Active Learning in General Chemistry: The Mechanics of a Gateway Course Redesign

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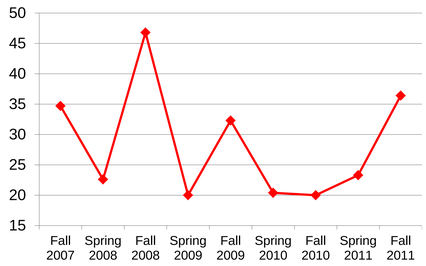
THE REDESIGN TEAM: UNM: K. Joseph Ho (Team Leader) ***Stephen Cabaniss***, ***Sushilla Knottenbelt***, ***Sarah Toews Keating*** *(GA)*, ***Christopher Larsen*** (GA) **CNM:** ***Clarissa Sorensen-Unruh***, ***Shaorong Yang***.

THE MOTIVATION FOR COURSE REDESIGN

General Chemistry II serves as a gateway course for majors in science and engineering, providing an introduction to intermolecular interactions, chemical equilibria, reaction kinetics, thermodynamics and electrochemistry. It is required by 4 of 5 engineering departments and by all A&S science degrees.

About 900 students at UNM and 400 at CNM enroll in this class per year. It has made the UNM 'killer course' list 8 out of the last 10 semesters, with the percentage of students not succeeding and hence unable to progress in their STEM field ranging between 20% and 40% (Fig. 1). The large enrollment lecture environment often results in, at best, knowledge transfer and passive learning.

Fig. 1: Percentage of students NOT succeeding in General Chemistry II by semester



Students do not have the time or opportunity in class to construct their own concepts and ask questions. Too often, students are alone at home when they must apply the most challenging material in the course. Students struggle with the pace of the course, the sheer volume of material covered, the mathematics needed to apply the material, the impersonal nature of the large lecture hall with little interaction among all members of classroom and the often very abstract nature of the course material. The aim of our redesign was to address these issues and improve student success and engagement with course material.

GOALS

- **Revise learning outcomes** to coordinate with skills and competencies needed in STEM majors requiring General Chemistry II.
- **Incorporate active learning** in the classroom in order to convert traditionally taught lecture courses into learner-centered environments
- **Develop interdisciplinary exercises** pitched at higher cognitive levels to provide a strong basis for student engagement and deeper learning.
- **Assess student, class and re-design performance** via multi-component measures of student learning and student opinions on how the class structure facilitates their own learning.

COMPONENTS OF THE REDESIGNED COURSE

Before class

Structured reading assignments, quizzes and 'muddy point' questions (where students reflect on the reading)

In class

Resolution of 'muddy points'
Peer learning facilitators (PLFs)
Application-based worksheets
Clicker questions based on common misconceptions

After class

Online homework to practice, integrate and synthesize information

All course materials were developed using a 'backwards design' approach: chosen to enable students to engage with and master the course learning outcomes

TIMELINE

Summer 2012

PLANNING AND COURSE MATERIAL DEVELOPMENT

- Finalize Course Learning Outcomes (CLOs)
- Establish website to facilitate communication, resource sharing and development of materials
- Pre- and post-test implementation and analysis
- Collaborative development of instructional materials in two working groups
- Trial of certain redesign features in classes by Ho and Sorensen

Fall 2012

PILOT IMPLEMENTATION

- UNM test group CHEM 122-004: 32 students, Yang
  Traditionally taught control groups CHEM 122-001 and 002, 145 and 83 students. CHEM 122-03 was a fully online course.
- CNM test group CHEM 1810 hybrid: 48 students, Sorensen-Unruh
- Assessment and feedback loop

Spring 2013

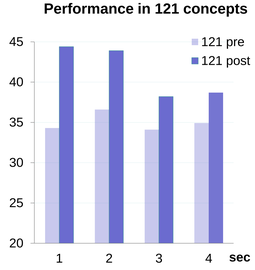
ALL GENERAL CHEMISTRY II SECTIONS AT UNM TAUGHT WITH REDESIGNED COURSE

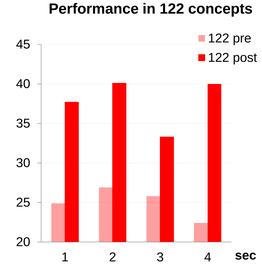
CHEM 122 002: 250 students, Knottenbelt
CHEM 122 003: 122 students, Yang
CHEM 122 004: 34 students, Luilo
CNM: CHEM 1810 hybrid: 48 students, Sorensen-Unruh
CHEM 1810 face-to-face: 48 students, Sorensen-Unruh

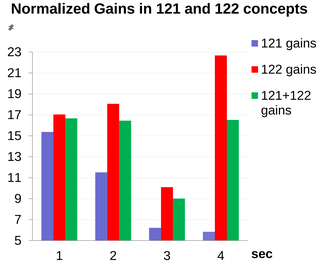
ASSESSMENT STRATEGY FOR FALL 2012

- A chemistry concept inventory was designed and given to all students in CHEM 122 as a pre- and post-test during the lab check-in and check-out. The test results were analyzed for student's concept learning.
- The Colorado Learning Attitude in Science Survey (CLASS) was also given during the lab check-in (CLASS I) and check-out (CLASS II). The results of the two surveys were analyzed for students attitude change toward chemistry.
- All face-to-face sections of CHEM 122 took a common final exam based on course learning outcomes (CLOs) written by faculty not teaching the course in this semester. Section 1 and 2 were traditionally taught control groups, Section 4 was the redesigned test group with an active learning approach. The results of the final exam have been used as a summative measure of achievement of CLOs.

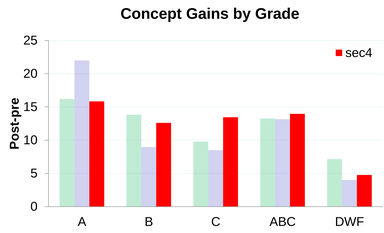
CONCEPT LEARNING

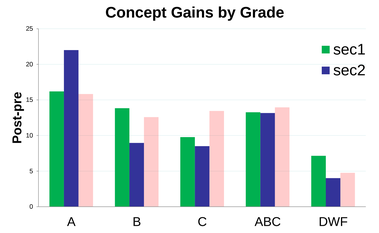




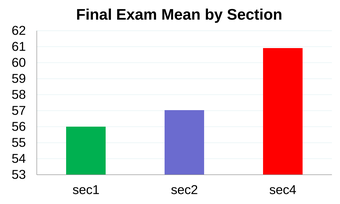


MORE DATA

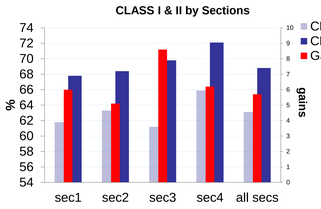




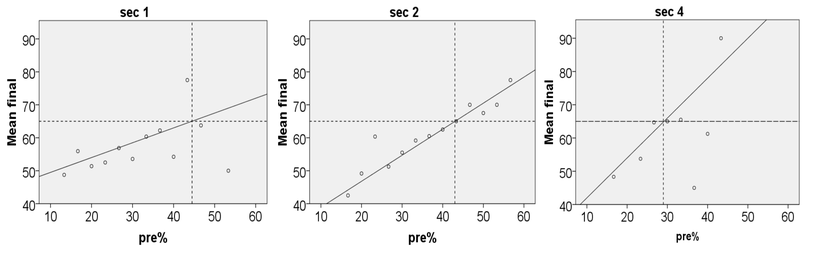
- Active learning brings similar concept gains to all students with a passing grade.



Students in the active learning section have a higher average score on the common final exam than the students in the traditionally taught sections.



Students in the active learning section have a higher average score on the Colorado Attitudes to Science Survey (CLASS) than in the traditional sections



CONCLUSIONS AND RECOMMENDATIONS

- Course redesign using active learning shows a positive effect on student performance.
- Students show good tolerance to the adaptation of the active learning approach
- The first-day of class is crucial for student to buy-in to the active learning methodology, and provides students necessary training of unfamiliar learning skills.
- The practical training for instructors who have no or little experience in learner-centered teaching should be required prior to the semester of their teaching
- A good assessment plan is necessary for summative and informative evaluation of student learning progress. An independent pre- and post - concept inventory test is recommended.