PEER REVIEW
PORTFOLIO

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COURSE: CHM 110 General Chemistry

DEPARTMENT: Chemistry
COLLEGE: Arts and Sciences
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Purpose of this Portfolio

In previous semesters, general chemistry has been taught using "traditional" large class lecture techniques. Because many students in the course are enrolled because they have to be (it's a requirement for graduation, but not my major), student interest in the course has been low and the students are not engaged. A casual inspection of exam grades and course evaluations would make it difficult to argue that a great deal of learning had taken place. Previous attempts to provide a better learning environment could be described as falling somewhere between moderate successes and dismal failures. The first attempt to improve the course focused on trying to make better use of PowerPoint®. Students were provided with incomplete notes that they would fill in during lecture as material was covered. Use of a remote control would allow the instructor to walk around the room and students would be able to listen and think more since they were writing less. It couldn't miss. But it did. Because, at the end of the day, students were still passive learners (a phrase that to me seems like a contradiction in terms. If learning is the construction of new knowledge, it cannot be done passively. The students could still try to memorize material and cram for an exam with little success. In hind sight, it is hardly surprising that students still earned low grades.

Group work was then introduced on an occasional and irregularly scheduled (not every Friday, for example) basis. Students would work in groups, learn new material, complete exercises and solve problems in an environment where they could get assistance from an instructor. Once they had mastered the basic material as a group, more difficult material could be covered in lecture. The lecture portion of the class would be more effective because students had already developed basic conceptual understanding of course material, they would ask more thought provoking questions during lecture, and the classroom would be more interactive. It couldn't miss. But it did. Attendance was sporadic. Students weren't obligated to keep up with course material. As a result, the times that they were working in groups weren't effective, and instead of lecture delivering more advanced concepts, it was used to complete activities that students hadn't been able to finish as a small group. Constant lecture didn't work. Occasional group work was no more effective than constant lecture.

I once heard that if you want to make a big difference, you need to make a big change. So I made a big change. Students were placed in learning *teams* the first day of class to make the learning environment an active one in every class meeting. Student response systems ("clickers") were introduced to help students keep up with material and provide the instructor with instant feedback on student comprehension. Through nothing more than sheer luck, I was given three TAs to help me in the classroom as students worked in teams to understand course material. This course portfolio attempts to discuss and evaluate the effectiveness of this fundamental change and reflect on my efforts to (as I once told my department head I intended to) deliver the best large course on campus.

The peer review process that accompanies preparation of this course portfolio presented an excellent opportunity for impartial outside analysis of the learning environment I was attempting to create in my classroom. Because I would be helping students as they worked in learning teams, it would be difficult for me to see the big picture of how well the class was working on a daily basis. My peers would be able to observe and comment on what worked and what didn't in ways that I could not. Was it too drastic a change? Did it seem like students were invested in the course format and in their own learning? What was I doing right? What was I doing wrong? What I was hopeful for (and what I got from my peer and my mentor) were questions I had not thought to ask. Had I considered this? Could you do this? This portfolio contains the results of those exchanges, student opinions of various components of the course, and examples of student work aimed at evaluating the effectiveness of the changes in the course. I am hopeful you will find this portfolio an interesting read. I am also hopeful that the changes I have made in the classroom have had a positive effect on the learning environment in the class and on student achievement.

Course Design

General Chemistry covers basic principles of chemistry and is designed for nonscientists. The chemistry content is built around contemporary social or political issues such as global warming, acid rain, ozone depletion, and medicine. Relevant chemical principles are explored as a means to answer questions such as "Why does carbon dioxide act a greenhouse gas?" or "How does the ozone layer protect us from harmful UV radiation?". Students will work in teams to develop an understanding of course concepts and answer questions relevant to science and to society. They will develop important process skills such as critical and analytical thinking, communication, and assessment. By the end of the semester, students should have developed a deep understanding and appreciation of the relationship between chemistry and important contemporary issues including pollution, global warming, and energy policy.

Primarily, this course is intended for students in non-science disciplines who need to fulfill a general education science requirement as part of the University's general education platform. The majority of the students in the course are freshman, from academic disciplines and colleges across the university. Because the students come from such a wide range of academic disciplines, the process skills are emphasized more than content. In most cases, these students have no intention of becoming practicing scientists and they are better served by a course that emphasizes a context for scientific issues, critical thinking, and problem solving than they would be by a chemistry course that acts as a foundation for further studies in the sciences.

The course also acts as a remedial science course for those students who plan on majoring in an engineering or science discipline but lack the background required for the two semester chemistry sequence that is needed for their chosen discipline. For these students, a thorough understanding of the content is important because they will be advancing to the two-semester chemistry sequence. But, if they are to succeed as scientists or engineers, the process and problem solving skills emphasized in the course will be just as important as content.

The backgrounds of the students are as varied as their majors. Some students have very strong science backgrounds and are taking the course only to fulfill the general education requirement. There are also those students with almost no science background and no high school chemistry course. In the past, I have tried to "lecture to the middle", an approach that has been less than successful. The bright students are bored and the students with weak backgrounds are still struggling to keep up. For the class entering in the Fall of 2007, math ACT scores (usually a reliable predictor of success in a science classes) ranged from as high as 30 to a low of 14. This broad range in abilities is one (and always will be) one of the great challenges in teaching this course, particularly in an atmosphere where students will work together in teams on a daily basis.

The lecture format typically used in large classes has been abandoned and replaced with the use of learning teams and guided inquiry to provide a learning environment consistent with the spirit of the university's general education platform. The goals of the general education program include providing an active learning environment, experiential context for what is being studied, and the opportunity to connect ideas. This course, as structured, meets these goals by emphasizing teamwork and guided inquiry (active learning environment), introducing content as being relevant to social issues (experiential context), and by focusing on the relationship between these issues and chemistry content (the opportunity to connect ideas).

Because this course is not part of the chemistry major and is intended for nonscientists, the emphasis of the course is more on skill development and less on content. The chemistry content covered in this course includes basic atomic and molecular structure, chemical reactions, the chemistry of aqueous solutions, acid-base chemistry and nuclear reactions. In addition, students will also become familiar with some of the mathematics required to understand concepts such as concentration, the pH scale and mass relations in chemistry.

The idea that the content is secondary to the development of process skills is supported by the philosophy of the authors of the course text, *Chemistry in Context, 5e*. At the beginning of each chapter, an issue is addressed and questions asked. The chapter then proceeds through just enough chemistry to answer these questions. This format is also intended to provide a general sense of why and how science is done. That is, the book presents content as a means to provide a natural explanation for an observation. This text in particular is very useful in helping meet the course objectives laid out in the syllabus.

More important than what students know is what they are able to do. Each day in the course students will work in teams to answer questions intended to lead them to build their own understanding of some part of course content. In addition to completing these guided inquiry activities, students will also assess how well they worked together that day and how well they feel that they understand the material covered. In completing the activity and answering important self-assessment questions, students will develop the ability to work effectively as a team and learn how to critically analyze their own understanding of course material. As they evaluate their group's performance they can actively take the steps needed to improve group interactions. The self-assessment of understanding course material provides critical daily feedback for students so that they can work outside of class on areas where their understanding is less clear.

By working in teams and exchanging ideas, students develop an understanding of the critical and analytical thinking skills needed to address current science related issues. Climate change and meeting the worlds increasing energy demands are becoming an increasingly important part of public discourse. For many of the students in this class, exposure to these ideas is limited to what they see and hear on TV, too often as part of a 30 second sound bite or two minute news story. What students should understand is that these issues cannot be debated in a minute or two, and that complex problems require complex solutions. By discussing these issues and ideas with their peers, students are exposed to mutliple points of view on this issue, which helps deepen their own understanding.

When students leave this course, they should understand the role that chemistry plays in their everyday lives. For most students, they are taking this course as either a general education requirement class or as a way to meet the chemistry standards required for the higher level two semester chemistry sequence that is required for their major. In either case, it is thought of as a course they have to take, not one they want to take. I want them to leave this course thinking that there are worse things in the world than taking a science course, and that whatever it is they want to do with their life, chemistry will in some way, impact them. If they walk out the course with a better opinion of chemistry than they had coming in, then I feel that the course has been a success.

Because the majority of my students are freshman, I also try to instill in them some of the habits that will make them successful students. Included with the course syllabus is a list of eleven action items for students to do if they want to be successful in the course. Items listed include keeping up with the reading and reviewing previous material to be prepared for class, making use of office hours if they find a concept difficult, how to make good use of the materials in the text the texts website, and participating in study groups outside of class. There is a certain specificity to these goals, but they could be easily adapted to any course a student may take in the future.

My main objective in completing the peer review process is to obtain outside review of how well I am meeting my goals for the course. I have attempted to design a course that students will find challenging and engaging. I want my students to leave the course and recommend it to others, and not think of it as a course that was just a degree requirement. I hope that students who pass through the course appreciate the complexity of and understand the science behind important societal issues.

Teaching Methods

The format for the General Chemistry course involves students working in learning teams almost exclusively, with the instructor acting as a discussion leader and not as a source of information. At the beginning of the semester, students were placed in learning teams with three students to a team. Although it would be preferable to group students in teams of four, the physical realities of teaching a large class in a typical fixed seat theater arrangement dictate groups of three. In the guided inquiry format I use, and based on discussion with others who use guided inquiry, teams need to be made up of students with similar abilities. If there is a great disparity in student ability, after a few classes, the students within a team will figure out who the "smart" student is. Within that team, work will degenerate into the smart student doing the work and everyone else just copying. It starts to look like lecture, just on a smaller scale. In the teams I have set up, the largest difference in Math ACT scores within a group is five (if the lowest score in a group is 18, the highest will be 23).

Another issue in setting up groups is the issue of gender. I have set up groups predominantly of single gender, although because of late additions to the class, there are some mixed teams. One reason for this is that in junior high school, middle school and high school, in a group environment, when it comes time to grab a calculator (or piece of equipment), female students will too often defer to male students and let them do the calculations. The result of this is that the female students don't have sufficient calculator practice and tend to score lower on the calculations on an exam. If the group is all female, they can't defer and they learn how to carry out the calculations. Also, and less importantly, comments from prior semesters suggest that in single gender teams, there is less chatter and more work. After the second exam teams were rearranged with mixed genders, but it is too soon to tell how this has effected team dynamics.

Because of the variation in ability between groups, careful attention was paid to where the teams are located in the room. The fixed seating arrangement in the classroom I use makes some teams less accessible than others. Each Monday, the less accessible teams switched with the more accessible teams to alleviate the problem. In addition, I made every attempt to keep the teams with low Math ACT scores more accessible (close to the front of the room or near an aisle). I also spread out the teams with higher ACT scores and surrounded them with groups with lower scores and encouraged discussion between groups, so that the teams that complete an activity slower can seek the assistance of a team that completed it faster.

In teams, students work on completing an "In-Class Activity" that has been structured to *guide* them to an understanding of the concept covered in that activity. Students also complete, as a team, a "Reflection on Learning" sheet that students use to assess their own learning. By completing the activity as a team, students build up a knowledge structure that works best for them, and in completing the reflection, students develop a greater understanding of their own learning *process*. When students arrive in class, one member of the team picks up that team's folder. The folder contains the activity and reflection from the previous session that has been reviewed by the course instructor, plus one blank copy of the activity and reflection to be completed that day. The folder acts as a way for students and the course instructors to communicate on a daily basis. Students recieve constant feedback on their progress, and the instructor gets a daily progress report on student learning and how well a team is functioning.

Neither the acitivity nor the reflection are graded, but they are assessed by the course instructor each day to provide teams with critical feedback on how they are doing. (From this point forward I will make a distinction between the terms "assess" and "evaluate". I will use assess when discussing those parts of the course that are not graded, but which act as a means for student and instructor to discuss understanding. I will use "evaluate" for those parts of the course which are scored and affect a students grade. The In Class Activities and Reflection on Learning are assessment tools, not evaluation tools). The daily back and forth between student and instructor that takes place when the folder changes hands provides students with feedback on their learning and acts as a valuable tool for the instructor to keep track of class understanding of a given topic. The assessment is an important component of their learning, but evaluation of these activities would likely force students to focus too much on the result (Do I have the right answer?). Assessment helps them focus on the process (Why is this correct, and how did I get here?). If review of the activities or the reflection indicates that a large portion of the class does not understand a particular topic, a short (5 min) lecture can be used the next session to clear up those misconceptions. If the misconception is only within a few teams, some comments on the paper can be useful to help redirect student learning.

The activity and the reflection are the backbone of the course and are designed to meet the goals I have for this course, which are outlined in the course syllabus in Appendix 1. They are designed to allow students to work in teams to develop their own understanding of course content (as opposed to memorizing my understanding). In most activities, students are given a visual model or some experimental data and are then given questions that are designed to lead them to their understanding of that concept. The bulk of each students time in class will be spent on the completing the activity and the reflection. Samples of activities and the accompanying reflections are included in Appendix 2.

As a compliment to group activities, I have incorporated the use of a student response system (clickers) into the course as an evaluation tool. The use of clickers benefits the student and the instructor and makes for a more active learning environment. At the beginning of each class, students are given two clicker questions that cover some aspect of the reading assigned for that day, questions to measure comprehension of the previous activity, or a survey question to gauge student opinion of some issue. The clickers are used to encourage students to show up to class each day, arrive on time, and be prepared. In responding to a survey question (See Appendix 3 for detailed survey information) 61% of the students either strongly agreed or agreed with the statement that the clicker questions at the beginning of class helped them keep up with course material.

At the end of each class session, students are asked two more clicker questions that cover the basics of the material covered in that day's activity. These last two questions provide instantaneous feedback to students and the instructor on how well students understand the activity they have just completed. By providing the instructor with instant feedback about student comprehension, misconceptions can be corrected before the next class. This helps students learn more and also helps them to be more prepared for the next class. Survey results show that 67% of the students who responded either strongly agreed or agreed with the statement that the clicker questions at the end of class helped them evaluate their own understanding of course material.

Based on previous semesters using learning teams but no clickers, I have come to the conclusion that the clickers are a necessity. In the absence of clickers, it is too difficult to track attendance and impossible to ensure that students show up prepared, on time, and ready to contribute to the team's success. The course rule is that students must answer the first and last question to get credit for any of the questions, so they must be on time and prepared, and must stay until the end of class when discussion is over. Because the students are placed in an environment where the focus is on team learning, I allow them to discuss (loosely defined) the answers to clicker questions. In a large class I don't think I could prevent discussion or looking to see what someone else chose for an answer even if I wanted.

Although these clicker questions are used as an evaluation tool, the total score from all clicker questions asked during the semester counts for 1/6 of a students grade in the course. Because so many questions will be asked over the course of the semester, no individual question or concept carries a great deal of weight. In addition, since I view these questions as a learning tool first and as an evaluation tool second, most of the questions are straightforward, with a correct response rate of about 85-90% on a given question. This weight seems to be about the right amount so that students take the questions seriously but aren't intimidated by the difficulty of the questions and become frustrated with the clicker system.

At the end of each chapter, students are given a written homework assignment that covers the major topics of the chapter and also contains more complicated problems to be solved. As with everything else, students are permitted to work in teams, but they are asked to include the names of any students they worked with on the paper. These homework assignments are graded by a grader, and detailed solutions are posted for students. Because the solutions are posted right away, and because the grader this semester has been especially diligent, students have been able to get rapid feedback on how they have done on these written assignments. In grading the homework, each question, of about ten on any particular assignment is worth two points and partial credit is possible. There will be eight such homework assignments collected during the semester, and combined, these assignments are worth 1/6 of the final grade. More details on the format of the homework can be found as part of the course syllabus in Appendix 1. Because the evaluation of student learning in this portfolio will focus on exam performance, the discussion of written homework be limited to student perceptions of how it helped included in the survey in Appendix 3.

Finally, the students will be evaluated on four exams throughout the course of the semester, and a comprehensive final. Each of the regular exams consists of 25 multiple choice exams and is worth 100 points and the final exam consists of 50 multiple choice questions and is worth 200 points. The exams are designed to evaluate student comprehension of concepts and the ability to complete mathematical exercises and solve computational problems. I place a greater emphasis on evaluating comprehension of concepts than on evaluating students' ability to solve computational exercises and problems. The most mathematically intensive exams will only require seven or eight calculations out of 25 questions, a small number when compared to other courses in chemistry or other physical sciences.

Each of the four types of assignments used in this class is designed to provide value to the students and feedback to the instructor. The formative assessment on activities and the reflection on learning give students the instructor rapid feedback on how well students are mastering course content. The daily clicker questions help students accrue points and evaluate their own learning, and provide the instructor with instantaneous information on how well students are prepared to work on the activity in front of them and how well they have mastered the basics of a just completed activity. The end of chapter homework gives students the opportunity to work on more complex problems without the pressure of the exam format, and gives them an opportunity to measure their comprehension of material in the context of an entire chapter. As an instructor, I can glance through the graded assignments and use that information as a guide in preparing for an exam review session. The four exams during the semester and the comprehensive final let students know how well they have mastered material, and give the instructor summary information on student understanding and effectiveness of each of the course components on student learning.

Analysis of Student Learning

Overall, this has been probably the most enjoyable semester I have had in the classroom because of pedagogical changes I have made in the class, the significant increase in student engagement that has resulted from this change, and the gains in student learning that I have observed. I am sure there are additional modifications that could be made to the course, though I do feel like I am very close to achieving the learning environment I have made in the class.

The In-Class Activities were successful and have lead to noticable gains in student learning. The class discussions each day indicate that students are constructing knowledge that is useful for them. The reflections on learning also suggest that students are developing the process skills of assessing their own learning and comprehension. In responses from a mid-semester survey, 68% of students either strongly agreed or agreed with the statement that the activities helped them keep up with course material. When asked about working in teams, 59% strongly agreed or agreed with the statement that working in teams helped them understand course material better than they would on their own. The 59% positive response seems low when compared to related survey questions. When asked about team dynamics, 69% of the students thought that the exchange of ideas within a team helped them understand course material, and 70% were more comfortable asking questions in a small group than in lecture. My own sense of things is that working in teams helps students more than they think it is. More detailed results of the survey can be found in Appendix 3.

The student survey also asked for positive and negative experiences of students that they experienced while working in teams. The most common positive experiences given are the opportunity to meet people in the course, assistance from TAs and the course instructor in class, and the opportunity to look at problems differently. Other positives include the increased accountability to have to read before class to keep up with the team and the chance to learn at their own pace. The common negative experiences given related to being shorthanded when a team member is absent, feeling rushed to keep up, and getting hung up when the entire team is stumped on a question. The absence policy that is included in the syllabus is strict, so I don't think I could do much to improve attendance. As a department, we are exploring new ways to get more TAs in the classroom so that help is more readily available to students. The last common negative experiences generally express the opinion that the respondents prefer the traditional lecture format.

Using clickers, students were also informally polled about their ability to solve problems as part of a team. Early in the semester (end of chapter 1), students were presented with a difficult, multi-step quantitative problem to solve. Before students were asked to solve the problem, they read the problem and were surveyed using the clickers about their confidence in solving the problem. Only 15% of the students thought that they could solve the problem independently (and only 6% thought that they could solve it and explain it to someone else). But 80% of the students thought that they could solve it as a team. When confronted with a similar (but different) problem on the exam, 62% of the students were able to solve the problem. This result suggests that this increased confidence in problem solving ability is real and transferable to an setting where students must solve the problem independently.

In addition to trying to measure student opinion of the guided inquiry format, the larger question I have been investigating this semester is how the course format affects student performance on exams. On Exam 1, using a typical lecture format (same instructor, same text) the class average has been a 72. Switching to guided inquiry and using clickers the class average on the exam that covered the same material was a 77; an upward (but modest) shift in student performance on this. On Exam 2, with the lecture format, the class average has been a 65. This semester, the class average on that same exam was a 72. The lower average on Exam 2 in both cases suggests this material is more difficult, but what I find most encouraging is that the biggest gain in student performance by switching to learning teams comes on the more difficult material! This upward shift in exam scores continued throug the rest of the semester, including the comprehensive final, and a comparison of exam scores in shown graphically in Appendix 4.

Finally, a comparison has been made between end of semester grades using lecture format and end of semester grades using guided inquiry and clickers. The focus of this analysis was placed on the percentage of students who fail to satisfactorally pass the course. Using a lecture format, the percentage of students who completed the course but made a D or F was about 33%. This semester, using guided inquiry and clickers, the percentage of students who made a D or F dropped to 18%, and only 4% of the students failed the course. It should also be mentioned that the percentage of As in the course increased only slightly, from 9% to 12%, suggesting that the reduced rate of Ds and Fs in the course is not the result of grade inflation. These results are also shown graphically in Appendix 4.

Reflection

In preparing this course portfolio, I have had a chance to evaluate the effectiveness of providing a learning environment that most students do not encounter in a typical college course, and almost certainly don't in a large course (more than 50 students), where students are seated in fixed chairs tiered from the bottom to the room to the top. I am pleased to say that, for the most part, the changes I have made in creating an inquiry based active learing environment have been positive. It is my intention to build on these positives, and to, where possible, reduce and eliminate the negatives. I am far from done, but I have made significant progress in getting this course where I want it to be. The gains I have observed in student learning, and the largely favorable feedback from students have made this semester of teaching the most enjoyable so far, and I am hopeful that continued progress can be made.

It is difficult for me to determine exactly which practices have been most effective in acheiving the goals I set for this course. The clickers have exceeded my expectations in helping me effectively provide the learning environment I am trying to establish in the classroom. In linking the beginning of class clicker questions to the activity students are about to work on, I can be sure they have a sufficient level of background understanding to work effectively that day. The end of class clicker questions provide an excellent opportunity for wrapping up an activity and evaluation of student learning that day. The use of clickers has made quite a difference in this course, and they are here to stay. I don't think I will ever teach a course without using them.

The daily activities are effective, and I can look at them each day to evaluate student progress. Where consistent misconceptions appear, I can correct them in the next class and I can also prompt students for more detailed explanations or give them something else to think about when considering a given concept. As students have worked through the activities, it has become clear that some of the activities need to be rewritten in order to better guide students through the learing process. I will be making those revisions over the summer in time for next fall. One of the major thrusts of this revision will be to have students more clearly explain the path they have taken in solving a problem. Getting the students to do this will likely mean a greater investment of time upfront, but should pay off later in the semester as students more thoroughly develop their problem solving skills.

The creation of learning teams in a large class has been a positive experience. Certainly in terms of exam performance, there have been measurable gains in student acheivement. But, there are some things that I know that I can change in the future that will hopefully make these groups more effective. Students were placed in teams by the instructor at the beginning of the semester, and unless there were withdraws from the course or extremely dysfunctional groups, the groups were left the same for the first half of the semester and then completely rearranged. In some teams, this led to some complacency, and some team members were content to let one person do all the work and just copy. I think this also kept some teams intact that just didn't function well (because of conflicting personalities for example) together too long. In future semesters, I will be rearranging groups after every exam so that students won't become so complacent. Another persistent problem is that some students will allow themselves to stay trapped in a bad team instead of discussing the issue and requesting a change. Unfortunately, this leaves those students thinking that learning teams in general can't work and they become less invested in the course. I am not sure I have any ideas on how to change this, except to change those groups that I perceive to be consistently dysfunctional.

One area where my peer and mentor have been most helpful is in helping me think about ways to improve the transition from the time when students are working in small teams to the times when we are having a large class discussion. It is, to be sure, a problem when you give 150 students permission (and encouragement) to talk, then change the classroom environment to one where a single conversation is taking place. At the beginning of the semester, I would just shout long enough and loud enough to get their attention, but even with that, it was impossible to hear in the back of the room when the final 20 conversations were still dying out. What I now do (and I can do this from anywhere in the room) is raise my hand when I want to get student's attention. When they see me raise my hand, they are supposed to raise theirs, and when their hand is up, they cannot be talking. This has helped me get control of the room quickly, stops conversations sooner, and now everyone can hear when I am speaking.

One important observation from my peer in this process was that the TAs would often wait for a student to raise their hand, then help, instead of just randomly stopping and asking a group what question they were on of how they were doing. In meeting with the TAs I mentioned this and now I think the TAs are getting better at randomly asking students how they are doing. It has helped get conversations going, but I think one of the real great challenges is finding a way to get more TAs into the room to act as discussion facilitators.

In conversations with my mentor, the idea of developing a Practicum in Chemistry was discussed. Students enrolled in the practicum would be students who had previously taken the course and showed superior performance. These students would return to class and act to facilitate discussion within and between learning teams in exchange for course credit. Although there are a list of changes that could be made to the course, it is my current opinion that the addition of the Practicum, should it attract a sufficient number of students, would probably bring about the greatest improvement. Currently there are 53 groups of students and one course instructor and three TA's to facilitate discussion. That gives each of us about 13 groups to manage. What I would like is to have about 10 practicum students in the classroom so that each us were now facilitating discussion between 5 or 6 groups. This increased discussion between teams would be anticipated to lead to additional gains in student learning.

This portfolio has given me the opportunity to obtain helpful suggestions from my peer review partner and mentor. The questions they asked were thoughtful and made me think about what I am doing in the class and how effective it is. Their suggestions and comments were useful and led to improvements in how the classroom worked each day. Although I have always been curious about student opinion of my courses (without wanting to wait for end of semester evaluations) I don't think I would have taken the time to set up and analyze a mid-semester survey were it not for wanting to include the results as part of this portfolio. Knowing how students feel about the course in general, what they like and don't like about working in teams, and what components of the course they find most useful has allowed me to make some changes in the course and has helped in the reflection of the learning process that is in this portfolio. I am hopeful that I will be able to make some of the changes discussed throughout this portfolio so that the course becomes even better in the future.

Appendix 1
Course Syllabus

GENERAL CHEMISTRY
SPRING 2008
COURSE SYLLABUS

General Information

Instructor: Dr. Wojcinski
Office Chem-Biochem 153
Phone 532-6036 **email** lmw2@ksu.edu
Office Hours M W F 9:30-11 or by appt.

Required Textbook and Other Materials

- The text for the course is "*Chemistry in Context*" 5^{th} edition; American Chemical Society; McGraw-Hill Publishing 2003.
- i-clicker (available at Varney's)
- CHM110 Classroom Activities Book (Varney's)
- Calculator

Mathematical Skills

To do well in this course, it is critical that you have a sufficiently strong set of mathematical skills. Over the course of the semester you will be exposed to new topics that at first may be difficult to grasp. The chemistry is easier if you have the mathematical background required to solve complex problems.

Goals for the Course

To successfully complete this course, students will:

- Learn how to work effectively as part of a group to understand course concepts and answer questions relevant to science and to society
- Understand the relationship between chemistry and important issues including pollution, global warming, and energy policy
- Develop the process skills necessary to solve complex problems and answer questions that demonstrate understanding of an issue
- Introduce students to some of the basic concepts of chemistry that are relevant to contemporary societal issues

SUCCEEDING IN GENERAL CHEMISTRY

The list below describes some of the things that you should do in order to excel in this course. Write True of False beside each of the following statements and use the scoring scale that follows to predict the course grade likely to result from your study habits.

1. I always complete the assigned reading and review prerequisites before class so that I am prepared for class each day.

2. I complete the *Your Turn* exercises and any additional problems listed at the end of each in class activity to be sure I understand the concepts covered.

3. I go to office hours, a tutor or the helproom regularly to discuss problems on the homework or in-class activities.

4. I spend some time studying chemistry at least five days per week outside of class time (excluding time to complete assignments)

5. I regularly make use of the *Figures Alive* section of the books website to reinforce ideas covered in class.

6. I review the *Chapter Summary* as each chapter is completed to be sure I understand all of the material from the chapter.

7. I use the *Study Quizzes* on the books website as each chapter is completed to asses my understanding of the material in that chapter.

8. I rework all the homework problems and Your Turn questions before the tests.

9. I participate in a study group where we work on homework together and quiz ourselves on the material.

10. I rework all of the quiz and test items I missed *before* the next class session.

11. I realize that I can still do well in the course, even if I have done poorly in the class up to this point.

Predicted grade for the course:

Number of True Responses	Predicted Grade
9 or more	A
6-8	B
4-5	C
2-3	D
less than 2	F

Helping You Succeed in General Chemistry

- **Office hours:** My office hours are posted at the beginning of this syllabus. If you are struggling with course material or if you feel that your group is a bad fit on a regular basis, my office hours are set up so that we can discuss these issues. If my office hours conflict with another class or work, let me know and we can arrange another time to meet.

- **Chemistry Help Room:** In addition to office hours, one-on-one help is also available in the Chemistry Help Room in Willard 102. Just after the beginning of the semester, a schedule of staff hours will be posted on the Help Room door. The people who staff the help room are there (as the name suggests) to help you. Don't be shy in taking advantage of this service that is available to you for **FREE**.

- **FREE Tutoring:** FREE (there is that word again) tutoring is also available to any enrolled KSU student. The tutoring center is in Room 201, Leasure Hall, or phone 532-5703.

- **Other Accommodations:** Any student with a physical or learning disability who requires any sort of academic or other accommodations should contact me as soon as possible, and also get the required forms from disability services.

Grades

Grades will be determined according to the following point totals:

Four exams	100 pts each	400 pts
i-Clicker questions	150 pts	150 pts
End of Chapter Hwk	150 pts	150 pts
Final Exam	200 pts	200 pts
		900 pts

Final grades will be assigned on a scale of: A = 90% (810), B = 80% (720), C = 70%(630), D= 60%(540)

Exam Dates

Feb 11	Chapters 1 and 2
Mar 10	Chapters 3 and 4
Mar 7	Chapters 5 and 6
Apr 28	Chapters 7 and 10
May 12	Comprehensive Final Exam

These exam dates are tentative and may be moved depending on how fast (or slow) material is covered. It is your responsibility to keep Monday nights open for these exams (including the Monday after spring break).

Attendance Policy

Because you will be working in small groups all semester, your attendance in class is required each day. You have a responsibility to your group members and to your classmates to help them learn the course material each day class meets. If you must miss class because of (1) a University sponsored activity (athletic team obligations, choir or theater practice, etc.), (2) a medical or family emergency or (3) some other miscellaneous reason *that has been approved by the instructor prior to class* your absences is excused and the absence will not count against you. In the case of an excused absence that falls under (1) or (2) it is your responsibility to bring written documentation to support the absence (note from a doctor, or something on university letterhead for example) to my office.

Any other absences will be considered unexcused absences. You are permitted two unexcused absences each semester, and after two unexcused absences, your grade will be affected as follows:

3-4 unexcused absences	final letter grade lowered by one letter grade
5-6 unexcused absences	final letter grade lowered by two letter grades
7-8 unexcused absences	final letter grade lowered by three letter grades
9 or more absences	you cannot pass the course.

Homework, Exams, and Excused Absences

Homework is due at the beginning of class, and should be in the format described in detail on the course website. Late homework is not accepted for any reason (so that solutions can be posted as soon as possible). In the event you are going to miss a class for a University sponsored activity, the homework should be handed in early. If you are unable to hand in a homework assignment on time because of a medical or personal emergency, you must provide written documentation to verify the absence. If the absence is excused, you will be given the average of the remaining assignments for the missed assignment.

Makeup exams are not provided for any reason. In the event you miss an exam because of a university sponsored activity or some emergency, you will be receive the average for the remaining exams including the comprehensive final. As with the homework, the absence must be supported by written documentation brought to my office. In the event you miss an exam but cannot provide written documentation to verify the absence, you will receive the average of your remaining exams, minus forty points.

Other Information

For additional information on the homework and exam policy, the proper format for the homework, course expectations and grades and the grading scale, consult the course website on KState Online.

Appendix 2
Examples of InClass Activities and Reflections on Learning

ACTIVITY 2-2

THE LEWIS MODEL OF MOLECULAR STRUCTURE

LEARNING OBJECTIVES

- To understand Lewis symbols and Lewis structures
- To understand the correlation between Lewis structures and the nature of chemical bonds.

SUCCESS CRITERIA

- To be able to use the periodic table and some rules about chemical bonding to draw Lewis structures for some common molecules.
- To be able to look at a Lewis structure and make predictions about bond length and bond strength.

PREREQUISITES

- Valence electrons

ROLES

- Manager:
- Recorder:
- Presenter:
- Reflector:

WHY?

Lewis structures are used to depict the bonding that takes place between atoms when they form compounds. These structures provide valuable information about the strength and length of the bond between two atoms, which will be important to us when we study ozone depletion chemistry in more detail. We will also look at Lewis structures when we study the chemistry of global warming in Chapter 3.

Information

The noble gases, with 8 valence electrons, form very few compounds. Those 8 valence electrons constitute a full outer shell, and that full shell gives those elements some extra stability. Most other atoms will combine to form molecules so that they have access to 8 electrons. By forming compounds, those other atoms become more like the noble gases, and acquire full outer shells. One important exception to the elements acquiring 8 electrons is hydrogen. Because of its small size, hydrogen only needs access to 2 valence electrons. You will also notice that helium (the noble gas nearest hydrogen on the periodic table) also only has 2 valence electrons.

Model 1 2 H atoms forming an H_2 molecule:

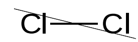
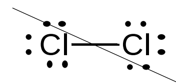
Step 1: Determine how many valence electrons each atoms in the molecule has.	Each H atom has one valence electron: H·
Step 2: Bring the atoms together to form a bond between them (the atoms will share valence electrons).	H:H
Step 3: The pair of valence electrons can be drawn as a line between the two atoms.	H—H
Step 4: Check each atom for the correct number of valence electrons.	H: 2 electrons (correct)

Questions:

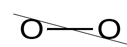
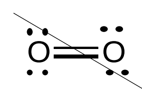
(1) How can you determine the number of valence electrons an atom has?

(2) What does the single line in the H_2 molecule represent?

Model 2 Drawing the Lewis Structure for Cl_2

Step 1: Determine how many valence electrons each atoms in the molecule has, and the total number of valence electrons in the molecule	Each Cl has 7 valence electrons Total = 14
Step 2: Bring the atoms together to form a bond between them (the atoms will share valence electrons).	
Step 3: Distribute the remaining electrons **in pairs**, so that each atom has 8 valence electrons **(an octet)**	
Step 4: Check each atom for the correct number of valence electrons.	Cl: 8 correct

Model 3 Drawing the Lewis structure for O_2. The need for double bonds

Step 1: Determine how many valence electrons each atoms in the molecule has, and the total number of valence electrons in the molecule	Oxygen has 6 Total = 12
Step 2: Form the bonding framework of the molecule	
Step 3: Distribute the remaining electrons **in pairs**, so that each atom has 8 valence electrons **(an octet).** It many necessary to place additional pairs between the atoms to give each atom an octet.	
Step 4: Check each atom for the correct number of valence electrons. It is also a good idea to double check to be sure you have used the correct number of total valence electrons.	O: 8 correct 12 used to make molecule.

In some molecules it will be necessary for atoms to share more than two electrons. The four shared electrons (two shared pairs) in the O_2 molecule are called a double bond. Double bonds are shorter and stronger than single bonds. Some molecules will have triple bonds, which are shorter and stronger still than double bonds.

Questions

(3) Looking at the total number of electrons available in Cl_2 and O_2, when will it be necessary to put double or triple bonds between atoms in a Lewis structure?

(4) How does the Lewis structure help you find the strongest bonds in a molecule?

For molecules like H_2 and O_2 building the basic framework of the molecule is simple. There are only two atoms, and they must be bonded to each other. But what about polyatomic molecules like formaldehyde (COH_2) of carbon dioxide (CO_2). It is best to think in terms of *exterior atoms* and *interior atoms*. Exterior atoms will be bonded to only one atom; Interior atoms will be bonded to more than atom. A few general rules can help build the basic framework of the molecule.

- Hydrogen will always be an exterior atom.
- In many cases, the atom written first is the interior atom. In CO_2 for example, C is the central (interior) atom, and the O atoms are on the exterior, each bonded to C.
- In some molecules, the way the atoms are written indicate the manner in which the atoms are connected. In OCS for example, the atoms are connected O-to-C-to-S.
- Multiple atoms of the same element are usually the exterior atoms, surrounding a single interior element. In H_2O for example, the H atoms are distributed around the central O atom.

Exercises

(5) Draw Lewis structures for the following molecules:

CCl_4

H_2S

HCN

N_2O (atoms connected N-N-O)

A More Challenging Problem

(6) Draw the Lewis structures for the following molecules:

C_2H_6

C_2H_4

C_2H_2

Which of those molecules has the strongest C-C bond? Which one the weakest?

Free Radicals

There are certain chemical species called free radicals, which will become important as we study ozone depletion. Some important free radicals include NO_2, ClO, and HO.

(7) Draw the Lewis structures for these three compounds.

(8) What structural feature do these three compounds have in common?

For Next Time

(1) Complete this Activity

(2) Read section 2.3 of *Chemistry in Context*

(3) Your Turn 2.8-2.10

Reflector's Report

Team Members (write name by role) *Rotate roles each week*

We verify that we understand and agree with all of the solutions to the problems included with our report

Manager:________________________________

actively participates, keeps the team on task, distributes work and responsibilities, assures that everyone participates and understands

Recorder:________________________________

actively participates, keeps the log of work and other documentation in consultation with the team

Spokesperson:____________________________

actively participates and presents reports to class

Reflector:_________________________________

actively participates, identifies and keeps notes of problem solving strategies, use of process skills, what the team is doing well and what needs improvement, prepares written report in consultation with the team

Homework

Each member completed the homework assigned in the previous class:

YES **NO** Verify with initials of group members:

Reflection on Learning (Use the other side of this page for your answers)

(1) In no more than three sentences, sum up what was learned about Lewis structures today.

(2) Identify one concept from today's that you have mastered. Identify one that you understand the least.

Self-Assessment

(3) What problems do your team members have in working together? What might your team do to eliminate these problems?

Assessment

Provide your self-assessed grade for the session (3, 4, or 5)_____
Rationale for grade:

Instructor's Comments:

ACTIVITY 7-1
BALANCING NUCLEAR REACTIONS
THE ENERGY OF NUCLEAR FISSION

Group_________
Time__________

LEARNING GOALS

- Understand how to balance nuclear reactions
- Understanding the changes that take place in the nuclei of some atoms that produce large amounts of energy.

SUCCESS CRITERIA

- Balance nuclear reactions
- Carry out calculations on energy given off in nuclear reactions

READING

- *Chemistry in Context,* pp. 309-317

PREREQUISITES

- Activity 2-1 (Atomic structure and isotope notation)

ROLES

- Manager
- Recorder
- Presenter
- Reflector
- Technician

WHY?

Each year, the demand for energy increases in the U.S. as we desire more goods and services and the economy continues to grow. Demand for energy is increasing even faster in other parts of the world as those nations develop and become more prosperous. Most of the electricity we use today is produced by the combustion of fossil fuels such as coal and natural gas. In previous chapters (1, 3, 4 and 6) we looked at the consequences of fossil fuel combustion as we studies issues like pollution, global warming, and acid rain. Clearly the combustion of fossil fuel comes with costs. But, if the economies of the U.S. and of the world are to continue to grow, we must find a way to meet the energy demands of those economies. One potential alternative is to use nuclear power to produce more electricity. In this chapter, we will study nuclear reactions, radioactivity, and look at nuclear waste issues. We begin our study by looking at nuclear reactions and look at how it is that nuclear reactions produce so much energy.

INFORMATION

The energy supplied by most nuclear reactions is produced by a process known as nuclear *fission*, where a *large nucleus* is *split into smaller nuclei* and energy is given off. Typically, the fuel used in nuclear reactors is uranium-235 (U-235). When a neutron collides with a U-235 nucleus, smaller nuclei are produced and a great deal of energy is produced. Before we look at the energy produced, we will first look at how to balance nuclear fission reactions.

MODEL 1 FISSION OF U-235

Balanced fission reaction: ${}^{1}_{0}\nu + {}^{235}_{92}Y \rightarrow {}^{141}_{56}B\alpha + {}^{92}_{36}K\rho + 3\ {}^{1}_{0}\nu$

QUESTIONS

(1) What does the subscript to the left of each atomic symbol indicate?

(2) What does the superscript to the left of each atomic symbol indicate?

(3) How many neutrons are there in a U-235 nucleus?

(4) How many protons are there on the left side of the equation? How many protons on the right?

(5) What is the total mass (total number of protons and neutrons) on the left side of the equation? What is the total mass on the right side of the equation?

(6) Does this equation seem to obey the law of conservation of mass? Explain your answer.

(7) How is balancing nuclear reactions different from balancing "typical" chemical reactions

EXERCISES

(8) What other nucleus is required to balance the following nuclear reactions:

$$^{1}_{0}\nu + {}^{235}_{92}Y \rightarrow {}^{97}_{40}Z\rho + \_\_\_\_\_ + 3\,{}^{1}_{0}\nu$$

$$^{1}_{0}\nu + {}^{235}_{92}Y \rightarrow {}^{92}_{38}\Sigma\rho + \_\_\_\_\_ + 2\,{}^{1}_{0}\nu$$

INFORMATION

One of the most recognizable images in science is the mushroom cloud that has come to symbolize the devestation that is unleashed in a nuclear blast. For nuclear explosions to cause so much devestation, enormous amounts of energy must be released. In this part of the exercise, we will look at how the nuclear reactions that can be used to either power reactors or produce mushroom clouds release so much energy.

MODEL 2 CONSERVATION OF MASS IN A NUCLEAR REACTION

$$ {}^{1}_{0}\nu + {}^{235}_{92}\mathrm{Y} \rightarrow {}^{141}_{56}\mathrm{B}\alpha + {}^{92}_{36}\mathrm{K}\rho + 3\ {}^{1}_{0}\nu $$

Masses of Reactants and Products:

Nucleus	Mass (amu)
${}^{1}_{0}\nu$	1.00866
${}^{235}_{92}\mathrm{Y}$	235.04392
${}^{141}_{56}\mathrm{B}\alpha$	140.91436
${}^{92}_{36}\mathrm{K}\rho$	91.92627

QUESTIONS

(9) From the masses given in the table, calculate the combined mass of the reactants.

(10) From the same information, calculate the combined mass of the products.

(11) Looking at your answers to Q9 and 10, does this reaction obey the law of

conservation of mass? If not, what is the change in mass for this reaction.

(12) If 235 g of U-235 (one mole, or 6.02×10^{23} atoms) underwent nuclear fission, what would be the change in mass in amu? (*Hint: The change in mass you calculated in Q11 is for a single atom)*

(13) Using your answer to Q12, calculate the change in mass (a) in grams, and (b) in kilograms. 1 amu = 1.661×10^{-24} g 1000 g = 1 kg.

INFORMATION

The energy (E) change in a nuclear reaction and the change in mass (m) are related by Einstein's famous equation, $E = mc^2$. We can modify this equation somewhat to a more convenient form:

$$\Delta E = \Delta mc^2$$

Where the greek letter delta is used to mean "change", and c is the speed of light, 3×10^8 m/s. In english, this means that the energy given off in a nuclear reaction (or any reaction for that matter) is equal to the change in mass multiplied by the speed of light squared.

EXERCISES

(14) Using your answer to Q13(b), calculate the amount of energy (in joules) given off when 235 g of U-235 undergoes fission ($1 \text{ J} = 1 \text{ kg}\bullet\text{m}^2/\text{s}^2$).

(15) If instead we used 235 g of coal to produce our energy, how much energy (in J) would be given off by the combustion of this mass of coal? The heat of combustion of coal is 30 kJ/g.

(16) How does the amount of energy produced from the fission of 235 g of U-235 compare to the energy released during the combustion of 235 of coal? How does this comparison highlight the enormous amounts of energy that can be produced from nuclear processes?

FOR NEXT TIME

(1) Complete any unfinished portions of this activity

(2) Your Turn 7.4-7.6

(3) Visit the Figures Alive section of the *Chemistry in Context* website and complete the section on nuclear fission.

Reflector's Report

Team Members (write name by role) *Rotate roles each week*

We verify that we understand and agree with all of the solutions to the problems included with our report

Manager:________________________________

actively participates, keeps the team on task, distributes work and responsibilities, assures that everyone participates and understands

Recorder:________________________________

actively participates, keeps the log of work and other documentation in consultation with the team

Spokesperson:____________________________

actively participates and presents reports to class

Reflector:_________________________________

actively participates, identifies and keeps notes of problem solving strategies, use of process skills, what the team is doing well and what needs improvement, prepares written report in consultation with the team

Homework

Each member completed the homework assigned in the previous class:

YES **NO** Verify with initials of group members:

Reflection on Learning (Use the other side of this page for your answers)

(1)Explain why and how an understanding of atomic structure helps us understand nuclear reactions.

(2) What was the most useful thing you learned in this session?

Self-Assessment

(3) Which team member contributed the most? What could be done to equalize the contributions from each team member?

Assessment

Provide your self-assessed grade for the session (3, 4, or 5)_____

Rationale for grade:

Instructor's Comments:

Appendix 3
Results of Student Survey

AXIO SURVEY

SURVEY REPORT

Summary

Survey Name:
Mid-semester evaluation

Offering Name:
Mid semester evaluation

Offering Date:
4/1/08 to 4/4/08

Statistics
A total of **55** out of **164** people started this survey.
5 of the people who received the survey opted out.
55 people completed it.
0 people quit before completing it.

Number of people who left the survey without completing it per page number:

- Page 1: **5**

Average completion times:

- Average Time To Complete Survey: **8 minutes 14 seconds.**
- Average Time Spent Before Quitting: **Not enough information.**

Page 1

Question 1

For the following questions, indicate the extent to which you agree/disagree with the following statements.

1.1 The clicker questions at the beginning of class make me keep up with the course material

Strongly agree	11 (20%)
Agree	23 (41.82%)
Neutral	13 (23.64%)
Disagree	5 (9.09%)

Strongly disagree	3 (5.45%)
N/R	0 (0%)

1.2 The clicker questions at the beginning and end of class help me evaluate my understanding of course material

Strongly agree	18 (32.73%)
Agree	19 (34.55%)
Neutral	7 (12.73%)
Disagree	8 (14.55%)
Strongly disagree	3 (5.45%)
N/R	0 (0%)

1.3 The in class activities help me keep up with course material

Strongly agree	12 (21.82%)
Agree	26 (47.27%)
Neutral	7 (12.73%)
Disagree	7 (12.73%)
Strongly disagree	3 (5.45%)
N/R	0 (0%)

1.4 Working in a group has helped me understand course material better than I would on my own

Strongly agree	14 (25.45%)
Agree	19 (34.55%)
Neutral	15 (27.27%)
Disagree	2 (3.64%)
Strongly disagree	5 (9.09%)
N/R	0 (0%)

1.5 The feedback on the daily activities has helped our group better understand some of

the concepts covered in the course

Strongly agree	8 (14.55%)
Agree	16 (29.09%)
Neutral	14 (25.45%)
Disagree	12 (21.82%)
Strongly disagree	5 (9.09%)
N/R	0 (0%)

1.6 The end of chapter homework helps me evaluate my understanding of course material as each chapter is finished

Strongly agree	12 (21.82%)
Agree	19 (34.55%)
Neutral	11 (20%)
Disagree	9 (16.36%)
Strongly disagree	4 (7.27%)
N/R	0 (0%)

1.7 The exam review sessions have helped me evaluate what material I need to study to prepare for the exam

Strongly agree	17 (30.91%)
Agree	13 (23.64%)
Neutral	15 (27.27%)
Disagree	6 (10.91%)
Strongly disagree	4 (7.27%)
N/R	0 (0%)

Question 2

For the following questions, indicate the extent to which you agree/disagree with the following statements concerning how well you work in a group and how well your group works together.

2.1 Most days I have completed the assigned reading and I am prepared to contribute to the group

Strongly agree	14 (25.45%)
Agree	23 (41.82%)
Neutral	7 (12.73%)
Disagree	9 (16.36%)
Strongly disagree	2 (3.64%)
N/R	0 (0%)

2.2 Most days my group members have completed the assigned reading and are prepared to contribute

Strongly agree	14 (25.45%)
Agree	18 (32.73%)
Neutral	11 (20%)
Disagree	10 (18.18%)
Strongly disagree	2 (3.64%)
N/R	0 (0%)

2.3 If I think I am right about a question and my other group members are wrong, I can be stubborn about changing my mind

Strongly agree	5 (9.09%)
Agree	9 (16.36%)
Neutral	21 (38.18%)
Disagree	15 (27.27%)
Strongly disagree	5 (9.09%)
N/R	0 (0%)

2.4 My group members do not value my input enough

Strongly agree	8 (14.55%)

Agree	1 (1.82%)
Neutral	11 (20%)
Disagree	25 (45.45%)
Strongly disagree	10 (18.18%)
N/R	0 (0%)

2.5 We delegate tasks each day to make sure the work gets done

Strongly agree	22 (40%)
Agree	18 (32.73%)
Neutral	7 (12.73%)
Disagree	4 (7.27%)
Strongly disagree	4 (7.27%)
N/R	0 (0%)

2.6 My group is very good about exchanging ideas and making sure everyone has input

Strongly agree	19 (34.55%)
Agree	16 (29.09%)
Neutral	13 (23.64%)
Disagree	2 (3.64%)
Strongly disagree	5 (9.09%)
N/R	0 (0%)

2.7 The exchanges within our group help me to understand course material

Strongly agree	16 (29.09%)
Agree	22 (40%)
Neutral	7 (12.73%)
Disagree	3 (5.45%)
Strongly disagree	6 (10.91%)
N/R	1 (1.82%)

2.8 I am more comfortable asking questions in a small group setting than I ever would be in a large lecture

Strongly agree	31 (56.36%)
Agree	8 (14.55%)
Neutral	6 (10.91%)
Disagree	4 (7.27%)
Strongly disagree	6 (10.91%)
N/R	0 (0%)

Question 3

Rank the following items with respect to how well you think they have improved your understanding of course material

3.1 clicker questions

1	7 (12.73%)
2	16 (29.09%)
3	15 (27.27%)
4	11 (20%)
5	5 (9.09%)
N/R	1 (1.82%)

3.2 in class activities (working in small groups)

1	20 (36.36%)
2	7 (12.73%)
3	11 (20%)
4	8 (14.55%)
5	8 (14.55%)
N/R	1 (1.82%)

3.3 class discussions (discussions as a large class)

1	9 (16.36%)
2	10 (18.18%)
3	5 (9.09%)
4	19 (34.55%)
5	10 (18.18%)
N/R	2 (3.64%)

3.4 end of chapter homework

1	5 (9.09%)
2	9 (16.36%)
3	6 (10.91%)
4	11 (20%)
5	22 (40%)
N/R	2 (3.64%)

3.5 exam review sessions

1	11 (20%)
2	11 (20%)
3	17 (30.91%)
4	4 (7.27%)
5	8 (14.55%)
N/R	4 (7.27%)

Question 4

For the following questions, provide short answers. Your input is valuable to the course instructor and some changes may be implemented in the second half of the course.

List two positive things that you have experienced as a result of working in small groups in class.

- More one on one time with teachers or TA's, easier to communicate problems or misunderstandings
- Friendship and another way to look at problems

- When I do not understand a concept, someone in my group usually does. I am much more comfortable asking questions in a small group than I would be in a large group or lecture.
- (1) self learning. (2) We can help each other out.
- New friends and working together
- understanding the info
- I have made new friends with my group members, and we learned to work together even though we didn't know each other very well.
- I have enjoyed having the feedback and additional experience. They have also been an accountability group to stay on top of things.
- I did not take a chemistry class in high school so I was lost going into the class. They guys in my group have helped me keep up. The small groups feel more personal and able to ask questions.
- Gives me the incentive to go to class that I might not have otherwise If I don't know the answer or am unsure, I've got 2 other people to help
- Sometimes I haven't had time to check my e-mail or read something that my groupmates have. Sometimes I am wrong and my groupmates can explain the correct answer or workt o me.
- Being held accountable to read the material BEFORE class and understand it better; Being able to ask many questions and discuss all problems thoroughly without waiting a great deal of time for help.
- It is easier to ask questions if you are confused about something. And there are different viewpoints to help you come to an understanding.
- Establishing better work ethic and communication skills
- 3 heads instead of one, it goes faster
- If I don't understand something usually someone in the group is able to explain it. It has allowed me to get to know more people!
- ive met new people,and you can actually teach yourself you dont need someone to tell you everything.
- I have gotten to know the people in my group and around me. If I miss a day of class I can still get the corrected assignment to look over.
- friends, understand material better
- I have gotten to know to extremely nice girls
- met some really nice girls and am more comfortable asking questions when i don't understand
- can ask more questions and better understanding and also gaining friends in a class that I can study with and consult with. I wish we didnt have to switch groups.
- Each member has a little different style of completing a task. When you miss a class you feel like you are letting your group members down.
- *Have people to check my answers with *If I don't understand the material, surely someone in my group will and they can help me
- I have been able to learn at pace that fits the team. I feel as if I have learned everything we have gone over and it shows since I have recieved a 98% avg on the tests.
- Get to know more people in class, can work together to try and get an answer instead of just yourself.
- 1. I find it easier to ask those around me questions as well as the professor and TA's circulating around the room. 2. Because of our groups, I met a good study buddy.
- Learned the material better Got to meet two new people
- I have made two great friends I have learned to communicate better
- Working in small groups is ultimately beneficial for when students get into the real workforce and have to cooperate on a daily basis. Also, it sort of allows you to see how well you know the material
- getting more help when I needed it, and asking more questions
- better understanding and more helpful.
- I have pushed myself further to understand the material in order to more of an asset to the group. My group members have also helped apply the concepts in better ways that are easier to understand.

- 1. I have met new people 2. We challenge each other
- Get the assignment done faster, and discussing the right answers
- 1. I have gotten to know two persons in a class, and if I need help outside I can study with them. 2. We argue with one another until we understand the question.
- meet new people and easier to ask questions
- I have made new friends but sometimes they don't help very much when it comes to getting things done.
- met new friends and easier to learn
- had a chance to get others ideas about the problem when i was not sure how to do it.
- 1. More points of views 2. More socilization
- If I do not understand my group members will help me. If I do understand I am given the opportunity to teach others that do not.
- I was able to discuss with my group and understand it better. Also we could ask student teachers or teacher questions more often.
- They help me to understand something I wouldn't. They helped me to keep up with my work.
- 1. Meeting new people 2.Helping each other understand the material
- it is nice to get the reading ezplained with many points of view. I like that I can ask questions frequently

Question 5

List two negative things that you have experiences working in small groups.

- Don't learn a lot because none of us originally know what we're doing and then it is not taught, we will often times have different opinions of the correct answer
- Rushed amount of time to complete activity, and hard to concentrate with lots of groups around us
- Everyone does not always contribute equally everyday. Not getting extra credit on exams.
- (1) sometimes we lose track of what we're supposed to be doing.
- Nothing
- people talk way too much around me when they shouldnt be talking
- Some of us do more work than others, sometimes things just don't get done
- We have just built some group chemistry, so switching groups will be difficult and frustrating. There are no other negatives that have come from it.
- nothing really
- nothing comes to mind
- Sometimes groupmates make you feel stupid and on the outside. Someetimes they do not understadn because they haven't done the reading and you have and so you have to explain it all to them.
- Not all members of the group come prepared to class or participate; My group only has two people, so if one of us is gone the other is left by themselves.
- It can be hard when doing the clicker questions and you know for a fact that you are right and you argue with your groups about the answer. But it hasn't been to big of a problem thus far.
- Disagreements, Stubbornness
- Noone understanding, teaching ourselves
- We don't always understand everything. Sometimes none of us feel like doing anything!
- When our group doesnt know the solution its hard to proceed, and when group members are absent.
- If someone doesn't show up then its more work for the other people and we have pressure from each other to do good on tests and feel like a disappointment if we let them down.
- its so loud and hard to hear group members, distracted easily
- they always wait for me to answer the question rather than trying first, and the first test one didn't get the best grade
- we don't always understand the material and are unable to explain it to each other. when

one member doesn't show up, the rest of the group has to do more work.
- nothing.
- I learn better in a normal classroom setting. Three peers discussing things that they know very little about does not make as much sense to me as the instructor lecturing.
- *Some people didn't always contribute *Would make one person look up all the answers/calculate everything during clicker questions and they would just wait for them to get the answer
- Sometimes every one of us doesn't know what is going on. Sometimes influenced to put down a wrong answer when I was correct.
- Sometimes no one in the group knows, and you don't get much help from the teacher or aids.
- 1. It's sometimes hard to agree on one answer when there are at times two or three differing opinions on the question. 2. At times it goes slower and less material can be covered in class.
- Sometimes hard for group to get along Not always getting whats going on if two members are doing most of work because they understand better
- I have learned nothing about chemistry I DO NOT understand anything
- to distracting and cant concentrate.
- Students have to teach themselves the material rather than the instructor lecturing, and while this is a course that students must practice at to prepare for exams, higher level material is difficult
- differance in opinions, and trying to explain things to others when they don't understand
- One of my group memebers talked to much so we would never get through all of the material. sometimes my partners weren't prepared for class, so they would be a little lost.
- The pressure to get a 72% is really stressful. I have test anxiety as it is but to know that if I am the one who doesn't get the grade no one in my group will get the extra points.
- 1. I don't like relying on other students 2. I don't like having to work in groups all the time
- Not everything is explained very well,we all have different opinions.
- 1. I may understand something while my group members talk me thru it, but on my own I don't. 2. We have started to focus on rather or not we will get done, and not on our own comprehension.
- we have to teach ourselves what we dont understand already, and we go WAAAY too fast on the exercises that we cant even fully understand how to do them
- Sometimes prople don't show up and that makes the day go HORRIBLY!!!! Also not everyone has the same attitudes toward grades so it is sometimes difficult to get everyone motivated to read before class
- not every member is as intelligent and not every member always participates daily
- some times groups mebers doint care or they just work on it by themselfs.
- 1. Not everyone contributes 2. Lack of communication at times
- Hard to hear, not equal participation
- One of the girls does not like to listen to anyone, she thinks she is always right. And working in a small group makes it so she wants to rush things and be done and not work together as a group.
- If no one understands it's hard to learn. Not enough information in some questions and it's hard to get your questions answered.
- 1. Forceful people 2. Not always getting the information explained.
- even though we work hard my group is always rushed. sometimes we teach our selves some that is not right.

Question 6

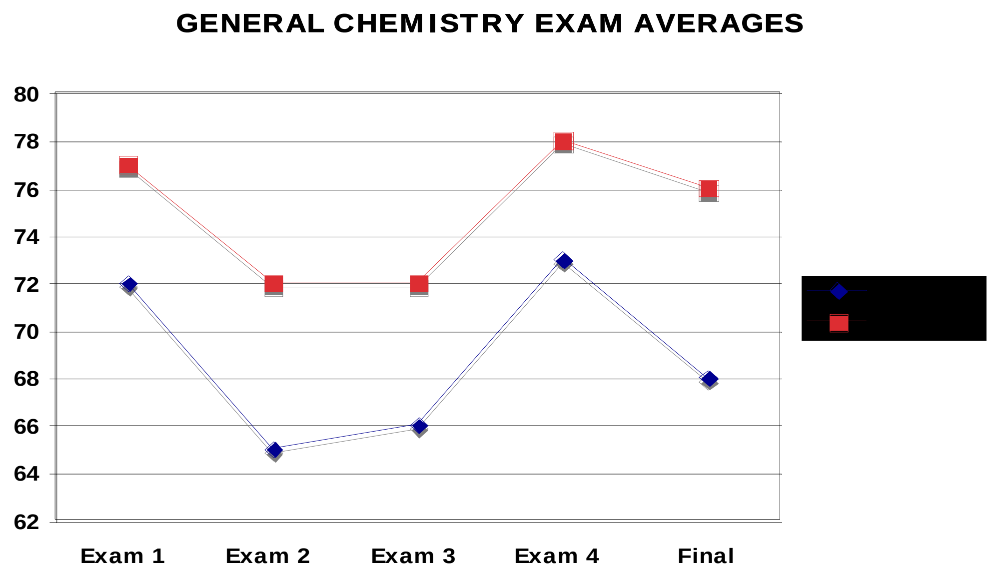
List any suggestions that you would give to the course instructor to improve things in this course.
- Teach more at the beginning of class, then go into small group activities
- Don't ask for 1-2 more minutes, ask how much of the class is done with the activity before moving on because it frustrates people when they can't complete an activity. Keep the same groups.

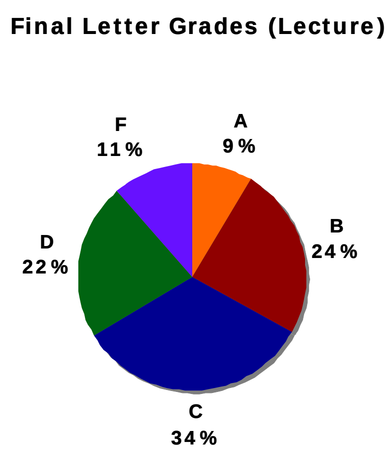
- I really like the set up of the course and feel that I am learning much more than I would in a traditional style lecture. I do not have any suggestions to improve the course, I think that you work wel
- It's important to review the questions in the chapter material. A lot of the time we have questions that go unanswered.
- Nothing
- -
- make sure everyone is on the same page, which they are most of the time!
- The h.w. has been frustrating for me. I do the work and readings, however the questions in hw seem ambigious have had a negative affect on my grade. Same is sometimes true for the clicker questions.
- not sure what the scale was on question 3 but 1 was best and 5 was worst
- Groups are okay, and activities make us learn, but more explanation of math and theories would help. I feel like I could do activities alone, but your explanation is the thing that helps the most.
- More helpers going around to help the small groups, sometimes they don't have enough time to get to everyone.
- The reflector sheets are not necessary, it seems like it is hard to complete them when trying to truely work through the material and understand it.
- Easier homework, explain math problems thoroughly
- Once in a while a lecture would be just fine with me.
- We should go over more of the math questions during class or have the answers available to us.
- It seems like the instructor realized we were behind schedule, so now he is really speeding everythin up. It is making it hard to follow and get the work done, even when we come to class prepared.
- keep doing what you are doing, i like the class, and i think you are a very entertaining yet very informative teacher. you make chem, enjoyable.
- I would suggest not switching groups this late in the semester. By doing so it pulls us away from a group that already fucntions and puts us into one that will be questionable for some time.
- I don't like the rule about group members getting a C and then everyone gets 10 points. It should be either no one gets any extra points of just put a curve on the test.
- The grading scale is messed up. For some reason the clicker questions grade is not right!
- explain the material. don't make the students teach themselves because that doesn't work for everyone. and the class needs to be slowed down because we cover way too much material each day.
- dont change groups. We are already in the groove of things and switching up groups makes me just start from the beginning.
- Mix some lecture into the course, especially when it comes to calculations. The group work is good, but I think mixing in some lecture would help. I know that it would help me out immensely.
- *Maybe more large discussions -- large discussions really help me understand what is going on
- I would keep it the same as it is. I have picked up on all of the material. This is the best taught class I have been in at K-State.
- Make exam review "sessions" a little more applicable to the tests and better explain answers to questions during them, rather than just trying to get through it all.
- Not switch up groups midway through
- Lecture, show us how to do more problems, explain things! Then let us work as a group
- lecture and go through things not small groups.
- Lecturing more often would be EXTREMELY beneficial. Also working out more example problems in class that will be on the exam.
- don't have the reflectors report because it takes to much time away from learning the activity for the day.
- Not to go so fast through the material, chaps 1 and 2 were a good pace,then we moved on to 3 and 4, and I felt we flew threw it w/ out any explanation about the material.

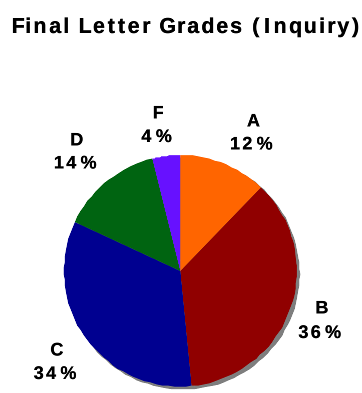
- Spend more time explaining the math problems.
- More test reviews during class, maybe 2 days of review because some days we don't get through the entire review questions
- Maybe spend more time lecturing and explaining the concepts. Don't just speed through the lecture and hope we all understand what you are talking about.
- Next year I would make this a tuesday thursday class, it allows for more time and exposure to the topic.
- TEACH THE CLASS. we took this class because we dont understand chemistry so how do you expect us to teach ourselves??
- I think you should curve grades and not pentalize students who get put in a crappy group of people who don't really care about grades or getting a 72 on exams
- I like haveing a review the day of the exam i think it helps more and maybe not to get into the next chapter
- 1. More lecture time 2. Lesson the strict grading on homework assignments
- Maybe groups of 2 instead of three
- I wouldn't change groups in the middle because most groups find their groove and then you mess it all up by switching groups. I don't understand the point of switching groups.
- Go in to more detail when going over the questions.
- longer time seggments(my group and other groups feel very rushed some days) since the clicker questions are for attendence, they should't be so hard or out of 5 beacuse there aren't five questions

- End of Survey -

Appendix 4
Summary of Student Performance on Exams







Appendix Five
Memos and Exchanges

Classroom Visit 1

CLASSROOM VISITS
PREPARATORY MENU

The format for the General Chemistry Course involves group work almost exclusively, with the instructor acting as a discussion leader. In using group work and class discussion, students become active learners. This avoids the problems typically associated with large lecture (passive learning environment, lack of engagement). Each class begins with a couple of clicker questions, followed by a two or three minute "lecture" about how the topic to be covered in that session relates to the larger class picture. Students then work in groups of three for ten to fifteen minutes, followed by a five-minute class discussion of the activity so far. Students then work for an additional ten-fifteen minutes in small groups, followed by some wrap-up discussion and two more clicker questions to finish the session.

The topic to be covered the day of the visit will be the mathematics of chemistry. The discussion will involve how to setup and solve math problems that come up frequently in a chemistry course. One of the consistent weaknesses in the students who do not perform well in the course is a lack of problem solving skills. This activity will probably get spread over two days to make sure that students develop this critical skill before moving on with additional course material.

For many students the consistent group work in class is a new thing for them. The first few classes, one of the challenges was getting them to pick up the group folder before class, being in their seats, and having the clickers ready at the beginning of class. With practice they are improving. In a class as large as this one, the transition from small group work to large class discussions can be tricky. In this area too I sense some progress in that students are beginning to recognize the need for quiet during large class discussions.

To this point in the semester, the class is going well. Students are attending regularly. In previous semesters, attendance was spotty and I think implementation of clickers has been the real difference in promoting and enforcing attendance. The students seem excited about the group work so far and interactions between groups seem to be slowly increasing. I will be keeping a close eye on student enthusiasm during the semester, but so far it appears to be high.

Prior to each class, students are expected to complete some assigned reading and review activities that serve as prerequisites for that day's session. The material covered in the reading and in the prerequisites is used as a basis for start of class clicker questions. These questions cover some basic part of the reading, such as terminology, or the prerequisites for the day's activity. By asking these basic questions, I can be sure that students know the vocabulary and have a clear understanding of those ideas that serve as background for the day's activity. If there are widespread misconceptions early in the class, I can clear them up with a short mini-lecture before students begin to work. Also, by keeping the questions easy, students are acquiring points each day, which makes them happy. Having everyone on the same page early in the class also helps make the group work proceed more smoothly.

Following the clicker questions, students spend most of the class working in small groups, with the instructor and three TA's acting as discussion facilitators. Each group is responsible for handing in one copy of the activity that reflects the group understanding of the activity. This copy is assessed and returned to the students with comments that are intended to encourage students to refine their thinking and correct any misconceptions that they have quickly. Also, each day a "Reflectors Report is collected. This reflector's report is designed to provide students with an opportunity for them to reflect on their own thinking and to assess how well they worked as a group that day. It is just as important for students to reflect on their own thinking and how their knowledge structure is developing as it is for them to get right answers on an activity.

The clicker questions at the end of class are questions that relate to the material covered in that day's session. By asking these easy questions at the end of class I can evaluate student understanding quickly and see what adjustments need to be made to clear up any student misconceptions at the beginning of next class. As with the beginning of class questions, the questions provide students instant feedback on how they are doing, and because the questions are usually straightforward, students can see themselves acquire points for learning.

In measuring students' work, I separate out assessment and evaluation. The in class activities that the students complete are looked at after each class, commented on, and returned to students but no grade is attached. I refer to this as assessment because no score is attached. The clicker questions are graded for credit and scores are attached. Because scores are attached and it is a part of student grades, I refer to this practice as evaluation. So, each day, students are both assessed and evaluated, but on completely different parts of their work. I read the assessment/evaluation distinction somewhere in the chemical education literature, and it makes sense to me, so I have adopted it.

CLASSROOM VISITS
FOLLOW-UP MEMO

From the class visits by my Marne and Robbie, I have learned a great deal about how things are going in class. The feedback I have gotten from them is valuable and useful. I can say that we are unanimous in recognizing the classroom for the disaster that it is. The optimist in me will always hold out hope that one day we will build classrooms designed for learning, but until that happens I am determined to make the most of the facilities at my disposal. During both visits, at the end of class, it was also hard to hear from the back row. Since I am usually near the podium at the end of class in case I have to write something down, I have tried to get in the habit of turning the microphone on as well as reminding students that class lasts until 12:20 and that everyone in the room is entitled to be able to hear me.

The day Marne visited, the Activity was particulartly difficult (as I knew it would be), and from some observations from her that day and from some of my own, I am more confident that I am getting student buy-in on working in class. I had anticipated that activity taking two days. We got through it as a class in just over three. Because the process covered in that activity is so vital, I wanted to make sure that eveyone understood everything before moving on. Even after the second day, about half of the students had mastered the skill, half had not. Losing half of the class in the third week seemed counterproductive and contrary to the idea of what I am trying to accomplish with learning teams. The observation from Marne is included here as direct quote relating to a conversation she overheard between students: "As they were leaving, one of the women in front of me apologized to her group member for not listening to her when she was trying to guide the group through one of the problems. She commented that she could be stubborn when she is confused, and encouraged her group member not to back down, but to stand up for what she was saying. In other words, I think there was some true process learning going on in that group today, on multiple levels."

Some observations of my own also indicate that the students really are making progress working together in teams. At the end of the third day of the Activity, the student success rate on some questions related to the activity had a correct response rate of about 90%. That is, as slow as it might have been, by the time we were done as a class, 90% of the students could solve problems correctly. Finally, on the day we wrapped up the activity, one difficult problem that required some out of the box thinking was left to be done. Before we went through the problem, students were surveyed, using the clickers, on what they thought about the problem. The possible responses and the percentage replying with each response were:

I can solve the problem and explain it to others:	6%
I could solve it, but not explain it:	8%
As a group, I am confident we could solve it	43%
As a group, we might be able to solve it:	37%
Our group could not solve it:	6%

These results suggest that 80% of the students in the class believe that they are better off and can do more as a group than as individuals. Hopefully, that will set the stage for a good semester and productive group work.

Following the difficulties students had with this activity, I am going to be doing some rewriting on this, similar to what Marne had suggested. In the first part of the activity, students were shown a step-by-step solution to the problem solving and were then asked about the importance of each step. Although students recognized the reason for doing and the importance of each step, when confronted with a problem, they forgot all about the steps and didn't know how to solve the next problems. In the future, this activity will be rewritten so that they asked for each step explicitly before they are even asked for an answer to the problem, Maybe this will make it a two day activity (or at least not three and half days).

Classroom Visit 2

CLASSROOM VISIT 2
PREPARATORY MEMO

In this session, the students will work in small groups to understand and draw the Lewis structures for simple molecules. The concept of molecular structure has been framed around the context of understanding ozone depletion. At the beginning of the chapter, students were shown an image of the ozone hole over Antarctica as well as a short time sequence series of images that measure the size of the ozone hole over the past 25 years. Understanding Lewis structures was presented as a requirement for understanding the science behind the ozone hole.

In previous semesters, Lewis structure have been a difficult concept for some students to master. In the Lewis model for electronic structure, each atom in a molecule must have access to eight electrons. The common misconception for students when they attempt to draw Lewis structures is to leave each atom with only the electrons it originally had. When atoms combine to form a molecule, the number of electrons each atom originally had is secondary to the fact that each atom must have eight electrons in the molecule. I am hoping that by working in groups, students will be able to get past this misconception collectively and better understand Lewis structures.

The makeup of each group is determined by the course instructor, and careful attention (as careful as possible in a class of 150 students) is paid to group dynamics and attendance. If a group is consistently dysfunctional or one member is consistently absent, I will rearrange groups so that each group consists of three reliable members who work together as a team to master course content. With some teaching assistants, I can pay some attention to group attendance and dynamics.

In a large class, keeping control of groups is a challenging but doable feat. At the beginning of the semester, the Math ACT scores for each student were obtained. In the absence of a chemistry placement exam, the Math ACT score is the best predictor of student success in a chemistry class. In reading the literature dealing with group work, there seems to be a general consensus that groups should consist of students with diverse ability. However, in the guided inquiry format I use, and based on discussion with others who use guided inquiry, groups need to be made up of students with similar abilities. That is, after a few classes, the students within a group will figure out who the "smart" student is. Within the group, work will degenerate into the smart student doing the work and everyone else just copying. It starts to look like lecture, just on a smaller scale. In the groups I have set up, the largest difference in Math ACT scores within a group is five (if the lowest score in a group is 18, the highest will be 23). This seems to keep groups actually discussing, not just copying. Although by their own admission, some groups still don't talk enough.

Another issue in setting up groups is the issue of gender. I have set up groups predominantly of single gender, although because of late additions to the class, there are some mixed groups. One reason for this is that in junior high school, middle school and high school, in a group environment, when it comes time to grab a calculator (or piece of equipment), female students will too often defer to male students and let them do the calculations. The result of this is that the female students don't have sufficient calculatorial practice and tend to score lower on the calculations on an exam. If the group is all female, they can't defer and they learn how to carry out the calculations. Also, and less importantly, comments from prior semesters suggest that in single gender groups, there is less chatter and more work. After the second exam I will be completely rearranging the groups and I am considering mixing genders.

Because of the variation in ability between groups, careful attention was paid to where the groups are located in the room. The fixed seating arrangement in the classroom I use makes some groups less accessible than others. Each Monday, the less accessible groups switch with the more accessible groups to alleviate the problem somewhat. In addition, I have made every attempt to keep the groups with low Math ACT scores more accessible (close to the front of the room or near an aisle). I have also spread out the groups with higher ACT scores and surrounded them with groups with lower scores and encouraged discussion between groups, so that the groups that may complete a task slower can seek the assistance of a group that completed the task faster. I have noticed a slight up tick in discussion between groups that leads me to believe this might be starting to pay off.

CLASSROOM VISIT 2
FOLLOW-UP MEMO

The class began (as it does every day) with two clicker questions. The clickers are used to encourage students to show up to class each day, arrive on time, and be prepared. In previous semesters using group work (but no clickers) I have noticed that the clickers are a necessity. In the absence of clickers, it is too difficult to track attendance and impossible to ensure that students show up prepared and on time. The course rule is that students must answer the first and last question to get credit for any of the questions. Also, because the students are placed in an environment where the focus is on group learning, I allow them to discuss (loosely defined) the answers to clicker questions. In a large class I don't think I could prevent it if I wanted. The downside to this is that a student can walk in, have someone tell them "it's B dude" and get credit. The students are unaware of this, but I think those clickers have a range of a couple of hundred feet, so they could even guess from down the hall if they wanted. My main purpose for adopting clickers was to encourage attendance and get everyone there on time at least semi-prepared to that groups work as smoothly as possible, so I am willing to tolerate "it's B dude".

In this class, I have noticed that there are some groups that don't seem to discuss things amongst themselves as they work. I have some theories as to why this might be (ultimately not interested in a 100 level course, afraid to be wrong, afraid of science, too worried about finishing that they don't think they have time to discuss), and have tried to encourage discussion by pointing out that it is OK to be wrong. As they discuss things in a small group and when we discuss things as a large class, an important part of the learning process is for them to recognize their misconceptions and reform their own ideas correctly. On the papers I read at the end of each class, some groups have even commented that they need to discuss things more, but I do not know if they are actually doing it.

I meet once a week (or at least try to) with the TAs to discuss issues such as how the students are doing and how well the activity seemed to achieve my goals for student learning. The observation about the TAs waiting for a question is a good one, and something I will work with them to change. It doesn't seem so unlikely that if the TAs ask more questions of the group, the groups will begin to discuss more amongst themselves. As an aside, the department is also working on adding a practicum of teaching course so that former students can come back into the class and receive course credit for acting as group facilitators and describing their experiences in writing. The goal is to have ten TAs in the classroom and have them in seats to encourage discussion within and between groups. Encouraging discussion is my next goal for improving the course.

I was also pleased with the results of having students work on the board. But, they are really afraid of it. What I have found is that it speeds up discussion, because solutions to exercises can be posted more quickly. I select students to go to the board by looking at their work as I walk around the room. Because I want the students to be more confident in themselves, not less, I look for groups with the correct answer and have them put their work on the board. I am pretty sure that in a 100 level course in a large class, asking students to put up incorrect work and then having to point out that is incorrect would do much more damage than good. Based on the success I had in class one day, I have used it more and will make this a regular part of the course. It also makes the class more active and less passive, which is always a good thing.

In general, I was pleased with how the lesson went. It seemed like by the end of the class, most students had a good grasp on Lewis structures. The questions from the large class are an encouraging sign that students are getting more comfortable in the class and with the class format.

I feel like I should close this memo with a note that may not pertain to the memo directly, but I feel should be included. So far this semester I am extremely happy with how the class is going. The attendance is up. Most of the time, the correct response rate on the clicker questions is about 85%. This suggests that students are showing up prepared because the beginning of class questions are getting answered correctly, and the end of class questions indicate that the individual activities are successful. In the time between the class visit and the completion of this memo, the students took their first exam. I got the impression that a significant fraction of the students were nervous about the exam, at least in part because the class format that is strange to them. The class average on that exam was a 77, the highest average I have ever had on an exam. The students seem happy (so far) and I am pleased with how things are going. In this class, it seems like it is going to be a good semester.

CLASSROOM VISIT 3
PREPARATORY MEMO

In this class students will work in groups to understand the physical phenomena that makes certain compounds soluble in water. This will be the last activity in a series that has focused on the unique chemical and physical properties of water. The activities completed related to this material have focused on calculating and expressing the concentrations of aqueous solutions, investigation of the nature of the chemical bonding within a water molecules, and the physical interactions between water molecules. This activity will combine ideas from those activities with the aim of developing a conceptual understanding of the forces which affect solubility of a compound in water. As has been the case all semester, students will work in small groups, with the instructor acting as a discussion facilitator.

Until recently, students have been working in the same group they were placed in at the beginning of the semester. Following the second (of four) exams, group assignments were completely changed. Because the success of guided inquiry hinges on the participation of every group member, groups have been assigned based on exam performance. Students are placed in a group with two other students of similar ability (or at least similar exam performance). In most every case I have seen, in groups where there is a wide range of abilities, the smarter (or more dominant) students will complete the activity while the others just watch. Work just gets completed faster, but without any real understanding taking place. In addition, students rapidly develop a sense of which student is "smart", and if any discussion does take place, the other students will automatically defer to the smart student, limiting the effectiveness of debate between group members.

FOLLOW-UP MEMO

It seems that as the semester has progressed, students are becoming more comfortable working in groups. They have been continually reassured of their progress by giving them exam averages and comparing those averages to previous semesters. This comparison is highlighted in detail in Appendix 4 of this course portfolio. They have after some initial adjustment, adapted to being placed in new groups, and students have commented that they like the new groups better.