CASE STUDY: UNIVERSITY OF TEXAS AT DALLAS

Instructor: Gregg R. Dieckmann, Associate Professor of Chemistry John W. Sibert, IV, Associate Professor of Chemistry

Academic Objective: To foster continuing development of chemistry skills and understanding for introductory chemistry students

To improve course pass and student retention rates

Academic Background and Challenge:

The University of Texas at Dallas (UTD) is a young, dynamic research institution on the cutting edge of science, technology, engineering, business and the arts. Founded in 1961 as the Graduate Research Center of the Southwest, an outgrowth of technology giant Texas Instruments, UTD fosters a strong tradition of academic excellence. UTD became part of the U. T. System in 1969, offered only graduate degrees until 1975, and admitted its first freshman class in 1990. Today, it ranks at or near the top in the number of computer science degrees awarded each year in the United States.

UTD offers more than 125 academic programs across its seven schools, offers an array of interdisciplinary degree programs, and features a student population as diverse as its areas of study. With a current enrollment of more than 14,000 students, 29 research centers, and a world-class faculty that includes two Nobel laureates, UTD aims to provide Texas and the nation with the benefits of educational and research programs of the highest quality.

In 2008, UTD completed the development of a comprehensive five-year Quality Enhancement Plan (QEP) to significantly enhance student learning on the UTD campus. Developed as an important component of the Southern Association of Colleges and Schools (SACS) reaffirmation process, the QEP looks to the future to leverage the best faculty thinking and community support to deliver an unrivaled academic experience for UTD students.

Thus, in response to local and national data on student performance and engagement in math and science courses, UTD created Gateways to Excellence in Math and Science (GEMS). GEMS is a comprehensive plan to enhance the quality of student learning in mathematics and science by providing students with innovative, intensive, and active learning experiences both inside and outside the classroom. At the core of GEMS is the design and implementation of a series of interventions that target improving student success, retention and persistence in gateway science, technology, engineering and mathematics (STEM) courses. The decision to target gateway courses stemmed, in part, from consideration of ongoing studies conducted for several years by the dean of undergraduate education. These studies revealed problems in student performance in introductory math and science courses, and some troubling patterns concerning students' persistence in, or migration from, STEM courses and academic programs – and even continuation of their college careers.

While poor student performance in gateway STEM courses has been well documented at the national and international levels, this challenge is magnified at a STEM-intensive university like UTD. A large percentage of UTD students are required to take chemistry and/or calculus for their degree programs. Thus, it's critical to their ultimate academic success that they not merely pass these gateway courses, but finish with a very solid foundation of understanding.

"We were being charged with educating more students, more effectively – and measurably – at a reduced cost."
Dr. John Sibert

Formally stated, the overall objectives of GEMS are to provide a foundation and locus for sustainable faculty and administrative activities that:

- Increase student retention in science, technology, engineering, and mathematics (STEM) fields
- Decrease the number of "D" grades, "F" grades, and withdrawals (DFWs) in STEM classes
- Create supportive, engaging learning opportunities

General Chemistry with ARIS: Pilot Program History and Goals

UTD has just begun the implementation phase of GEMS with a variety of interventions for gateway STEM courses, including:

- Curriculum alignment and realignment
- Course redesign
- New course design
- The introduction of new modes of curriculum delivery
- Faculty development

Though diverse in nature, the interventions share one common goal: increasing student engagement, which is essential to meeting learning objectives and boosting students' mastery of course content in problem-solving oriented disciplines like mathematics and science.

According to UTD Associate Professors Gregg Dieckmann and John Sibert, "increasing student engagement opportunities" and "tapping into student curiosity" were their primary goals when they started discussing re-structuring CHEM 1311 (General Chemistry I, the first semester of a two-semester course sequence) in the summer of 2008. The department had already begun the course re-design process back in 2000, with an eye to "normalizing" course content and delivery across multiple instructors. Now, however, Dieckmann and Sibert focused their attention on interventions to boost student engagement specifically, to "provide a richer experience, allowing students to be validated in a field in which they've demonstrated curiosity, ability, a need to simply use course content in relevant applications, or some combination thereof."

At the same time, other factors forced Dieckmann and Sibert to seek instructional and administrative efficiencies. A jump in projected CHEM 1311 student enrollments coupled with fewer instructors assigned to the course, meant the fall 2008 course sections would nearly double in size in comparison to previous years' offerings. So instructors would face enormous challenges not only in engaging lecture audiences of unprecedented size, but in creating homework, and administering and grading quizzes and tests in a timely and efficient manner.

Sibert observed, "We were being charged with educating more students, more effectively – and measurably – at a reduced cost." Sibert noted that while one response to this challenge might be to lower academic standards to "game" the results, UTD would never compromise its academic integrity in this manner, remaining committed as ever to maintaining the academic rigor for which UTD is well known.

CHEM 1311's instructional format had varied slightly over the years, but typically consisted of:

- Lecture – 3x/week for the 15-week semester
- Weekly lab
- Print textbook, plus homework assigned from the back of the textbook – students complete by hand; not graded or corrected
- Weekly in-class quiz – short, 2-3 question quiz, hand-graded by instructors
- Optional review sessions, led by undergraduate Supplemental Instructors (SIs)

Dieckmann and Sibert's search for a solution that would increase student engagement opportunities while also delivering significant administrative efficiencies led the instructors to consider implementing a technology-based assignment and course management solution like ARIS. Most importantly, they were confident that their multi-tasking, self-directed "Net Gen" students would embrace such a digital learning solution. As Sibert observed, "This isn't 'technology' for students, it's only technology for those who were born before it was developed (i.e. instructors). This is just how these students live."

"This isn't '*technology*' for students…This is just how these students live."
Dr. Gregg Dieckmann

At the same time, an ARIS-like tool would create efficiencies and save time for instructors who were serving record numbers of students.

After reviewing the available textbooks, as well as assignment and course management systems on the market, Dieckmann and Sibert (as part of a team of six general chemistry instructors at UTD) adopted the McGraw-Hill textbook *Chemistry* (Julia R. Burdge) and ARIS for its pilot program in its two fall 2008 sections of CHEM 1311.

Their selection of the ARIS system was based on the following rationale:

- Digital format plus intuitive interface engages "Net Gen" students
- Efficient for instructors – large database of homework-style questions means instructors don't have to create – or grade – assignments or quizzes by hand
- Assignment efficiencies mean instructors can create lengthier assignments/quizzes – so students get more work/practice in a subject where students learn by doing
- Integration with the course's McGraw-Hill textbook

To add another important student engagement opportunity to CHEM 1311, Sibert and Dieckmann also decided to add optional weekly 90-minute Peer-Led Team Learning (PLTL) workshops, conducted at UTD's new GEMS Math and Science Success Center. PLTL sessions, a core component of the GEMS initiative, created small groups of 6-8 students, who formed a learning community where learning and success are a shared endeavor. Trained undergraduate student leaders (who performed well in the class previously) facilitated the PLTL workshops, where students learn to integrate course content and study skills working together.

The Chemistry department's objectives for the pilot program were:

- Increase student engagement in CHEM 1311, with ARIS and PLTL workshops
- Use ARIS (quizzes) to improve student learning outcomes – as measured by mastery of student learning objectives as well as course grades
  - Support struggling students but also enhance concept mastery of successful ("A" and "B") students
- Raise course pass and student retention rates

CHEM 1311 with ARIS: Pilot Program Design

- Fall 08 semester – General Chemistry I, CHEM 1311, a 15-week one semester course – (CHEM 1311 is the first semester of the two semester general chemistry sequence)
- 600+ total students enrolled
- 2 sections – (4 sections in fall 07) – results in section size increase to > 300 students
- Instructional format:
  - Three 50 minute lectures per week – Same as historical course format, but with twice the number of students in attendance per section
  - One lab per week
  - ARIS pre-quizzes and quizzes
    - Pre-quiz–10 to 15 questions – or 3x the previous number – 3 to 4 per section of material. Students can take as long as they need to complete; can take unlimited times on any computer (not proctored). An added benefit of the pre-quizzes was that students, through repeated access, became much more familiar with the ARIS platform in a "low stakes" assessment.
    - Quiz – 4 to 6 questions – a representative subset of the pre-quiz material – proctored in newly created Math and Science Success Center. Students can take as long as they need to complete; can take only once
    - 28 total assignments (14 pre-quizzes, 14 quizzes) over the course of the semester
    - 200 total questions/problems for students to solve, versus roughly 50 in prior course format

Results included "Significant improvement in…student performance on [the] American Chemical Society's standardized first semester general chemistry final exam."

- Sibert noted that this pre-quiz and quiz format "helps provide the redundancy necessary for students to become successful in math and science."
- Homework – still assigned from the back of the book – instructors' approach is to use ARIS pre-quizzes, quizzes and review content to build students' problem-solving skills sufficiently so that they can solve the book problems independently – the "true test of content mastery."
- ARIS Online Review – Students could also spend an unlimited amount of their own time on ARIS, reviewing course content and previously-submitted homework assignments.
- 90-minute weekly PLTL workshop of 6-8 students. These sessions were optional in that interested students chose to participate. However, once in PLTL, they were required to attend all semester.

Pilot Program Results:

Dieckmann and Sibert, in addition to an independent UTD assessment team, conducted post-course analysis of student performance data for the two sections of CHEM 1311 in the fall 08 semester – with the recognition that the course structure remains an evolving model, as much was learned during this first semester. They determined, based on independent learning outcome metrics, as well as historical data points, that the ARIS and PLTL workshop interventions achieved the desired objective of boosting student achievement in CHEM 1311. They also anticipate better optimization of the various interventions in future semesters to maximize their positive contributions to student learning outcomes. Their data analysis revealed:

Quantitative and Qualitative Impact:

- Increased Student Engagement:
  - Students completed/solved more than 200 total questions/problems, in some cases, multiple times with ARIS over the semester. This represents more than 4x the number in the previous course format.
  - Sibert observed that "ARIS created the opportunity to discuss course content with students throughout the semester. Students would try to work problems on their own, get the wrong answer, and then come to see me, saying 'there's a problem with ARIS.' Well, the problem typically wasn't ARIS, but the student, who'd made a mistake. This dynamic forced students to come see me, their instructor, to talk about chemistry. These conversations would not have taken place without ARIS."
- Improved Student Learning Outcomes:
  - Significant improvement in student mastery of core concepts (greater than 10% improvement in some areas) as measured by student performance on American Chemical Society's standardized first semester general chemistry final exam
    - Independent measure of students' mastery of core general chemistry concepts
    - Fall 08 students performed much better on midterm and final exams than previous students–instructors did not need to 'curve' exam grades, as in past
  - Increase in number of "A/B" grades; decrease in number of "D/F" grades.

Future ARIS Plans

The UTD Chemistry department is currently using ARIS in CHEM 1311 and 1312 (General Chemistry II) and would like to use it in the future in downstream courses as a tool to provide remediation and assessment opportunities for chemistry foundations.