

# An Instructional Strategy to Improve Problem Solving Skills in General Chemistry Recitation

Madhu Mahalingam, PhD

Elisabeth Morlino, PhD

Elisabetta Fasella, PhD

University of the Sciences in Philadelphia

Please sit in groups of 4-5 participants according to the type of skills required to succeed in your discipline

## FRONT

Quantitative Problem Solving  
(physics, chemistry, etc)

Situational Problem Solving/Logical Reasoning  
(psychology, etc)

Interconnecting Factual Knowledge  
(anatomy, etc)

Evaluation/discussion of ideas  
(Literature etc.)

## Prior to 2002 at USP

- Students did not do well in General Chemistry
- Students felt that General Chemistry was a 'hard' course
- Attendance in optional recitation was low

# Solution- Group problem solving in recitation

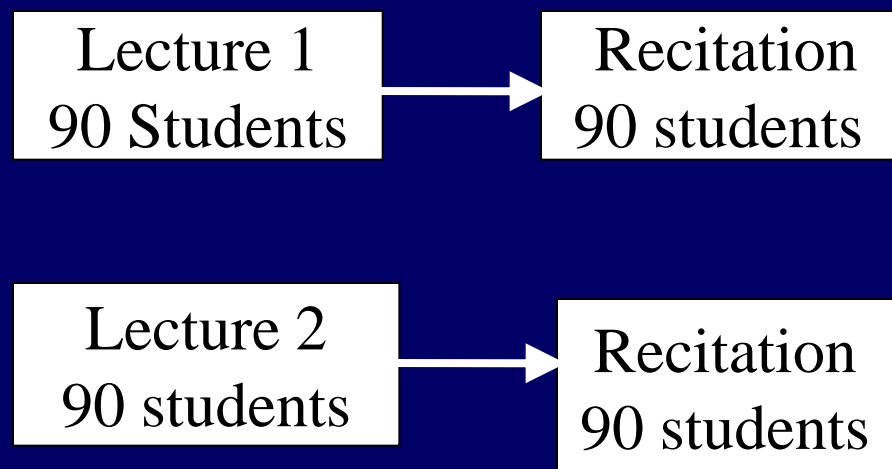
- 3-5 students per group
- Groups assigned by instructor based on Math SAT
- Less than 12 groups per recitation
- Use undergraduate TAs to guide problem solving

# Goals for mandatory recitation

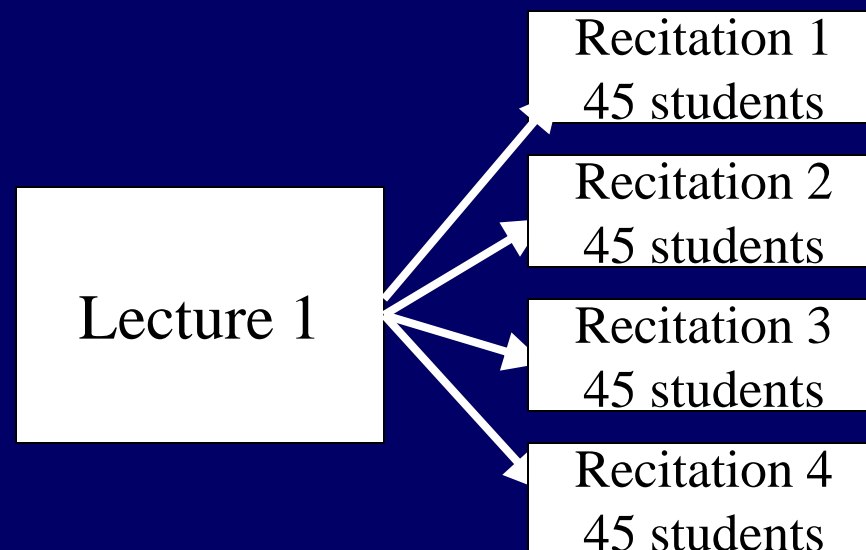
- Develop problem solving skills in general chemistry
- Improve conceptual understanding
- Improve communication skills
- Promote a team approach to learning

# Restructuring General Chemistry at USP

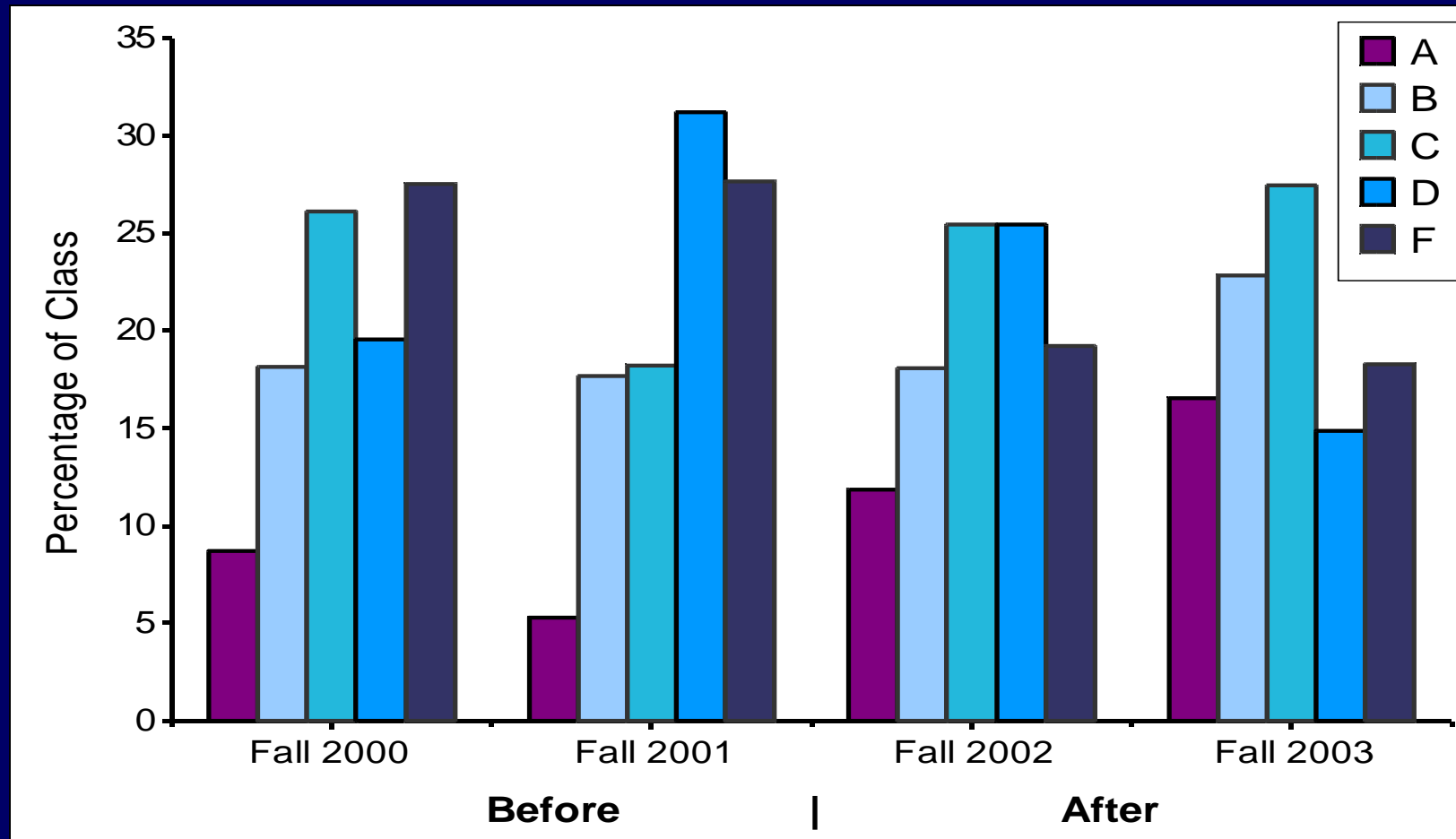
Before



After



# Effect on Exam Grade Distribution



“Promoting Student Learning Through Group Problem Solving in General Chemistry Recitations”, *J. Chem. Educ.* 85, 1577 (2008)

# Problems in General Chemistry

- Well-Structured
  - Problems with a correct answer
  - Limited number of principles
  - Parameters are well defined

# Problem Solving requires

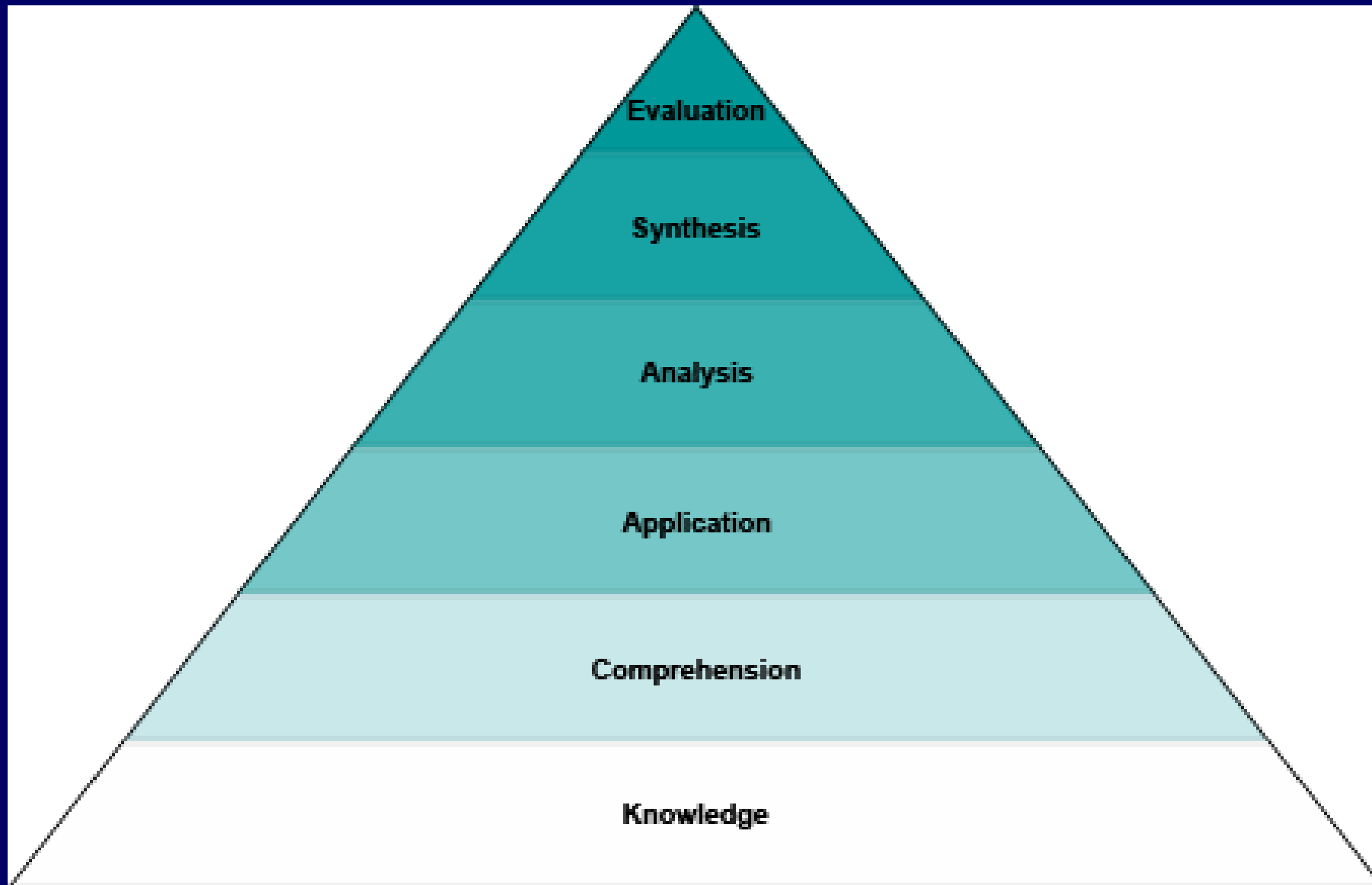
## Knowledge

- Domain knowledge – concepts, formulas
- Structural knowledge – how these connect with each other

## Skills

- Draw inferences, see analogies
- Metacognitive skills such as assessing prior knowledge

**Jonassen D., Instructional Design Models for Well-Structured and Ill-Structured Problem-Solving Learning Outcomes, ETR&D, Vol, 45, No. 1, 1997, pp. 65-94 ISSN 1042-1629**



Bloom's Taxonomy of learning. Adapted from: Bloom, B.S. (Ed.) (1956) Taxonomy of educational objectives: The classification of educational goals. Handbook I, cognitive domain. New York ; Toronto: Longmans, Green.

# Problem Solving Levels

	Type of Knowledge	Learner Attributes	Process
<b>Level 0.5 Pre-Informational (Language)</b>	Terminology	Knows meaning of words	Follows a method
<b>Level 1.0 Informational</b>	Memorizes and repeats information	States facts and definition	Initiates use of a method-how
<b>Level 2.0 Comprehension &amp; Understanding</b>	Interpret, summarize and/or compare information	Is able to make connections between concepts	Rationalizes the use of a method-why

Adapted from Nygren K., Elevating Knowledge from Level 1 to Level 3, Faculty Guidebook, 4<sup>th</sup> Edition, Pacific Crest Publications, 165-168.

# Preparation for Recitations- Foundational Knowledge

## Component

- Background knowledge (Level 0.5 & Level 1)
- Basic level of comprehension (Level 1 and low Level 2)

## Tool

- Terminology, equations
  - Webassign\*
  - Online quizzes
  - In class clicker questions
- Webassign

\*<https://www.webassign.net/>

# Problem Sets in recitation (Level 2 and Level 3)

- Multi-step problems
- Answers not obtainable from direct application of formula
- Problems that encourage discussion of ideas (estimation, qualitative answers)
- Comprehensive problems that require use of concepts/skills learned previously

## Level 1 Question

- How many  $\text{N}_2\text{O}_4$  molecules are contained in 76.3 g  $\text{N}_2\text{O}_4$ ?

The molar mass of  $\text{N}_2\text{O}_4$  is 92.02 g/mol.

## Level 2 Question

- Determine the limiting reactant (LR) and the mass (in g) of nitrogen that can be formed from 50.0 g  $\text{N}_2\text{O}_4$  and 45.0 g  $\text{N}_2\text{H}_4$ . Some possibly useful molar masses are as follows:  
 $\text{N}_2\text{O}_4 = 92.02 \text{ g/mol}$ ,  $\text{N}_2\text{H}_4 = 32.05 \text{ g/mol}$ .

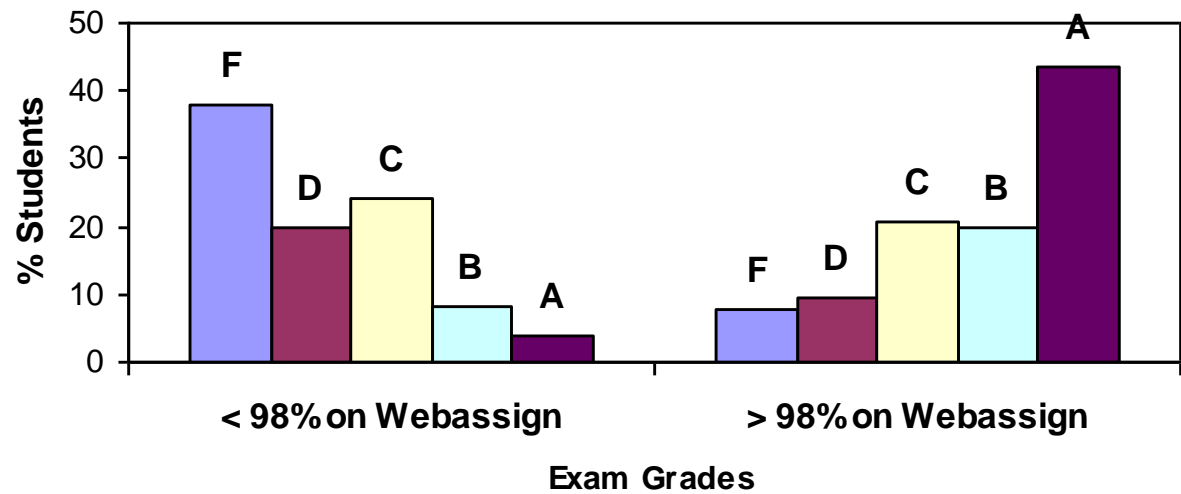


# Using online homework to prepare students for recitation

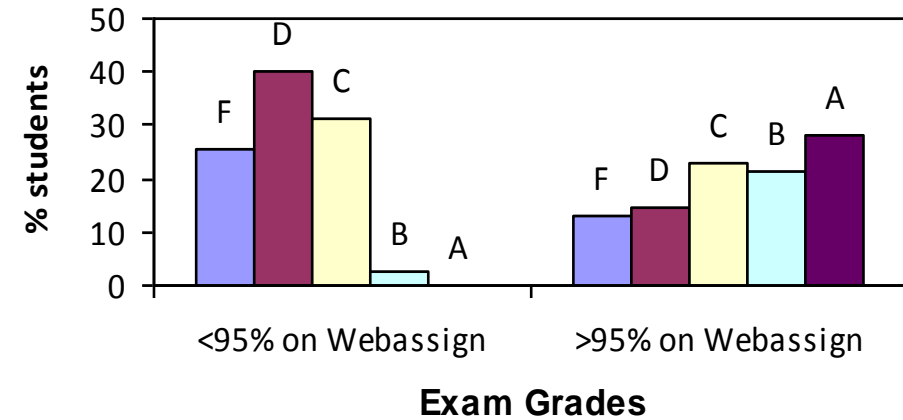
- Webassign
  - Assignments can be mostly individualized
  - Students get immediate feedback
  - Specific due dates can be assigned

# Correlation of exam grades and webassign

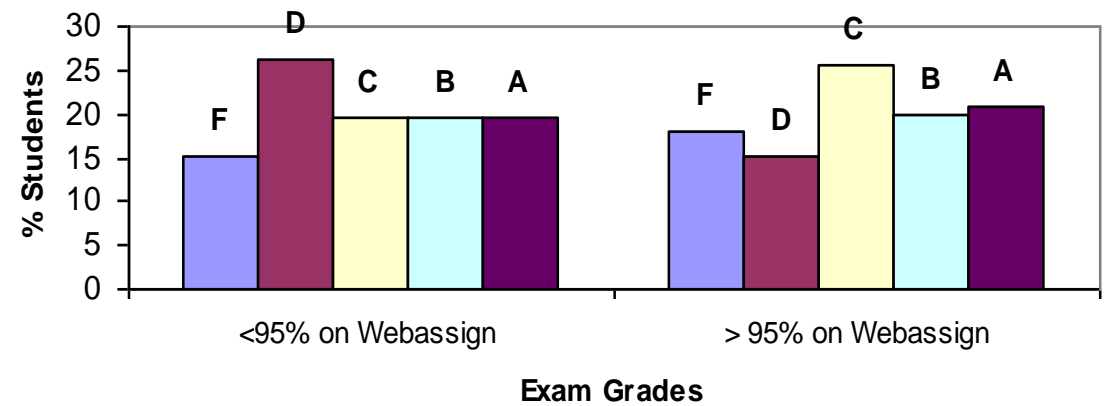
Correlation of Exam Grades with Webassign- Section 1



Correlation of Exam Grades with Webassign- Section 2

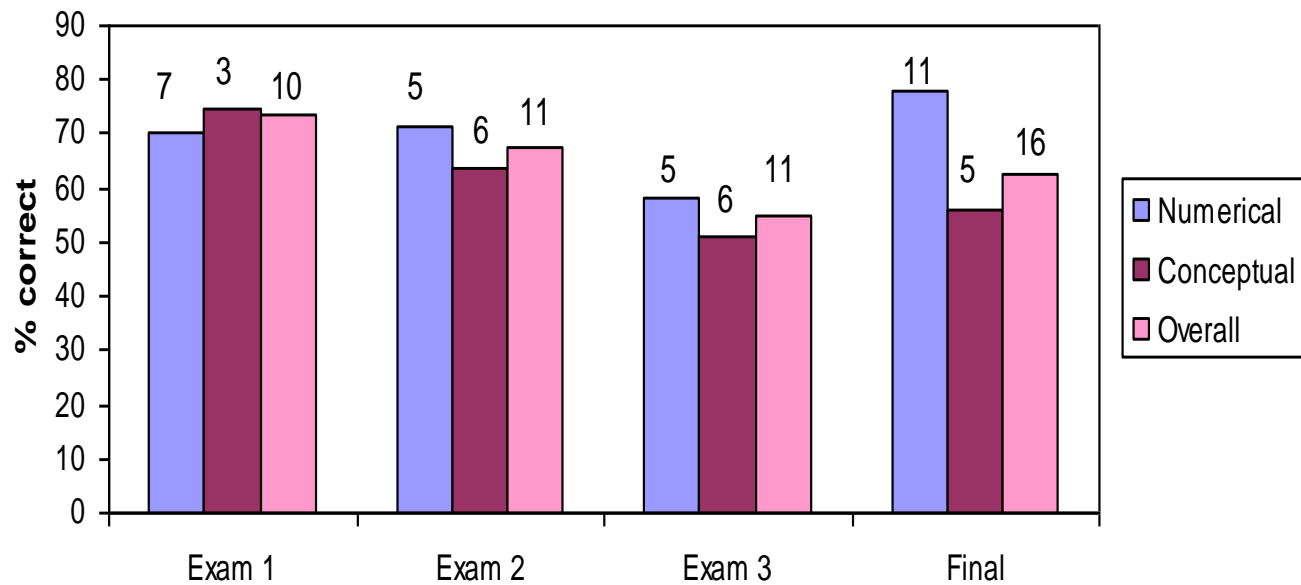


Correlation of Exam Grades with Webassign-Section 3

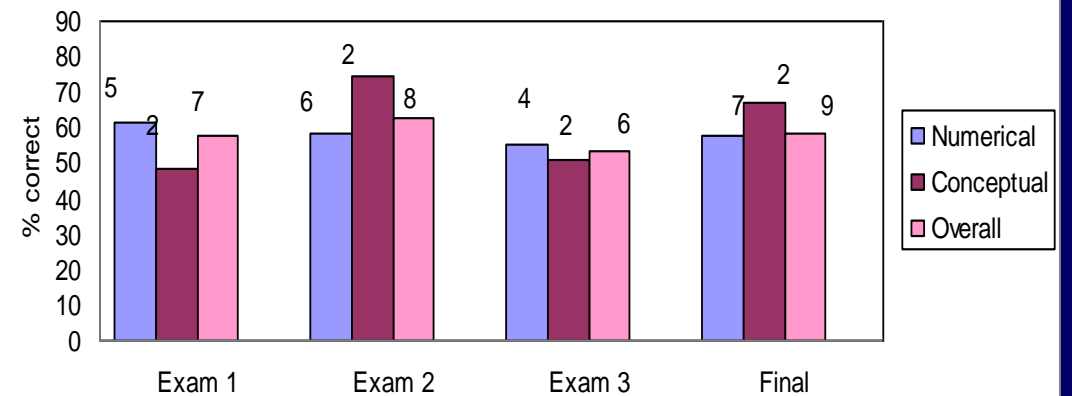


# Average percent correct on Level 2 exam questions by type

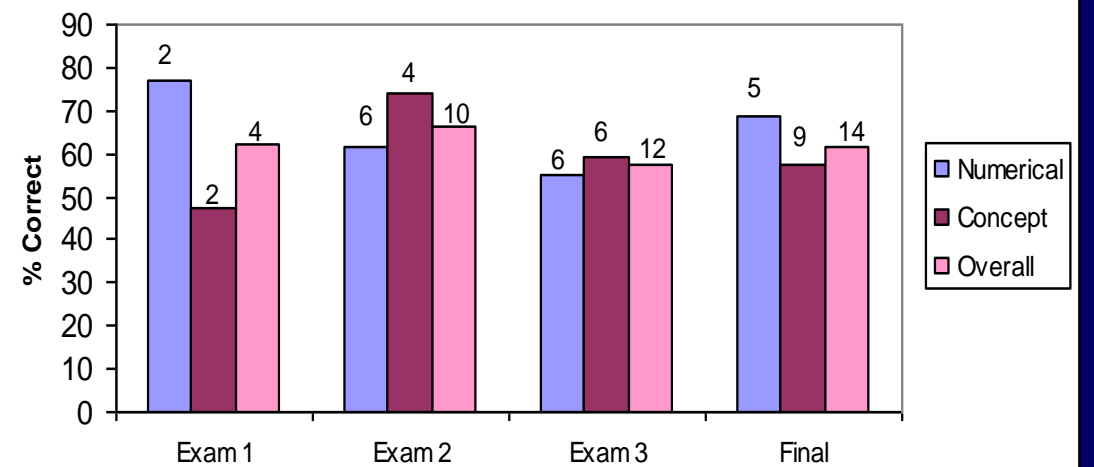
Performance on Level 2 Questions- Section 1



Performance on Level 2 Questions-Section 2



Performance on Level 2 Questions-Section 3



## Results of Student Assessment of Learning Gains Survey

<b>Assignments, graded activities and tests</b>	n	No help	Little help	Moderate help	Much help	Great help	NA
HOW MUCH did each of the following aspects of the class HELP YOUR LEARNING?							
Webassign Homework	89	1: 0%	2: 2%	3: 21%	4: 28%	5: 51%	9: 0%
Online Lecture Quizzes	89	1: 9%	2: 10%	3: 29%	4: 35%	5: 17%	9: 0%
Recitation Problem sets	89	1: 5%	2: 7%	3: 18%	4: 31%	5: 39%	9: 0%

<b>Increases in your skills</b>	n	No gain	Little Gain	Moderate Gain	Good Gain	Great Gain	NA
As a result of your work in this class, what GAINS DID YOU MAKE in the following SKILLS?							
Discussing ideas with peers for better understanding of concepts	87	1: 2%	2: 8%	3: 19%	4: 35%	5: 34%	9: 1%
Ability to explain or verbalize concepts that you feel you understand	88	1: 3%	2: 10%	3: 22%	4: 38%	5: 27%	9: 1%
Ability to solve problems	89	1: 1%	2: 16%	3: 11%	4: 35%	5: 37%	9: 0%

# Student Response

- “I think recitation is very beneficial to get a better understanding of the material. It gives us a chance to ask questions and to work on problems. It is also good to work with others to get a little help or a better understanding.”
- “Overall, I like how the recitation has been organized. Sometimes I have no clue how to do the problems that have been assigned, but I learned how to do it from my group.”
- “I was not too fond of group activity because I found it difficult to rely on other people, but this worked out very well.”

# Steps in developing problem solving skills in General Chemistry

- Step 1- Assignments that help build foundational knowledge
- Step 2- Assignments that allows practice of various problems – helps build problem schema
- Step 3- Take it to the next level in a structured environment that provides guidance but not solutions

# Acknowledgements

- Teaching & Learning Center, University of the Sciences in Philadelphia
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