would be more successful in chemistry if...

I was more organized and really studied. I studied more each day. I
studied more for quizzes and tests. There were more hands on
activities. I looked over my notes everyday. We could work in groups.

I studied a lot more!

The hardest part of learning chemistry is...

Memorizing/remembering facts, chemistry is just complex, content
material, following the pace of the teacher, understanding concepts
and materials, and math concepts.

The one thing I enjoy most in chemistry class is...

Working in lab groups, conducting experiments in lab, and the demonstrations.

During class I incorporated five instructional strategies that engaged students and
made them more active in learning the chemistry content. Some worked well and others
were not as effective. In group work activities, students were more engaged. Students
were able to communicate with each other and ask questions. The problem encountered with this technique occurred during implementation. Towards the end of the school year students often become set in their ways. As a result group work at times, did not seem to be exceptionally motivating for the students. In incorporating the idea of group work, the group needed to have a specific objective or task and the teacher needed to model all expectations. When this was absent there tended to be side conversations and some off task behavior. In the students’ view, they liked group work because it gave them an opportunity to socialize. The key was keeping the groups on task and productive.

Another strategy that I incorporated was having students read a section from the textbook and answer questions. The questions ranged in difficulty. Some questions were lower level and did not require students to apply knowledge. Instead students needed to memorize and then regurgitate the information back to me. Other questions were upper level and more difficult. These questions made students use higher level thinking skills and apply information in order to answer the question. Students appeared engaged and on task. Students were also able to work at different speeds. This allowed for differentiated instruction within the lesson. The students who finished early were able to help other students or start working on another assignment.

Throughout this time period I also focused on incorporating several classroom demonstrations. The students appeared curious while waiting to see the demonstration’s result. The use of the demonstration helped students visualize what was taking place. For example, when talking about indicators used in acids and bases I was able to talk about the indicators and then show students exactly what I meant about the color change. I also found that a demonstration was a great anticipatory set to lead into the formal part of
class. For example, I took three test tubes and filled them with hydrochloric acid, sulfuric acid and acetic acid all of 1 M concentrations. I then inserted a piece of magnesium into each, waited for the solid to dissolve, then repeated with a piece of aluminum and copper. The rest of the lesson was focused on teaching about strong and weak acids because the acetic acid reacted slower than the other two acids. We also talked about the activity of metals with acids and how using Reference Table J showed us that all the metals higher than hydrogen would react but at different speeds. For example, magnesium was a quick reaction and aluminum was very slow. We also discussed how copper was less active than hydrogen and would not react with an acid. The benefit to the demonstrations was that students became curious and they wanted to find out the explanation for what they observed.

I also conducted several laboratory and inquiry based activities. Prior to this research I would explain a lab procedure in the beginning of class by demonstrating each step. Students then went into the lab to complete the procedure, but relied more on what I demonstrated than what was written on the lab sheet. This method was altered by introducing the lab by stating the purpose and covering safety concerns. Then students went off into the lab and conducted the procedure. This seemed great from a teaching standpoint, because students were forced to read the procedure and attempt to be active in learning the lab. This focused on increasing the literacy in the laboratory as well as making students think about what they were doing.

Another technique that was used was the implementation of guided notes. This is a literacy strategy that the school district adopted as being a best practice literacy technique. Instead of writing notes on the board or using an overhead, a Power Point
presentation was created. Appendix D is of an example of a sheet of paper that students received containing information about Arrhenius Acids and Bases. Students would then sit in class and fill in the blanks from the Power Point screen (see Appendix E).

There are several strengths and some weaknesses with the note taking strategy that I observed. A major strength was the amount of time saved on note taking. The teacher did not have to be standing in the front of the classroom waiting for students to copy down the notes before going on with the lesson. Also, it kept students on task. By using group work every day the teacher often loses some classroom management. This allowed students to spend some of the class time in a structured environment. This was also helpful in chemistry because some of the content material was rather difficult and the teacher could really only explain what was happening by talking and “lecturing”. Another strength occurred while the teacher was explaining and reinforcing concepts. Students were usually engaged in taking notes. If the students had a large number of notes to copy and were writing as the teacher was explaining it was often difficult for the students to concentrate on both tasks. The guided notes provided the teacher with the ability to explain the paragraph as students took notes. Students finished relatively quickly and then the teacher had their attention to either explain in further detail or provide examples.
Chapter 5: Recommendations and Conclusions

Discussion

There are several conclusions that can be preliminarily drawn from this six week research period. When I first started this research I set out to see what could be done to replace the idea of lecturing to a class. From my initial findings I am not certain that lecturing should be replaced all together. I think that lecture should not disappear altogether but be limited to encompassing only part of the class period. During the lecture students have a structured environment and behavior is acceptable and on task. When the pre-test student survey was distributed for the first time, 14 of the 16 students agreed or strongly agreed that they liked it when the teacher lectured in front of the classroom some of the time. In addition 10 of the 16 students agreed or strongly agreed that they liked taking notes at least some of the time.

Some other conclusions that can be made are that students need to learn how to study and then actually do it. I was shocked in the pre-test student survey when I saw that 15 of the 16 students studied 30 minutes or less for a chapter test. This was confirmed when the post-test student survey questionnaire was distributed all 11 students studied less than 30 minutes per chapter test. Students also need to be motivated to do the work. The teacher can’t force the students to learn the material. Students need to show initiative and desire to learn chemistry. The methods that the teacher uses to deliver the content should incorporate a variety of techniques. Students should not expect the same thing day in and day out. That repetitive teaching style needs to be varied. Students shouldn’t have to sit in a desk and listen to the teacher for two days straight yet students should not do a lab each day either. The use of group work needs to be implemented early in the year.
Students need to see models of how group work can work and how it should not. The teacher should also use demonstrations, within the lesson to motivate students and to provide a visual for the content. The teacher can either start class with a demonstration that poses a question or that which can be used to emphasize a point within the lesson.

Through the data that was gathered it was learned that the teacher should incorporate a variety of methods into the classroom for delivering the content of the chemistry curriculum. These methods include demonstrations, inquiry lab activities, partner work and group work. The teacher should limit the amount of lecturing within the period and within the week. The idea of lecturing shouldn’t be eliminated, but should be used only when necessary. To help facilitate the delivery of instruction during the lecture the teacher should incorporate guided notes. The other major finding from this research is that study skills and techniques need to be incorporated into the weekly lesson plan. Students need to put forth more effort if they are going to be productive and effective in the chemistry classroom.

From these findings the teacher should then incorporate these instructional strategies throughout the school year. Instead of a six week window of time, the action research plan should be extended over the entire school year from start to finish. During this time the teacher can compare test scores from one year to another to see if there is a significant change in academic achievement. The students can complete a questionnaire periodically throughout the school year so the teacher can track their opinions and progress. The teacher should look at ways of incorporating technology into the daily lessons. There should also be an emphasis placed on literacy and the vocabulary used throughout the year.
Action Plan

The recommended action for the school is to look at ways that technology can be incorporated into the classroom. What resources can be purchased to help facilitate the learning process? Some examples are a smart board, software for test review and studying, online programs and the use of websites.

There are several people who need to be consulted. These include science colleagues within the building. Even though I focused on chemistry these findings are applicable to all areas of science. I have had dialogue with my teacher-in-charge, assistant principle and building principal of the high school. They are all curious of my findings. The action plan should begin in September of 2006 and conclude in June of 2007. This will give a year to implement this system. Students’ grades will also be able to be monitored for the school year. In July of 2007 the teacher can make a decision as to researching for a second year or reporting the data. Further recommendations would be made at that time.

Recommendations for Future Research

Once the action research plan has been carried out there are several other steps that can be followed. In July of 2007 the teacher can make a decision as to researching for a second year or reporting the data. Further recommendations would be made at that time for future research. In the meantime research should also be done to look into students’ studying habits. Some of the questions that could be looked at are: Why are students not studying? What are they doing instead? Why are parents not supporting and encouraging their children to study? Do students know how to study?
Conclusion

There were several findings that took place within this paper. The first was that to teach chemistry effectively, the teacher should use a variety of techniques. These include laboratory exercises, partner work, group work and demonstrations. The teacher should incorporate the technique of lecturing coupled with the use of guided notes. This is in place of using the overhead projector or board to give notes. The other major finding was that students should learn how to study and carry out this newly acquired skill. The teacher needs to focus part of a lesson, on a weekly basis, to teach students how to study.

I have been able to gain a deeper insight into my students from careful observations and analysis of their views. I believe all of my students are capable of doing the work I ask of them and being successful. However, most do not choose to put in the time and effort. I think that the guided notes are a handy and effective way of incorporating note taking into the classroom. I feel demonstrations are an exciting visual aid in the chemistry classroom. Students become excited and curious at the same time!
References


Appendix A

Statement of Informed Consent

Dear Parent or Guardian:

For the next 4-6 weeks I will be conducting research in my classroom for completion of my Master's degree at SUNY College at Brockport. This research is being done with SUNY Brockport and the department for Human Education and Development. The goal of my research is to see if alternative methods for teaching chemistry are more effective for student achievement in the classroom. I will be implementing a variety of strategies that will focus on teaching chemistry through the use of student centered activities. I will be asking each student to fill out two surveys that will assess their opinion about different aspects of learning in the chemistry classroom.

Please understand that:
1. Your child's participation is voluntary and she/he has the right to refuse to answer any questions.
2. Your child's grade will not be impacted if they choose to participate or not.
3. Your child's confidentiality is guaranteed. His/her name will not be included in the results of my research
4. There will be no anticipated personal risks or benefits because of your child’s participation in the project.
5. Your child’s participation involves completing 2 surveys, which will ask questions concerning their opinion to the teaching strategies that are implemented.
6. The results of my survey will be used in a research paper for completion of my graduate studies. Again, neither your child’s name nor school will be included in my research paper.
7. When the project is completed, all consent forms will be destroyed.

Please sign below to indicate that you have read and understand the above statements and that you agree to let your child participate in the research survey. You may change your mind and withdraw your child from the study at any time. If you have any questions please do not hesitate to contact me at or Scott Robinson, my faculty advisor at SUNY Brockport, at 395-5547.

Sincerely,
Christopher Amesbury

To be completed by parent:

Please print your name ________________________________
Please print your child’s name __________________________
Signature of parent/guardian ________________________ Date ____________
Appendix B

Statement of Informed Consent

Dear Student:

For the next 4-6 weeks I will be conducting research in my classroom for completion of my Master’s degree at SUNY College at Brockport. This research is being done with SUNY Brockport and the Department for Human Education and Development. The goal of my research is to see if alternative methods for teaching chemistry are more effective for student achievement in the classroom. I will be implementing a variety of strategies that will focus on teaching chemistry through the use of student centered activities. I will be asking each of you to fill out two surveys that will assess your opinion about different aspects of learning in the chemistry classroom.

Please understand that:
1. Your participation is voluntary and you have the right to refuse to answer any questions.
2. Your grade will not be impacted if you choose to participate or not.
3. Your confidentiality is guaranteed. Your name will not be included in the results of my research.
4. There will be no anticipated personal risks or benefits because of your participation in the project.
5. Your participation involves completing 2 surveys, which will ask questions concerning your opinion to the teaching strategies that are implemented. You may also be asked questions regarding your opinion.
6. The results of my survey will be used in a research paper for completion of my graduate studies. Again, neither your name or school will be included in my research paper.
7. When the project is completed, all consent forms will be destroyed.

Please sign below to indicate that you have read and understand the above statements and that you agree to participate in the research survey. You may change your mind and withdraw from the study at any time. If you have any questions please do not hesitate to contact me at or Scott Robinson, my faculty advisor, at 395-5547.

Sincerely,
Mr. Amesbury

To be completed by student:
Please print your name

Signature ___________________________ Date ____________
Appendix C

**Student Questionnaire**

Circle the best answer:

1. I am a: **Male or Female**
2. Class: **9th**  **10th**  **11th**  **12th**
3. My approximate current average is in the following range:
   - 60 or lower
   - 65-70
   - 71-75
   - 76-80
   - 81-85
   - 86-90
   - 91-95
   - 96-100
4. I am satisfied with my current average: **Yes** or **No**
5. After high school I plan on attending college: **Yes** or **No**
6. I plan on pursuing career that will use chemistry: **Yes** or **No**
   If yes that career is ______________________
7. The high school subject I like most is ______________________ this is because

Answer each question on a scale of 1-5. The numbers indicate: 5 - strongly agree with the statement, 4 - you agree, 3 - sometimes you agree and sometimes you disagree, 2 - you disagree and 1 - you strongly disagree.

8. I enjoy coming to chemistry class ........................................ 5 4 3 2 1
9. In looking back at the year I feel taking chemistry was worth while...... 5 4 3 2 1
10. I enjoy when Mr. Amesbury stands in front of the class and lectures ... 5 4 3 2 1
11. I do not like taking notes.................................................... 5 4 3 2 1
12. I enjoy working in groups with other students in class................ 5 4 3 2 1
13. I would rather stay at my desk and work independently.................. 5 4 3 2 1
14. I enjoy working in lab...................................................... 5 4 3 2 1
15. I am more successful when I work with other students................. 5 4 3 2 1
16. I enjoy being active in class and not just sitting at my desk listening ...... 5 4 3 2 1
17. I would enjoy doing a lab activity everyday in class................... 5 4 3 2 1
18. I would be more successful in chemistry class if I studied 15 minutes a day 5 4 3 2 1
19. I feel the group work was productive and we stayed on task.............. 5 4 3 2 1
20. I have an increased desire to learn chemistry............................ 5 4 3 2 1
21. I feel more confident in understanding the chemistry content............ 5 4 3 2 1
22. I have know have a higher grade in chemistry class than in previous marking periods.............................. 5 4 3 2 1
23. I enjoy using technology in the chemistry classroom....................... 5 4 3 2 1
24. I enjoy this newer style of teaching...................................... 5 4 3 2 1
25. I feel that chemistry class is more work, but I understand the material better.................................................. 5 4 3 2 1
26. For a chapter test I would study
   - (0-30 minutes) (30 minutes – 1 hour) (1-2 hours) (2-3 hours)
27. I would be more successful in chemistry if ______________________
28. If one thing could be changed in how Mr. Amesbury teaches it would be____
29. The hardest part of learning chemistry is ____________________________
30. The one thing I have enjoyed the most in chemistry class is ________________
Appendix D

**Arrhenius**

- The first __________ definition of an __________ and a __________ came in 1884 when a Swedish chemist named Svante Arrhenius (1859-1927) suggested that acids and bases could be __________ in terms of __________ they release when dissolved in water.

- **Arrhenius acid** – A __________ that dissociates in __________ to produce __________ ions (H+) called __________ (positive)

- **Arrhenius Base** – A substance that __________ in water to produce __________ ions (OH-) called __________ (negative)
Appendix E

**Arrhenius**

- The first successful definition of an acid and a base came in 1884 when a Swedish chemist named Svante Arrhenius (1859-1927) suggested that acids and bases could be understood in terms of the ions they release when they dissolve in water.

- Arrhenius acid – A substance that dissociates in water to produce hydrogen ions (H+) called cations (positive).

- Arrhenius Base – A substance that dissociates in water to produce hydroxide ions (OH−) called anions (negative).
To: Christopher Amesbury  
From: Colleen Donaldson, Institutional Review Board Administrator  
Date: April 4, 2006  
Re: Project #: 2005-209  

Project Title: Student centered learning in the chemistry classroom

Your proposal, “Student centered learning in the chemistry classroom” has been approved for one year from this date.

You must use only the approved consent form or informational letter and any applicable surveys or interview questions that have been approved by the IRB in conducting your project. If you desire to make any changes in these documents or the procedures that were approved by the IRB you must obtain approval from the IRB prior to implementing any changes.

If you wish to continue this project beyond one year, federal guidelines require IRB approval before the project can be approved for a second year. A reminder continuation letter will be send to you in eleven months with the specific information that you will need to submit for continued approval of your project. Please note also that if the project initially required a full meeting of the IRB (Category III proposal) for the first review, then continuation of the project after one year will again require full IRB review.

Please contact Colleen Donaldson, IRB Administrator, Office of Academic Affairs, at (585) 395-5118 or cdonalds@brockport.edu, immediately if:
- the project changes substantially,
- a subject is injured,
- the level of risk increases
- changes are needed in your consent document, survey or interview questions or other related materials.

Best wishes in conducting your research.