Assessing success of a gateway course redesign

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Authors: the above, David Keller and Gregory Smith
Why Redesign General Chemistry?

Student success, attrition and the WDF rate
Consistency within and across institutions
Enthusiasm and engagement
Real comprehension versus algorithmic problem-solving
How was the redesign achieved?

What resources are required?
How is success to be evaluated?
Maintaining initiative
People
Overview

Session 1
- Course redesign proposal scope
- Timeline
- Design strategies and platform
- Key elements of course design (example materials)
- Assessment data
- Faculty experience
- Resources
- Lessons learned and summary

Session 2
- More detailed assessment data
- Looking ahead
- Active learning and your institution/class
Course redesign proposal scope

- Specification of measurable learning goals
- Rigorous objective assessment of student achievement of goals
- Implementation of teaching methods to maximize achievement of the specified goals, that are consistent with empirically established results and principles
- Means for easy dissemination and duplication of materials, methods, and technology
- Sustainable and continued optimization based on results of assessment

- Faculty-driven + graduate student
- UNM and CNM
- Duration of 1 academic year and 2 summers
- Department commitment to extend scope
# Course redesign timeline

<table>
<thead>
<tr>
<th>Activity</th>
<th>Summer 2012</th>
<th>Fall 2012</th>
<th>Spring 2013</th>
<th>Summer 2013</th>
<th>Fall 2013</th>
<th>Spring 2014</th>
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<tr>
<td><strong>Strategy and Material development</strong></td>
<td>CHEM 122</td>
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<td>CCI 121 and 122 CIF 122</td>
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<td>Evaluation of CHEM 122 data</td>
<td>CCI AND CIF, 121 and 122</td>
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CHEM 121 and 122 = General Chemistry I and II. CCI = chemical concept inventory; CIF = Common Independently Written Final exam.
Design strategies and platform

- Two-day course design workshop (OSET)
  - Revising learning outcomes to coordinate with skills, competencies needed in STEM majors
  - Brainstorm general active-learning, learner-centered techniques

- Weekly meetings
  - Course policies, assessment approach(es)
  - Identify topic-specific active-learning materials
  - Organize materials centrally
  - Online discussion and resource-sharing (pbworks)
1. Explain the *Origin of* intermolecular forces; evaluate their relationship with *molecular size, shape, physical properties* and explain phase changes using *heating curves and phase diagrams*. Know Bragg's law and understand unit cells and packing efficiency (HED Area III no. 2)

Click on one of the following links to view or edit the questions:

**Bullet Points**
- Intermolecular forces - origin and relative strength
- Intermolecular forces - relationship with molecular size, shape and strength
- Intermolecular forces - relative strength of surface tension, viscosity, phase cohesion
- Changes of state - States of matter and molecular processes
- Changes of state - Heating curves and the enthalpy of transition
- Changes of state - Clausius-Clapeyron equation and graph
- Changes of state - Supercritical fluids and the critical point
- Changes of state - Phase diagrams, key features and phase changes
- Changes of state - Unique properties of water
- Solids - Types of solid states and their relative properties
- Solids - Unit cells and basic structures: calculation
- Solids - Determination of geometry using X-ray diffraction
- Solids - Band-gap theory and application in semi-conductors

**SK Question:** 6/6. Regarding Joe's question about the solid state not being expressed in the CLO explicitly, I wanted to get consensus as to the level of detail we will be going into for the solids section. Last semester, I gap theory or X-ray diffraction very much. This is an area I am finding a little difficult to find nice relevant examples - does anyone have any useful resources or ideas as to where to go with this? I think this could be an interesting area to dive into and I think springing might be a good time to do so. I also believed that it was most important to try to communicate the critical basic concepts of IM forces and phase changes in more detail.

**SK Comment:** 6/6 - I have now found several interesting resources to engage students in the area of the solid state and introduction to materials. I will try to work some of these up and have them ready by the meeting. KHo I have a book: general chemistry for material science students that I will bring to the meeting.

**Summary**
- Summary of objectives, etc.

**Pre-class questions (including the muddiest point questions)**
- Assorted Pre-Class Quiz Qs
- More Pre-Class and In-Class Exercises
- Pre-Class Quiz Qs
- [Extra Preclass Assignment Questions.docx](Extra%20Preclass%20Assignment%20Questions.docx)

**Clicker questions**
- Assorted clicker questions (includes all that were uploaded as of 6/15/12)

**In-class activity questions**
- IM Forces
- Intermolecular forces in action and heats of vaporization in-class exercise
- Phase Equilibrium and Intermolecular Interactions
- PHASE EQUILIBRIUM CONCEPT TEST
- Solid state structures worksheet in-class exercise
- CLO ICEs
- Joe's class slides
Design strategies and platform

- Two-day course design workshop (OSET)
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- Implement and assess
  - Weekly meetings during the term
  - Measures of student learning, student/instructor opinions

refine
Major Themes of the Redesign

**Interactive Learning**
- Doing, discussing (in-class exercises, clickers)
- Experiential, inquiry, problem solving
- Actual, simulated
- Usually Social (peer learning facilitators)

**Reflective Learning**
- Minute papers, free-writing, portfolios, journals
- Synthesis of main ideas (homework)
- Metacognition (muddy points)
- About the subject and/or learning process
- Usually solitary

**Acquiring Information & Ideas**
- Reading primary texts and textbooks (+ reading quiz)
- Listening to lecture
- Accessing information/ideas in class, out of class, online

The Learning Strategies Triangle (modified from Fink, 2003)
An example of the difference between traditional lecture and the redesigned course

Traditional classroom? Active learning classroom?
Traditional and Redesigned Course: Phase Diagrams

- Pressure
- Temperature
- Solid
  - Sublimation Curve
    - sublimation
    - deposition
- Liquid
  - Fusion Curve
  - melting
  - freezing
  - normal melting pt.
- Gas
  - Vapor Pressure Curve
  - normal boiling pt.
  - sublimation
  - deposition
  - vaporization
  - condensation
- triple point
- critical point
Redesigned Course: Phase Diagram

Pre-class assignment: We will be covering sections 11.6 to 11.9 in class. To be prepared for class, read and make notes, by the start of class, you should be able to:

1. use the terms sublimation, deposition, boiling, condensing, melting and freezing correctly to describe the appropriate phase transitions.
2. Identify the main regions, lines and points in a phase diagram.
3. Determine the phase changes that occur from any point in a phase diagram when specified changes are made to temperature and pressure.

Pre-class quiz: What phase/s is/are present when the temperature is 50 degrees Celsius and the pressure is 6 atm?

a. solid
b. liquid
c. gas
d. solid in equilibrium with liquid

Muddy point: What did you find most difficult or most interesting about the assigned reading?

‘What is happening on a molecular level when a supercritical fluid exists?’
In-class assignment:

Compare the water phase diagram with other common phase diagrams that undergo normal melting and vaporization, what are the major differences

What happens at the ice blade in ice skating? Explain with the phase diagram of water.

Carey is a geologist and uses carbon dioxide to extract an organic compound from a rock bed. He carried out the experiment at a pressure of 74 atm and 320 K. What phase of carbon dioxide is Carey using? Why would this phase be particularly useful as a solvent?
Redesigned Course: Phase Diagram

Part B

The phase diagram for an organic compound is shown.

What is the normal boiling point of this compound?

Express your answer as an integer and include the appropriate units.
Traditional and Redesigned Course: Phase Diagram

Traditional classroom?  Active learning classroom?

- Remembering
- Understanding
- Applying
- Analyzing
- Evaluating
- Creating
Assessments

• **Concept Inventory** – pre- (2\textsuperscript{nd} week) and post- (16\textsuperscript{th} week) and the normalized gains are calculated. \([\text{post-pre}/(100-\text{pre})*100]\]

• **Independently written final exam** – week 17

• **Course grade** – homework, midterm and final exams, class attendance, clicker questions.

• **Core questions for midterm exam** – assessment of CLOs
Assessment:
Mean Concept Gains in 121

- **Pre**: 40.30
- **Post**: 44.92
- **Gains**: 12.29

Comparison:
- CHEM 121 Fall12 vs Fall13
Assessment:
Mean Concept Gains in 122

CHEM 122
Fall12
Fall13
Assessment:
Mean Concept Gains in 122

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<th>pre%</th>
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CHEM 122

spring12

spring13
**No Significant Changes in Final Exam for 121**

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### Slight Improvement of Final Exam for 122

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A Decrease of Performance in Grades for 121

Pre-Reformed (3 semesters) vs. Fall 2013

Grades:
- A: 27.4% vs. 28.6%
- B: 30.4% vs. 30.4%
- C: 19.4% vs. 16.3%
- D: 7.0% vs. 9.8%
- F: 5.7% vs. 5.6%
- W: 10.1% vs. 12.6%
- ABC: 77.2% vs. 71.9%
- DWF: 22.8% vs. 27.9%
Also a Decrease of Performance in Grade for 122

CHEM 122
- previous 3 semesters
- Fall 12
- spring 13
- Fall 13
Why Different Trends?

- **Passing Grade %**
- **Final Exam %**
- **Concept Gains**

Timeline:
- Spring 12
- Fall 12
- Spring 13
- Fall 13

First Redesigned Class
Why Different Trends?

- Passing Grade %
- Concept Gains
- Final Exam %

First Redesigned Class

spring 12 | fall 12 | spring 13 | fall 13
Teacher-centered teaching results in little intervention in student’s grades.

Performance Gains by Grade
CHEM 122, Fall 2012
The redesigned section showed more uniform gains in CLASS survey than non-redesigned sections.
Assessments of Course Learning Outcomes

CHEM 121

SLO 1: Apply the mole concept to amounts on a macroscopic and a microscopic level and use this to perform stoichiometric calculations including for reactions in solution, gases and thermochemistry. (Addresses UNM/HED Area III, Competencies, 2, 4)

SLO 2: Describe the ways in which atoms combine to form molecules (ionic and covalent) using different bonding models. Apply knowledge of electronic structure to determine molecular structure, geometry and hybridization. (Addresses UNM/HED Area III, Competency, 4)

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Assume a beaker of pure water has been boiling for 30 minutes. What is in the bubbles in the boiling water?

1. Air.
2. Oxygen gas and hydrogen gas.
3. Oxygen.
5. Heat.
Studies of Misconceptions

• Assume a beaker of pure water has been boiling for 30 minutes. What is in the bubbles in the boiling water?

1. Air.
2. Oxygen gas and hydrogen gas.
3. Oxygen.
5. Heat.
Faculty experience
Evaluating the redesign: instructors’ perspective

- Learning curve
- Attendance
- Engagement
- Achievement
- Classroom environment
- Time management
Direct Quotes from New Redesign Faculty

• “One challenge is getting some of the students to seek help from the TA or instructor within the time allotted for the exercise” rather than waiting until the time is up.

• “The biggest challenge for me, compounded by being a new instructor, was time management.”

• “Having the strong faculty community and pre-prepared materials available for modification was invaluable…”

• “When prepping for the first semester of teaching 121, I found using all of the redesign a bit overwhelming, so I decided to pick and choose, and gradually add pieces in over several semesters.”

• “Talking/writing forces students to organize their thoughts...and encourages articulation of concepts…”
Required Resources

- Teaching Assistant – large class
- Peer Learning Facilitators
- A course management system – to host reading quiz and muddy points
- An online homework system
- Classroom response system (Clicker) – in-class assessment
- Weekly faculty (study) meetings – lesson study
- More paper – for worksheets
Give It A Try

• You don’t have to plan for a big change
• Observe an active learning classroom (if possible)
• Give yourself plenty of time to plan
• Let your students know how it works (in detail!)
• Don’t expect a quick result right away
• Don’t expect that you’ll like it right away either!
• Find a community group to join for support
• Reevaluate frequently to see what’s working and what isn’t working
• Communicate with administrators often
Part II

Session 1
Course redesign proposal scope
Timeline
Design strategies and platform
Key elements of course design (example materials)
Assessment data
Faculty experience
Resources
Lessons learned and summary

Session 2
More detailed assessment data
Looking ahead
Active learning and your institution/class
More detailed assessment data
Midterm Exams %

- low exam score, low homework score
- high exam score, high homework score

Homework %

- low exam score, low homework score
- high exam score, high homework score
Looking ahead

• Do active learning strategies of this reformed approach adequately prepare students to be successful in the next science courses?
• Does the reformed approach benefit a special group of students?
• How to extend the scope:
  – helping faculty new to active-learning to implement it
  – Sharing our experience in other courses and or disciplines
Course redesign possibilities for your institution/class

• Resource of course material for active learning
• Faculty development
• Lesson study/community groups
Summary

• Two general chemistry courses at UNM using active (student-centered) learning strategies have been developed by teams of faculty.
• Preliminary data show significant concept gains.
• No significant change of DWF rates during the first implementation of redesign.
• Longitudinal studies are needed for the effectiveness of the redesigned approach.
Acknowledgements

The STEM Gateway Program
Dr. Gary Smith