Abstract - On average, about 1-in-2 of the students who take the general chemistry course do not pass. Comparable DFW% in the remaining courses of the Chemistry program lead to a cumulative 85-90% DFW percentage for chemistry majors. The remarkably low pass percentages clearly reveal that the needs of a significant number of students are going unmet. Our hypothesis was that implementation of an increased number of learning modes for the students would increase the pass percentage for the course as well as creating better students.

Body - The first year of chemistry represents a major hurdle for the undergraduates at the University of New Orleans. The course serves a diverse set of students with typical class sizes ranging from 250-450, depending upon the semester. The UNO undergraduates are not traditional students who are matriculating upon their high-school graduation, instead half of the student body is over the age of 25 and many of the students have families and/or established careers. Within the College of Sciences, 30% of the students are African-American; however, less than 7% of students in Chemistry are African American\(^1\). The entrance requirements for the first year chemistry course are an ACT score of at least 19 or completion of pre-calculus algebra. An analysis of the pass/fail statistics from the last four years revealed that the percentage of students earning a passing grade has ranged from 35-55%. On average, about 1-in-2 of the students who take this course, do not pass. Comparable statistics in the remaining courses of the Chemistry program lead to a cumulative passing rate of 10-15% for chemistry majors. The remarkably low pass percentages clearly reveal that the needs of a significant number of students are going unmet. Our hypothesis was that if we increased the number of learning modes for the students, we could increase the pass percentage for the course as well as creating better students.

In response to the ‘No Child Left Behind’ Act, expectations of Louisiana students\(^2\) leaving 12th grade chemistry include basic mastery of

- Measurement and Symbolic Representation
- Atomic Structure
- The Structure and Properties of Matter
- Chemical Reactions
- Forces and Motion
- Interactions of Energy and Matter

In an effort to determine how much the students know prior to completing the general chemistry course, and thus provide a benchmark for determining how much they learn through the semester, students took a diagnostic exam on their first day of class. Questions were based upon the grade level expectations of 12\(^{th}\)-grade chemistry and results showed that about 50% of the students had mastered 70% or more of the represented material. From this data, we concluded that a significant percentage of students entering general chemistry lack the basic, necessary understanding of chemical concepts when they enter the course. The result also implied that significant work would be required in the recitations to level the skills of the class. We conjectured that such leveling would be possible if we used a greater number of learning modes within the course.

\(^1\) Office of Data Management, Analysis and reporting, UNO, 1999-2005
\(^2\) Louisiana Department of Education, Division of Standards and Assessments. Grade Level Expectations, 2004-2005
There are three learning modes: kinesthetic, visual, and auditory. Kinesthetic learning modes involve manipulation of objects, such as molecular models, to reveal and/or develop deeper understanding of the subject. Alternatively, visual learning modes involve linking abstract concepts to objects that students already understand; for example, students plot the speed of molecules versus the temperature to understand heat and molecular motion are linked together. Auditory learning often finds the students listening for the key information about a subject and then processing it into a tangible understanding. Students learn most effectively in an environment where multiple learning modes are presented for the subject\(^3\). Within a lecture, students often miss the larger issue of the presentation as they primarily depend upon one learning mode – writing notes. To increase the number of learning modes available to students in the general chemistry course, the Chemistry Department obtained a grant from the University of New Orleans Office of Student Technology to create a Chemistry Learning Center (CLC, http://www.uno.edu/~clc/CLC.html). The CLC implements a network of tools designed to engage the students. Molecular models, a wireless network of laptop computers that serves ~400 students/semester, and a room designed and furnished to foster student interaction provide the essential elements to the CLC. The final cost for this investment in infrastructure worked out to be less than $60/student•year. The CLC now supports mandatory recitations for the general chemistry course and establishes a learning-friendly environment for accomplishing inquiry-based learning. Multiple learning modes are accessed with the help of

- Blackboard integration with the text (visual and auditory modes)
- Molecular models kits, graphical analysis (visual and kinesthetic)
- Interactive, inquiry-based group activities with deep-probing questions (visual and auditory modes)

These three components utilize combinations of the learning modes and are used in a recitation-dependent fashion. The determining factor for deciding which mode to use is often the class demographics. For example, if the class is composed of mostly visual learners, then the auditory and kinesthetic are used in a supplementary fashion to enhance the learning experience. To quantify the effectiveness of a recitation, assessments are given pre- and post-recitation to track the educational gains, or losses, by the students. The assessments have proven to be effective in identifying both individual and class-wide problems with the material. The challenge of maintaining the records for such a large group of students is significantly reduced through Blackboard integration. As much as possible, automation was used for assessments, homework, and exams. The resulting free-time was then used to focus on teaching methodologies that demonstrate for the students how to evaluate and analyze information.

A significant challenge for the recitations has involved balancing the demands of the students versus those of the material. Students often want the teaching assistants to show them ‘how to solve the problem’ while the teaching assistants are being told by instructors that they should be illustrating how to analyze and evaluate information. The most pressing question becomes, “How is inquiry synthesized into a process-based (problem solving) course?” We have identified four hurdles, and our solutions, to merging inquiry into a learning-friendly environment:

<table>
<thead>
<tr>
<th>Problem</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation</td>
<td>Students require proof that the subject is relevant to them.</td>
</tr>
<tr>
<td>Knowledge base</td>
<td>Diagnostics provide direction for decisions regarding less plans.</td>
</tr>
<tr>
<td>Analytical skills</td>
<td>An interactive environment creates a minimum threshold for active learning.</td>
</tr>
</tbody>
</table>

Resistance to learning

Develop strategies that engage the students within the recitation

General chemistry is at the foundation of the chemistry curriculum, but for the non-majors who make up the majority of the class the material’s relevance is not readily apparent. Presently, routes for clarifying the material’s relevance are being evaluated for effectiveness. As mentioned previously, the knowledge base of our students varies substantially. Using computer-administered diagnostics allows the teaching-assistant to make quick changes based upon the outcome. One of the advantages of an environment that uses multiple learning modes is that students will learn at least some of the material and this can be quantified through the diagnostics which show pre-/post-recitation understanding of the lesson. Finally, a significant fraction of the students resist learning either actively or through apathy. To overcome this problem, groups have been created to establish in-class competitions, ‘Jeopardy-like’ game shows have been employed to increase student participation, and multi-dimensional problems have been used that require the strengths of different individuals.

The success of these efforts has been modest; an increase in the passing percentages has been observed, but not beyond the variance of the pass/fail data from the last four years. Analysis of the diagnostics and the student feed-back does provide a mechanism for improving the recitation and CLC; however the student feed-back highlights the difficulty of synthesizing inquiry into a process-based course. In an effort to create an environment which focuses upon the scientific method, the Chemistry Department has submitted a plan to the National Science Foundation that would re-structure the first two-years of the chemistry program. The re-structuring would establish inquiry-based, hypothesis-driven courses linked across lecture, recitation, and labs.

Office of Data Management, Analysis and reporting, UNO, Spring 2005

The Author would like to acknowledge the Student Technology Fee Project (#STF-31-SCI-2) for funding the creation of the CLC