UNM | Department of Chemistry & Chemical Biology

STEM GATEWAY

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

Activity	*Summer 2012*	*Fall 2012*	*Spring 2013*	*Summer 2013*	*Fall 2013*	*Spring 2014*
Strategy and Material development	**CHEM 122**	**refining**		**CHEM 121**	**refining**	
Pilot		**CHEM 122 test and control**			**CHEM 121 4 sections**	
Scale-up			**CHEM 122 All 4 sections**	**CHEM 122 1 section**	**CHEM 122 3 sections**	**CHEM 122 4 sections CHEM 121 3 sections**
Assessment	**Development of CCI**	**CCI 121 and 122 CIF 122**	**CCI AND CIF, 121 and 122**	**Evaluation of CHEM 122 data**	**CCI AND CIF, 121 and 122**	**CCI AND CIF, 121 and 122**

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 Brag 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 b Spring we found the time to be quite tight for this CLO and 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 meet KHo I have a book: general chemistry for material science studednts 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

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
- CLO1 ICEs
- Joe's class slides

Comments (0)

Design strategies and platform

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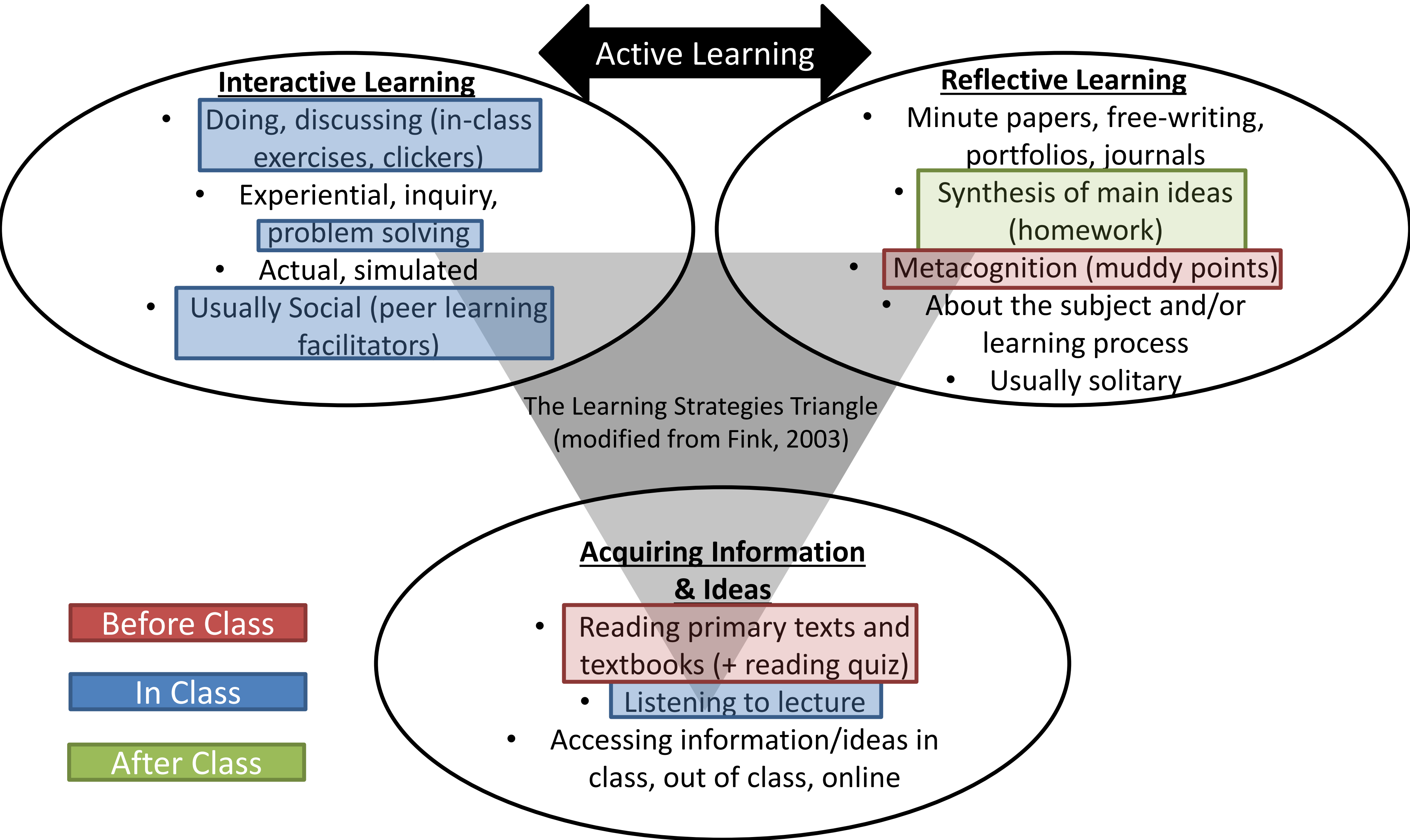
  - Identify topic-specific active-learning materials
  - Organize materials centrally
  - Online discussion and resource-sharing (pbworks)
- Implement and assess
  - Weekly meetings during the term
  - Measures of student learning, student/instructor opinions

refine

Major Themes of the Redesign

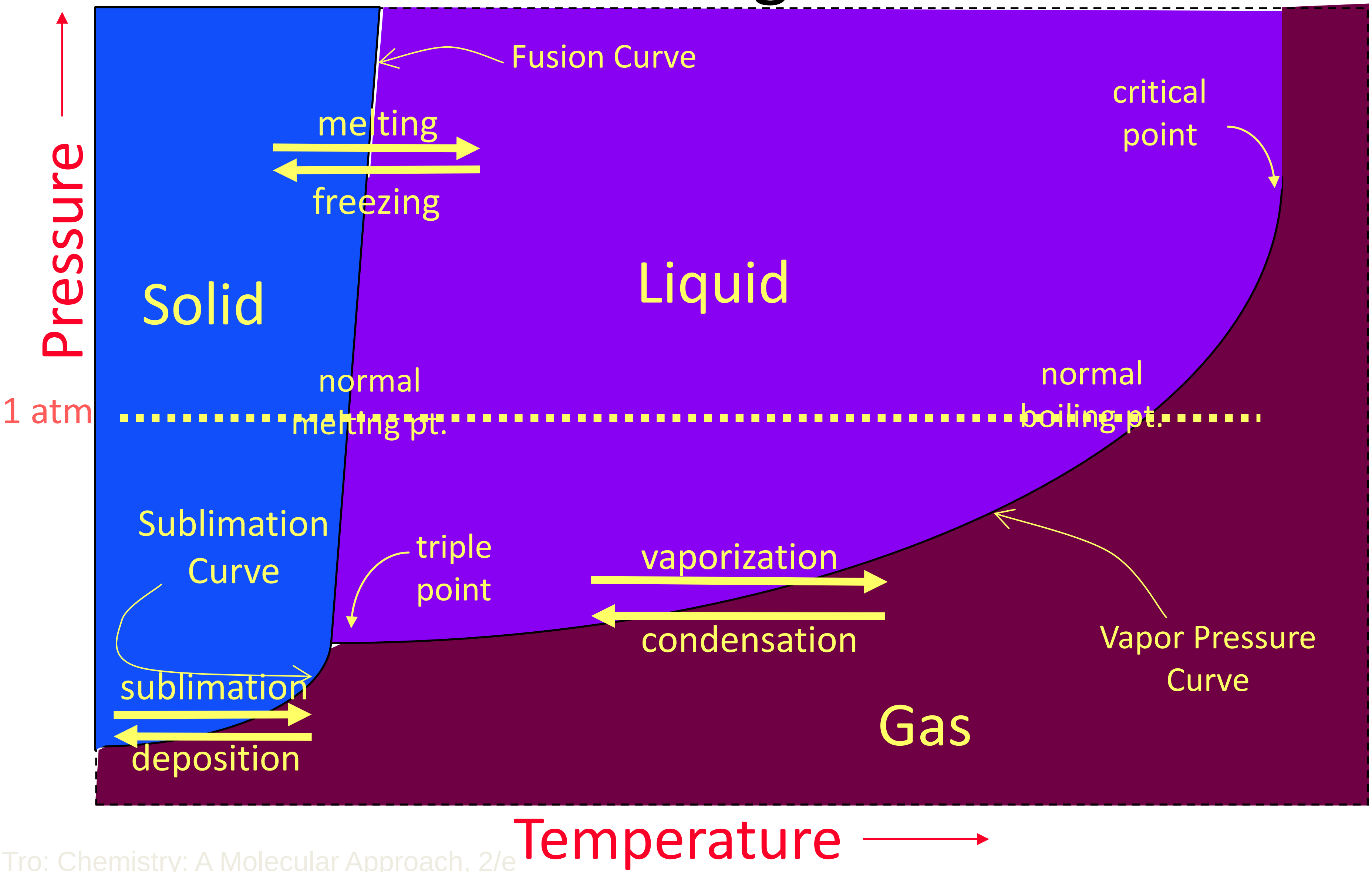


An example of the difference between traditional lecture and the redesigned course

Traditional classroom?

Active learning classroom?

Traditional and Redesigned Course: Phase Diagrams



Redesigned Course: Phase Diagram

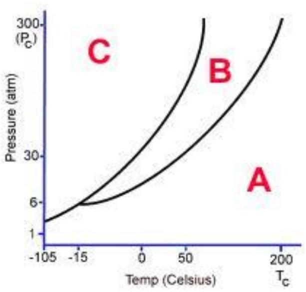
Pre-class | In class | After class

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?'

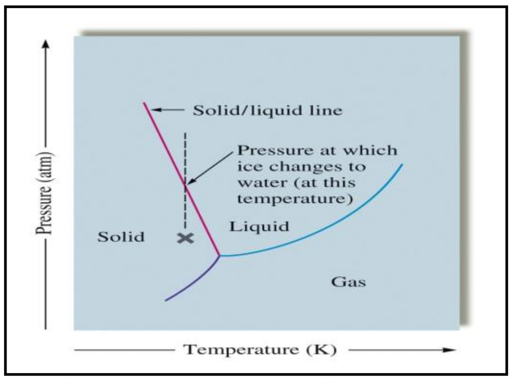
Redesigned Course: Phase Diagram

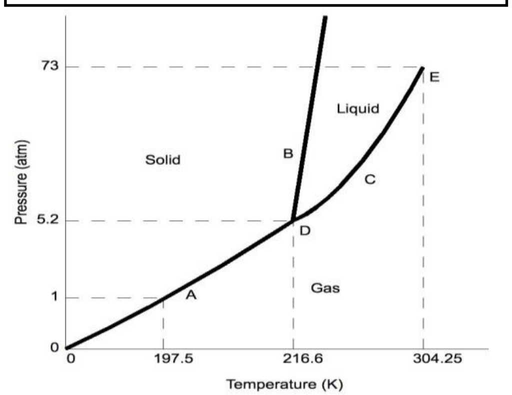
Pre-class

In class

After class

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.

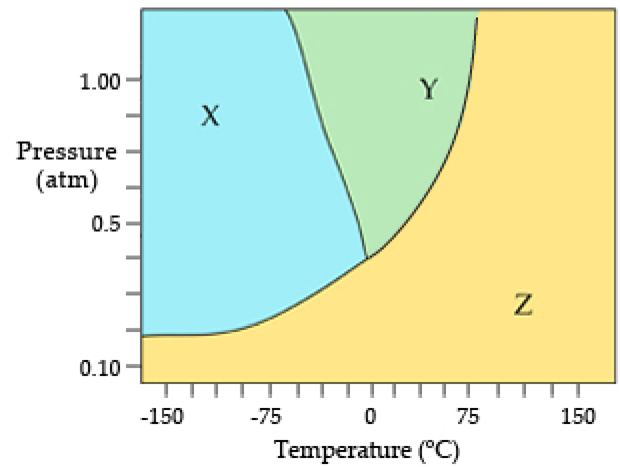
Carey is a geologist and uses carbon dioxide to extract an organic compound from a rock bed. He carried out the experiment at a pressure of 74 atm and 320 K. What phase of carbon dioxide is Carey using? Why would this phase be particularly useful as a solvent?

Redesigned Course: Phase Diagram

Pre-class	In class	**After class**

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.

normal boiling point = Value Units

reset shortcuts ? help

Traditional and Redesigned Course: Phase Diagram

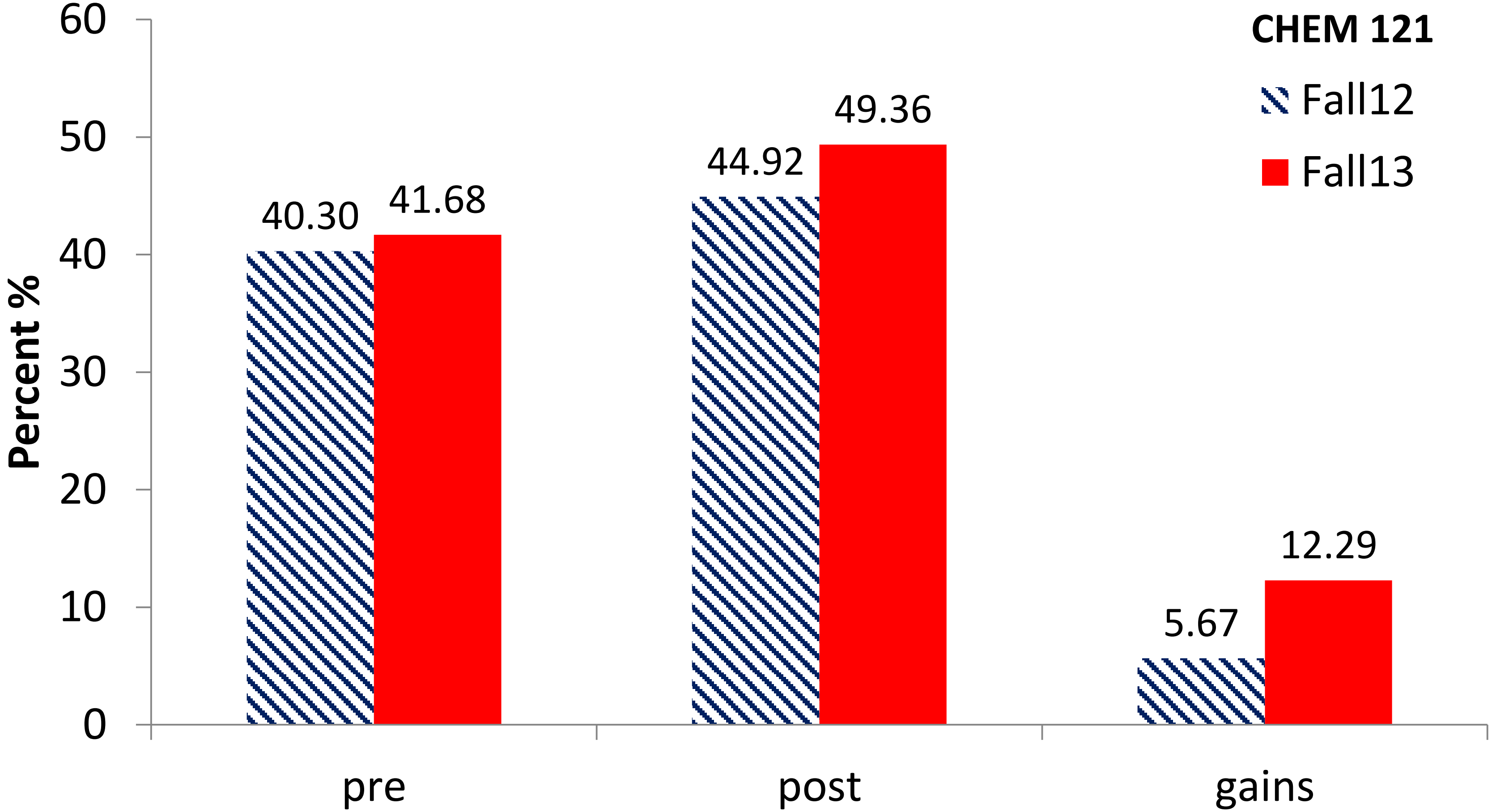
Traditional classroom?

Active learning classroom?

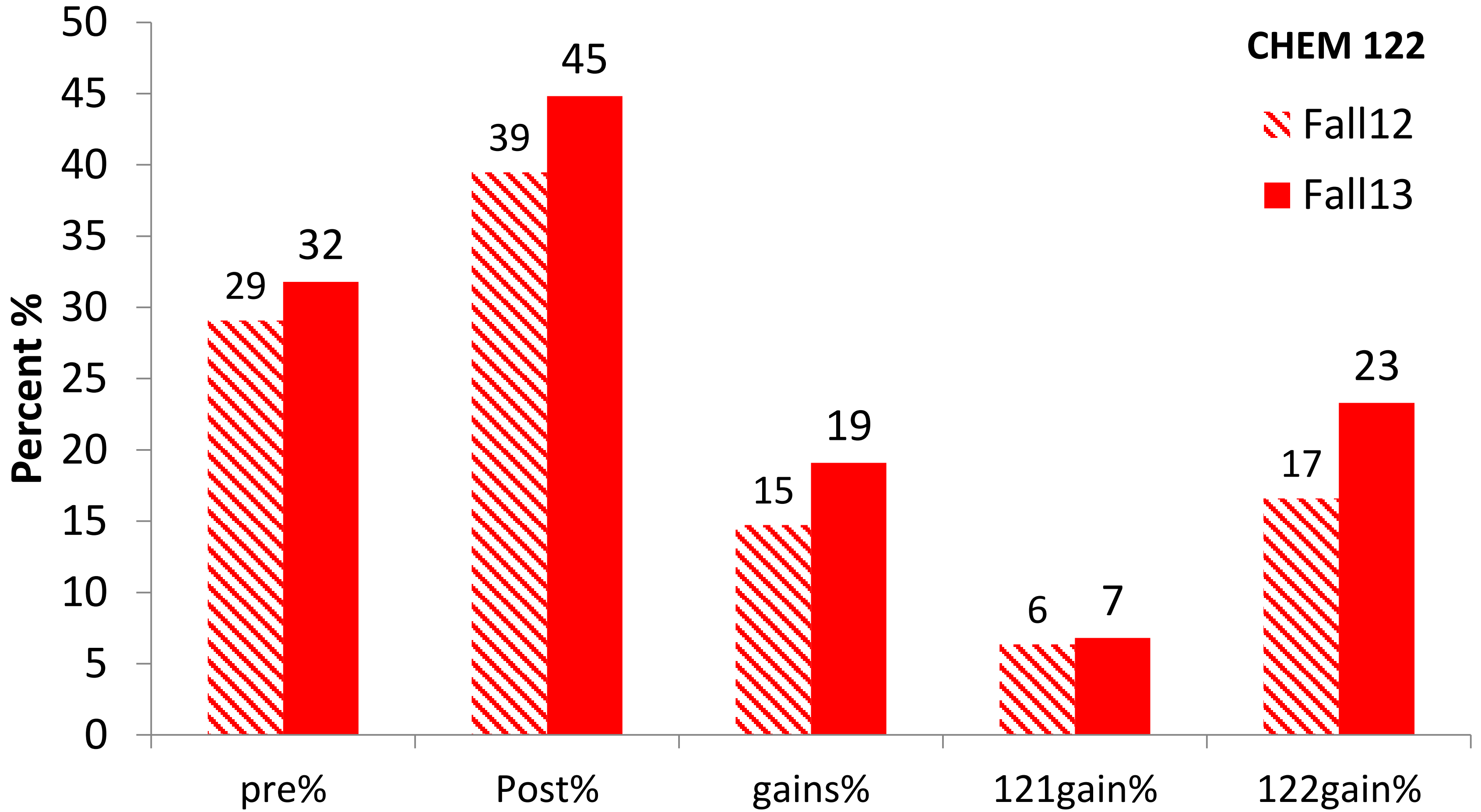
Assessments

- ***Concept Inventory*** – pre- (2nd week) and post- (16th week) and the normalized gains are calculated. [post-pre/(100-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

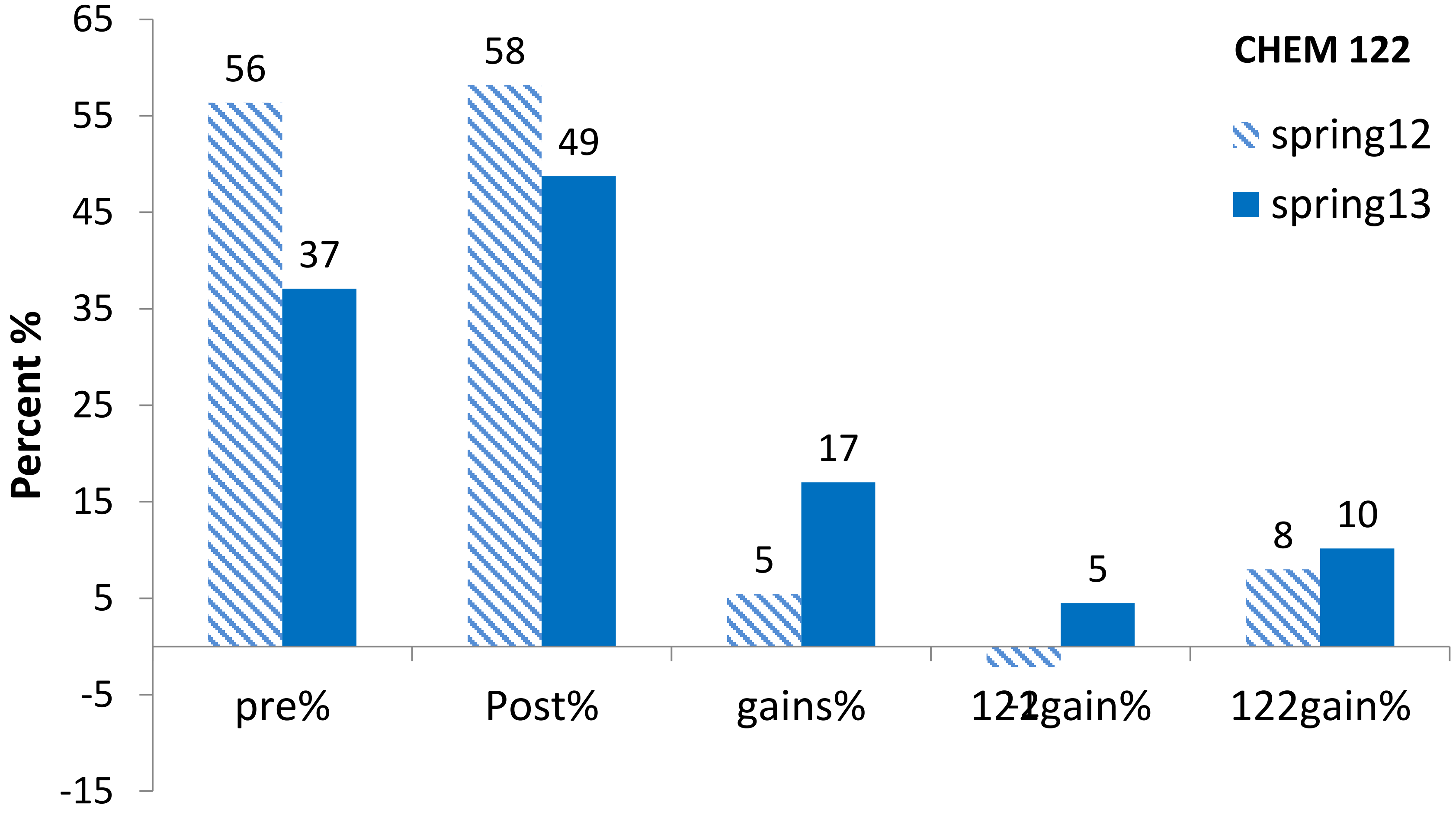
Assessment:
Mean Concept Gains in 121



Assessment:
Mean Concept Gains in 122



Assessment:
Mean Concept Gains in 122



No Significant Changes in Final Exam for 121

Spring13	Chem121 Final Exam		
	1	**2**	**Mean**
Final	64.03	64.28	64.16

Fall13	CHEM 121 Final Exam						
	1	**2**	**3**	**4**	**5**	**6**	**Mean**
Final	57.95	60.93	69.56	65.03	65.68	66.08	64.21

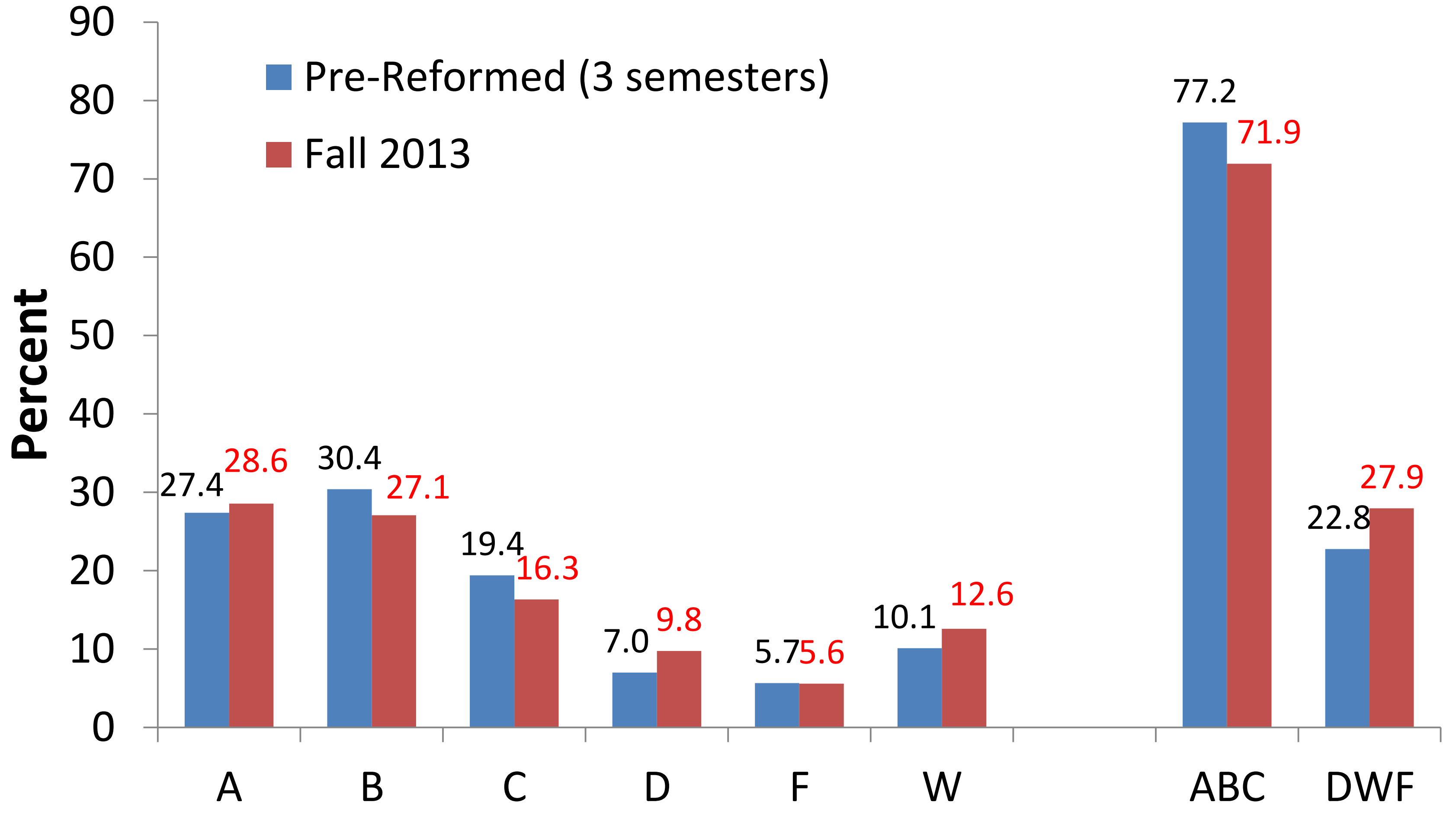
Slight Improvement of Final Exam for 122

Fall12	**CHEM 122 Final Exam**		
1	2	4	mean
56.005	57.03	60.92	$\boxed{57.98}$

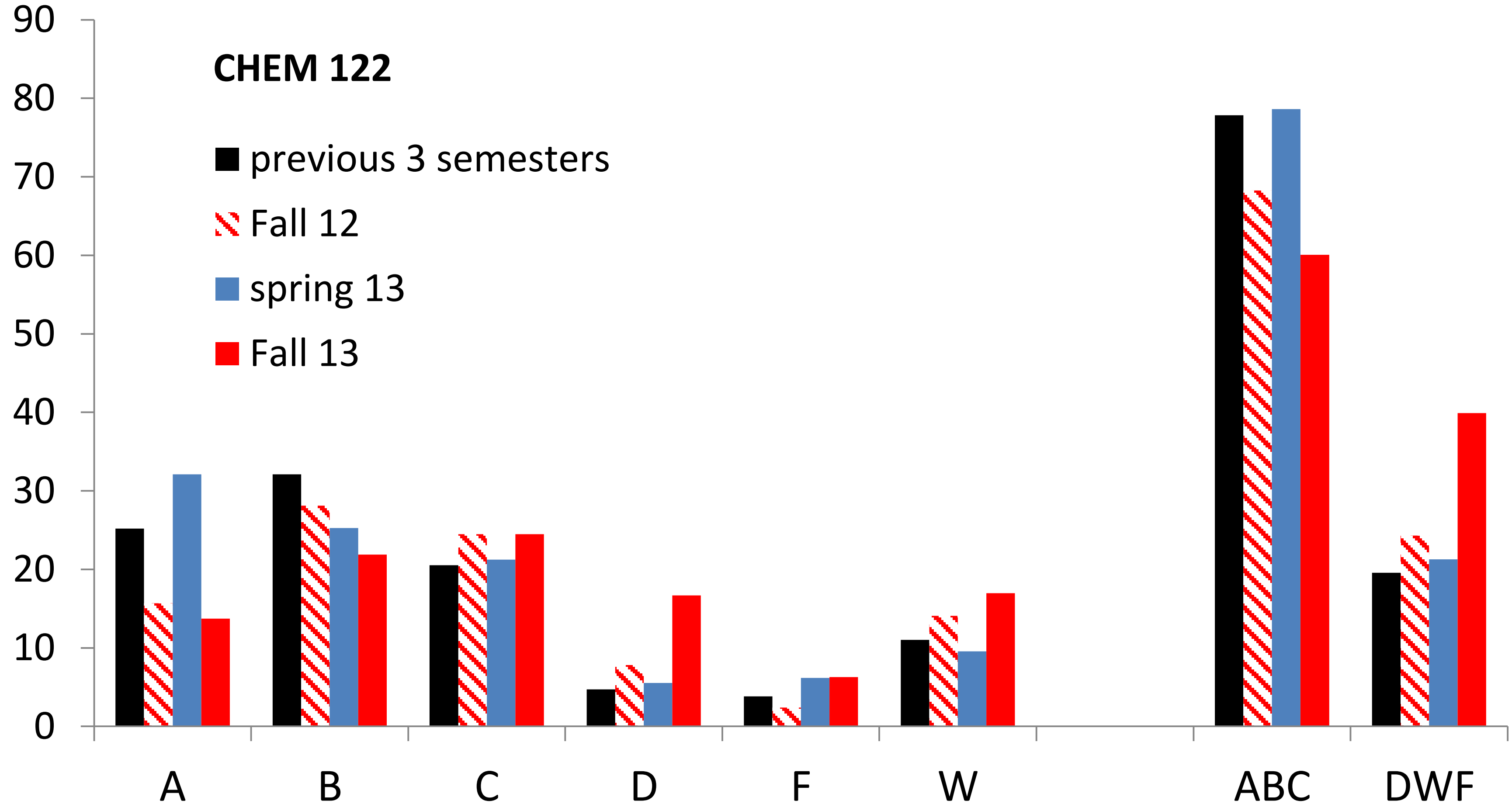
Spring 13	**CHEM 122 Final Exam**			
1	2	3	5	mean
58.91	66.43	60.48	72.81	$\boxed{64.66}$

Fall13	**CHEM 122 Final Exam**		
1	2	3	mean
62.17	60.53	61.62	$\boxed{61.44}$

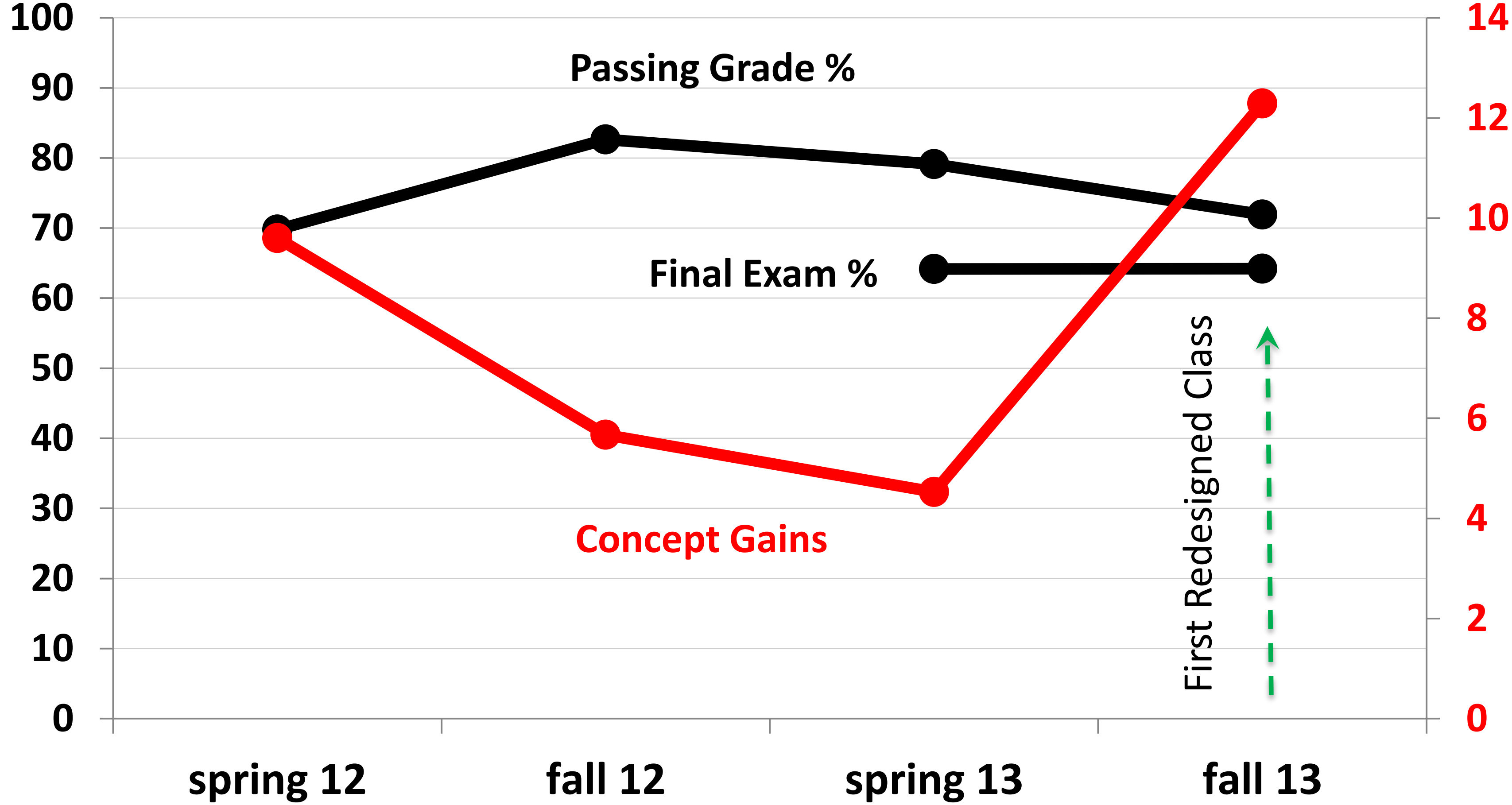
A Decrease of Performance in Grades for 121



Also a Decrease of Performance in Grade for 122



Why Different Trends?



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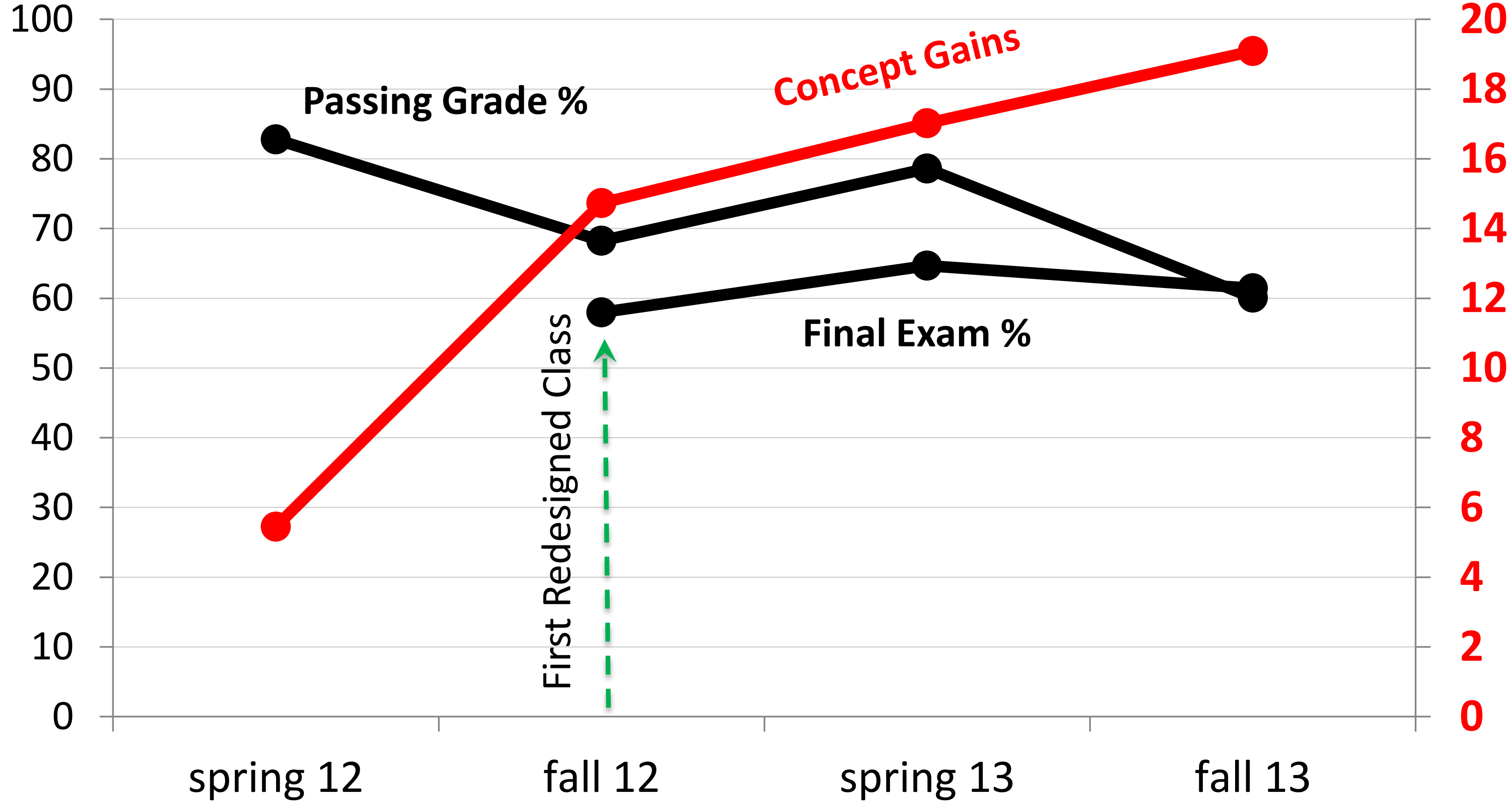
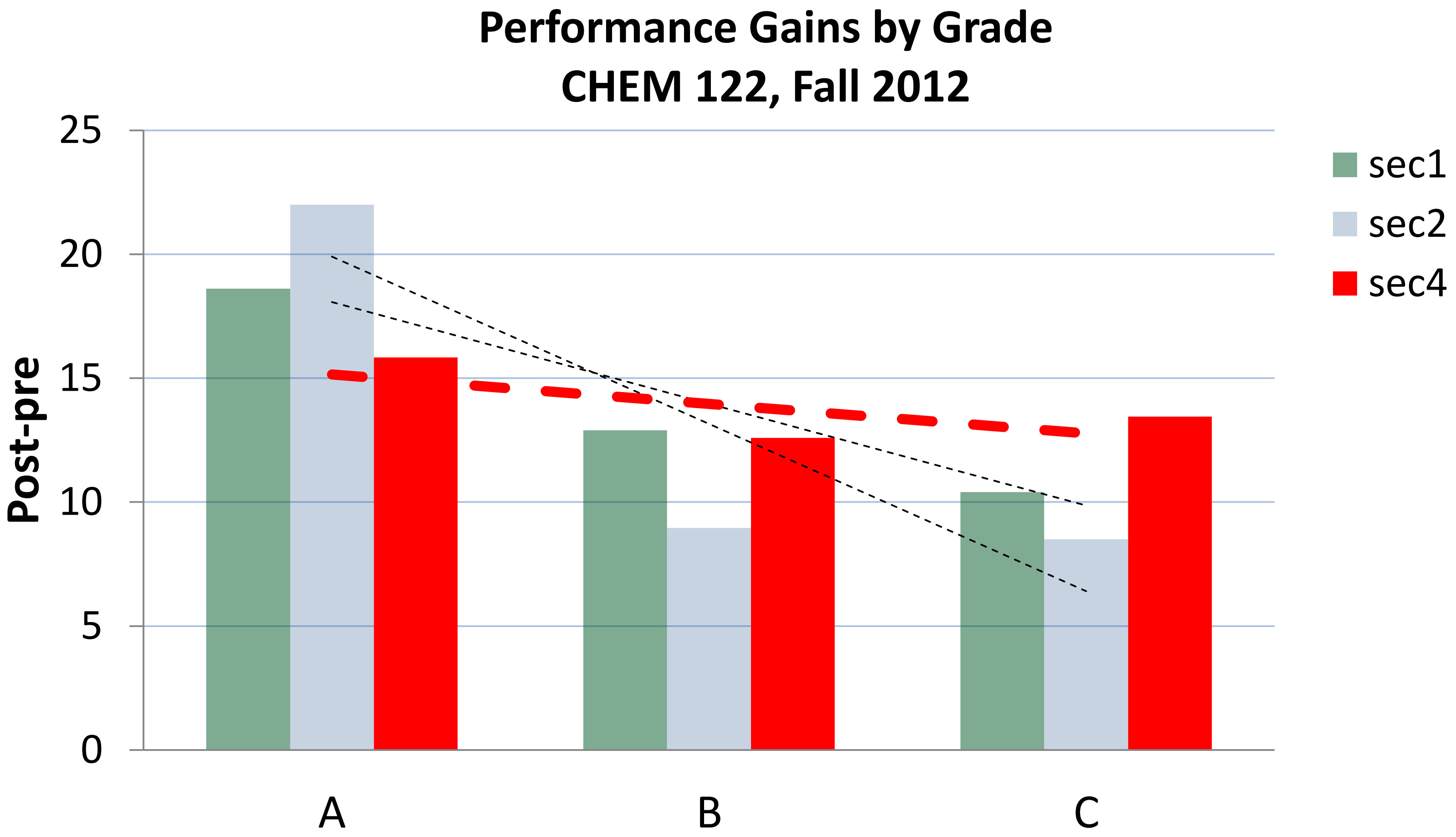
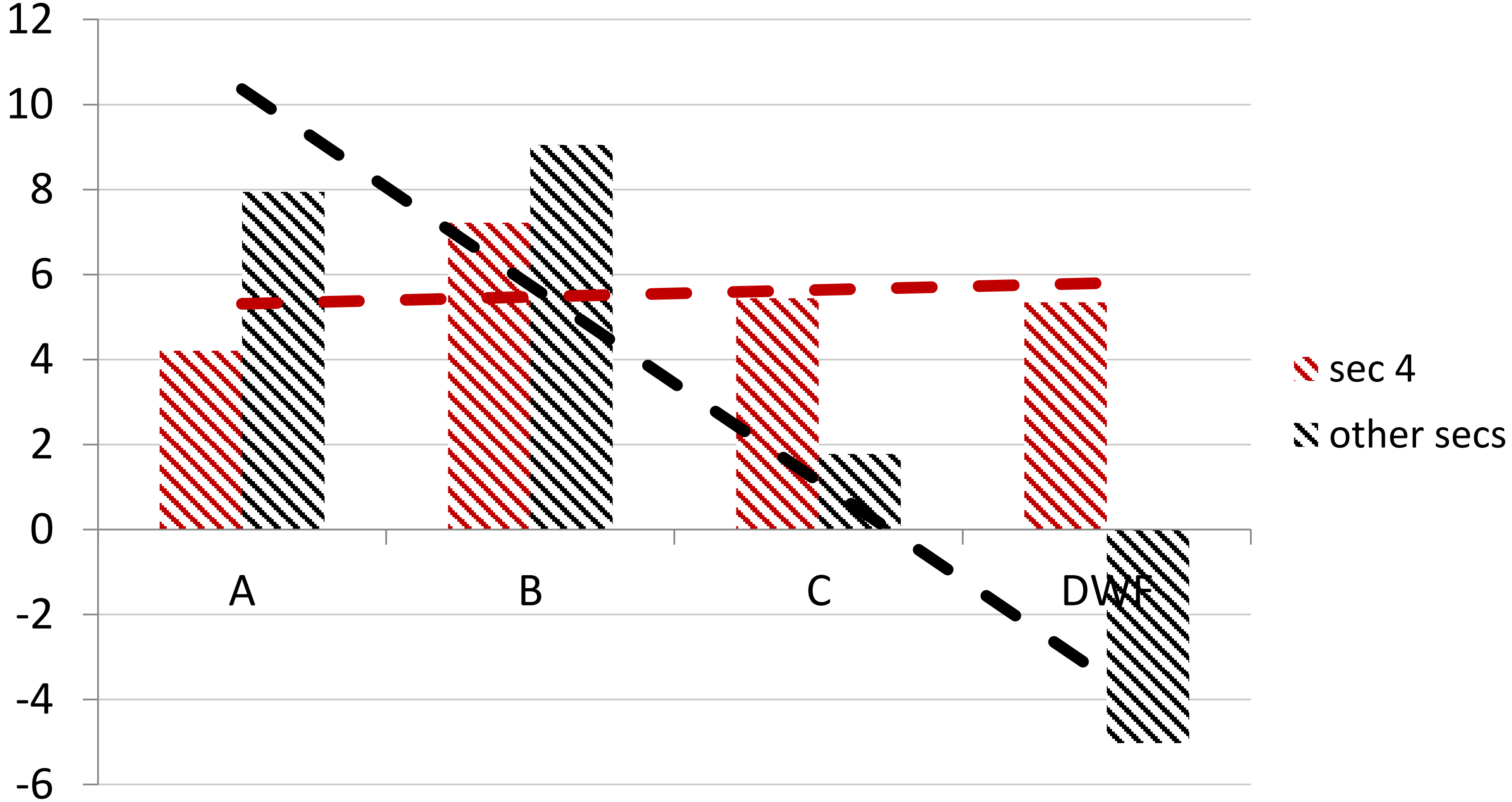


Teacher-centered teaching results in Little intervention in student's grades



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)

Sec	Q1.	Q2	Q3	Q4	Q5	Q6	Q7
1	38.1	54	60	61	81	46	57
2	42.4	40.9	68.2	61.1	78.41	55.6	69.9
3	56.0	68.6	68.6	92.1	96.1	64.6	87.8
4	36.4	47	61	74	79	52	77
5	62.6	74.6	64.8	74.8	86.8	56.4	71.4
6	39.9	60.0	70.6	56.7	88.1	49.1	61.4

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.
    4. Water vapor.
    5. Heat.

Studies of Misconceptions

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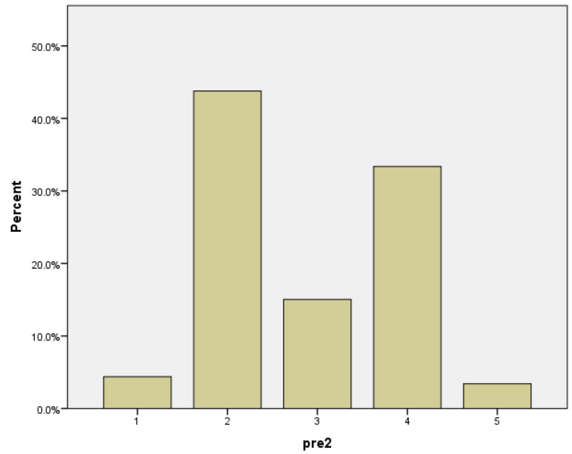

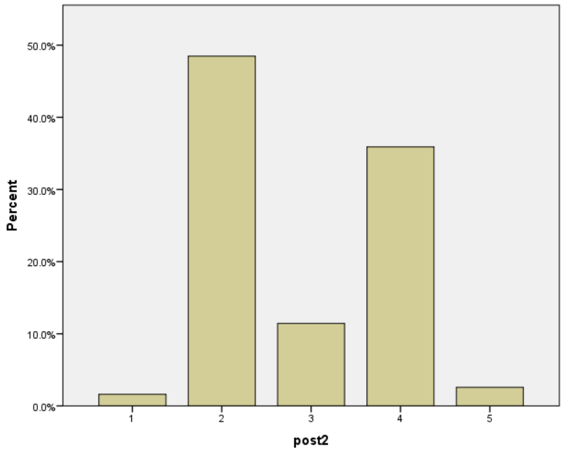

Faculty experience

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
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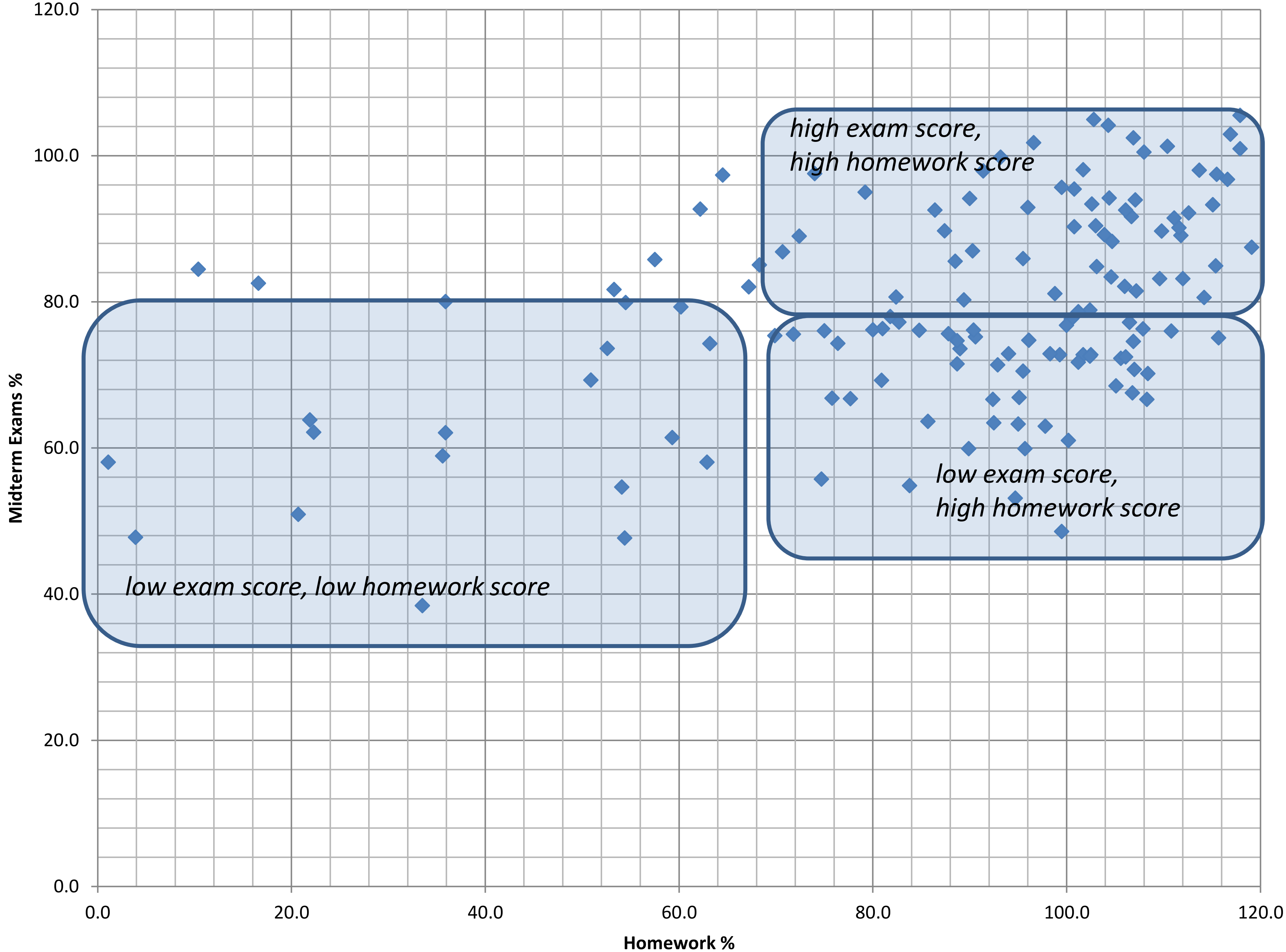
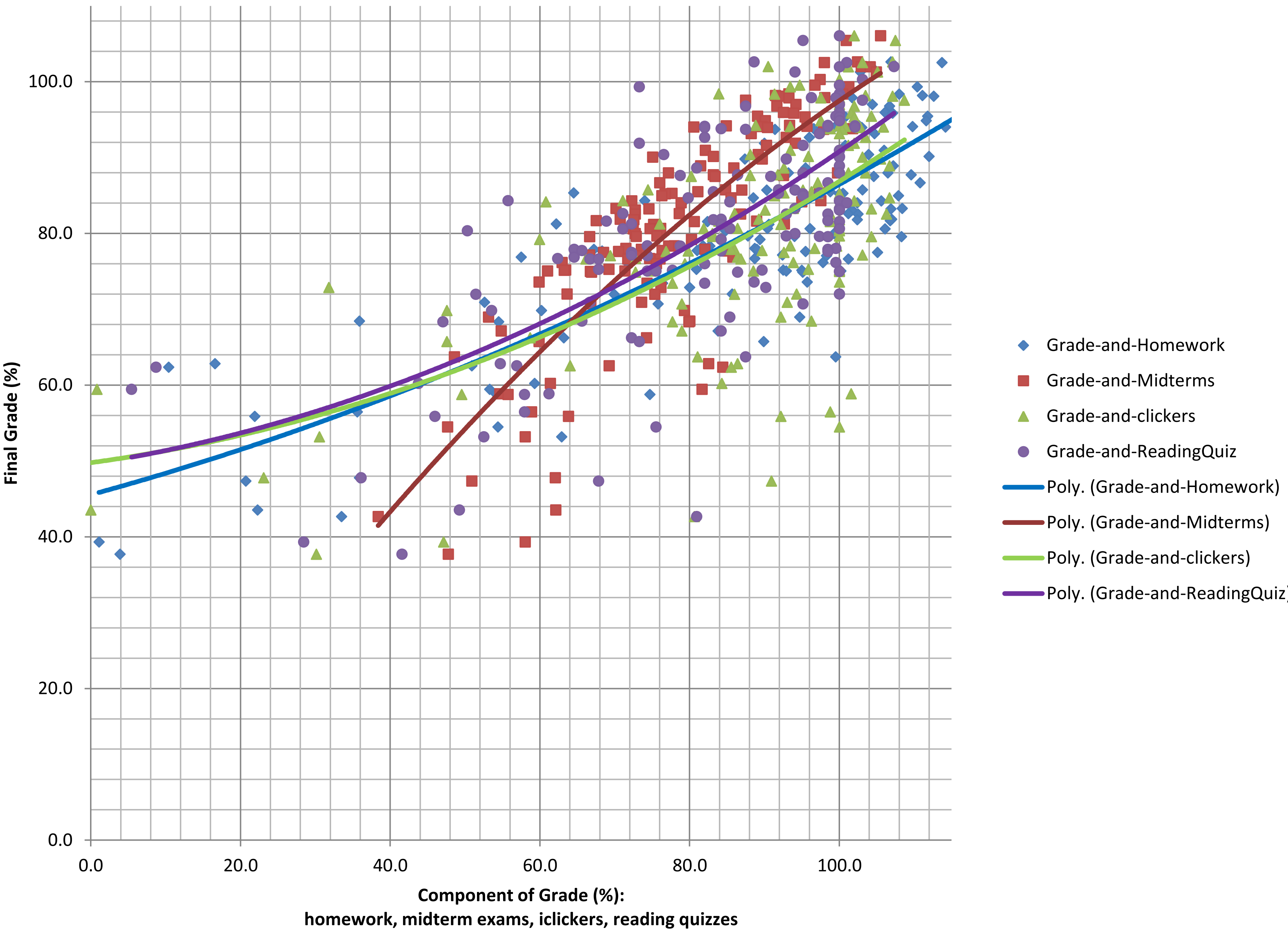
More detailed assessment data



Midterm Exams %
Homework %
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0.0
20.0
40.0
60.0
80.0
100.0
120.0
high exam score,
high homework score
low exam score,
high homework score
low exam score, low homework score



Final Grade (%)
100.0
80.0
60.0
40.0
20.0
0.0
0.0
20.0
40.0
60.0
80.0
100.0
Component of Grade (%):
homework, midterm exams, iclickers, reading quizzes
Grade-and-Homework
Grade-and-Midterms
Grade-and-clickers
Grade-and-ReadingQuiz
Poly. (Grade-and-Homework)
Poly. (Grade-and-Midterms)
Poly. (Grade-and-clickers)
Poly. (Grade-and-ReadingQuiz)

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