WRIGHT COLLEGE
PROGRAM/DISCIPLINE ASSESSMENT FORM

Program/Discipline: Physical Science (Department) / Chemistry **Instructional Manager:** Kevin Li

Semester/Year: Spring 2013 **Assessment Coordinator:** Dr. Tracy Mitchell **Department Chair:** Dr. Doris Espiritu
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Plan Title: Using ACS Examinations to Gauge the Achievement of Student Learning Outcomes for Chemistry 203 (General Chemistry II)

Part A: Initial Plan
Part B: Midsemester Update
Part C: Further Updates

The current submission is which of the following:

□ **Initial Plan date: _______**

□ **Mid-year update date: _______** **X Final Report date: 06/15/13**

College Mission: Wright College is a learning–centered, multi-campus institution of higher education offering students of diverse backgrounds, talents, and abilities a quality education leading to baccalaureate transfer, career advancement, and/or personal development.

Program/Discipline Mission: The mission of the Department of Physical Sciences is to provide our students with solid foundations in Chemistry, Physics, and Physical Sciences so that articulation of classes and material content will allow for a seamless transition into their chosen fields of interest. Our charge is to encourage students to view physical phenomena critically and develop insights which will help them discover and understand the principles that govern events in nature. All are encouraged to develop their curiosity, enhance their intellectual skills, progressively mature, and recognize the growing role of science in society.

A. Initial Assessment Plan

Area of Focus: Your department efforts are to improve learning in what topic/area?	Critical thinking.

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Evidence: What past results have led your department to conclude that this is an area needing attention?	Wright College's 2010 CAAP Scores indicated lower achievement in the areas of reading and critical thinking.
Course(s) of Interest: What courses will be involved in your plan?	Chemistry 203 (General Chemistry II)
Intended Program Student Learning Outcomes (SLOs) List each relevant SLO that this project pertains to.	DEPARTMENTAL SLO: Students who complete (physical) science courses at Wright College will be able to: 1) Reason methodically to evaluate and solve qualitative and quantitative problems using appropriate scientific models and/or mathematical manipulations. COURSE SLO's: At the conclusion of the term, the students will: 1. Recall the definitions of scientific terms and appropriately use the terms to identify various aspects of chemical kinetics, chemical equilibrium, thermodynamics, acid-base chemistry, electrochemistry, nuclear chemistry, and coordination chemistry. 2. Apply previous knowledge of chemical reactions in aqueous solution (acid-base, precipitation, redox) to provide a foundation for topics focusing on chemical equilibrium and thermodynamics. 3. Solve qualitative and quantitative problems which involve: Kinetics a. Predicting the impact of certain factors (concentration, temperature, catalysts, activation energy) on the rate of chemical reactions. b. Calculating the reaction rate given concentration and time. c. Relating the rate of formation of products to the rate of disappearance of reactants given a balanced equation. d. Formulating rate laws from experimental data or a proposed mechanism. e. Recognizing the differences between first order and second order reactions. Equilibrium f. Writing the equilibrium-constant expressions for reactions. g. Relating the magnitude of an equilibrium constant to the relative amounts of reactants and products in the equilibrium mixture. h. Manipulating the equilibrium constant to reflect changes in the chemical equation. i. Calculating an equilibrium constant from given concentrations/pressures or equilibrium concentrations/pressures from a given equilibrium constant. j. Predicting the outcome of disrupting a system at equilibrium by changing concentrations, volume/pressure, or temperature using Le Chatlier's principle.

Acid-Base Equilibria

k. Defining and identifying Arrhenius, Bronsted-Lowry, and Lewis acids and bases.
l. Defining, identifying, and relating (strengths) of conjugate acid-base pairs.
m. Relating (mathematically) the $[H^+]$, the $[OH^-]$, the pH and pOH of aqueous solutions using K_w and pK_w at 25°C.
n. Calculating the pH of a strong acid, strong base, weak acid, weak base, salt, or buffer solution given initial concentrations and equilibrium constants, K_a or K_b, when appropriate.
o. Calculating the K_a or K_b from an initial concentration and pH or from K_w for conjugate acid-base pairs.
p. Predicting the acidic, basic or neutral nature of an aqueous salt solution.
q. Defining and identifying buffer solutions.
r. Interpreting and extracting the information revealed by an acid-base titration curve.

Solubility Equilibria

s. Calculating K_{sp} from molar solubility and molar solubility from K_{sp}.
t. Predicting the outcome of disrupting a system at equilibrium via the introduction of a common ion, the hydronium ion, or a complexing agent.

Chemical Thermodynamics

u. Recalling the three Laws of Thermodynamics.
v. Defining, predicting (via sign designation) and calculating (via Hess's Law or tabulated standard state values) the enthalpy, entropy, and free energy changes for reactions.
w. Relating (mathematically) the enthalpy, entropy, and free energy changes for reactions using the Gibbs-Hemholtz equation.
x. Predicting the effect of temperature on spontaneity given the enthalpy and entropy changes for reactions.
y. Relating (mathematically and theoretically) the standard free energy change and equilibrium constant for a reaction.
z. Calculating the free energy change under nonstandard conditions.

Electrochemistry

aa. Defining and identifying oxidation, reduction, oxidizing agents and reducing agents.
bb. Assigning oxidation numbers to isolated atoms or atoms within molecules or ions.
cc. Balancing redox reactions in acidic or basic solutions.
dd. Identifying and defining the anode, cathode and salt bridge as applicable to voltaic/galvanic and electrolytic cells.
ee. Ranking oxidizing agents and reducing agents by strength given standard reduction potentials.
ff. Calculating standard cell potentials from standard reduction potentials and nonstandard cell potentials using the Nernst equation.
gg. Relating (mathematically and theoretically) the standard cell potential, the standard free energy change and equilibrium constant for a reaction.
hh. Relating (mathematically) the amounts of products and reactants in redox reactions to electrical

charge.

Nuclear Chemistry

ii. Defining the properties of alpha, beta, and gamma radiation.
jj. Constructing and balancing nuclear equations using nuclide symbols.
kk. Defining the processes and identifying the applications of nuclear fission and nuclear fusion.
ll. Calculating the ages of objects or the amounts of radioactive nuclei remaining given the initial amount and half-life.

Chemistry of Coordination Compounds

mm. Identifying the components, general properties and structural features of coordination compounds.
nn. Determining the central metal's oxidation number, the charge of the complex ion, and the coordination number.

4. Draw logical conclusions from laboratory activities using the scientific method and knowledge of chemical kinetics, chemical equilibria, acid-base chemistry, selective precipitation/qualitative analysis and electrochemistry.

Involved Faculty:

List the instructor(s) participating in the assessment process for each outcome listed above.

Chemistry 203 Course Coordinator: Tracy Mitchell
Chemistry 203 Instructors: Siddiq Tabba

Assessment/Intervention Process

Address the following questions:

- **What** approach will be used?
- **Why** was this process selected?
- **How** will student learning be measured?
- **When** will data collection be completed?
- **Who** will analyze the results?

What: The 2006 Second Term General Chemistry Exam is a 70-question, multiple-choice exam, prepared by the American Chemical Society (ACS) to assess the knowledge gained by students after completing the second semester of the General Chemistry sequence (i.e. Chemistry 203). Composite norms provided by ACS for this exam are based on the scores of 1,315 students in 16 colleges.

Why: The majority (i.e. 59/70) of the ACS examination questions are linked to the Chemistry 203 student learning outcomes (SLOs).

How: Externally, Wright College student scores are compared to the composite norms as an indicator of overall achievement with respect to student learning over the course of the semester. Internally, a question analysis is performed to identify the most commonly missed questions as a means to identify topics that require more time and attention. After identifying these questions, the course coordinator recommends certain topics be emphasized or particular correlations be made to improve student learning and general problem-solving skills.

When: The ACS exam is given during the 16th week of the semester. The data is typically analyzed within the next two-three weeks and is submitted as a report to the department Assessment Coordinator.

Who: Tracy Mitchell, Chemistry 203 Course Coordinator

B. Midyear Update

Completely describe all actions that have occurred since this past August with respect to your department's Assessment Plan.	Not applicable.
Attach any relative documents (rubrics, surveys, other assessment tools).	Not applicable.

Are there any obstacles to the implementation of the plan that the Assessment Committee should know about or can assist with?	No.
	Part C
Summary of Results and Analysis of Data Collected What were the results of the assessment process? What was learned from the results?	**<u>Overview of Results</u>** **Range of Scores Possible:** <u>0 – 70 (0% - 100%)</u> **Range of Scores Achieved:** <u>20 – 58 (29% - 83%)</u> **Average Score:** <u>36/70 (51%)</u> **Benchmark Score:** Originally: <u>30/70 (43%)</u> Modified: <u>28/70 (40%)</u> **Number of Students Achieving the Benchmark Score:** Originally: <u>65/86 (76%)</u> Modified: <u>71/86 (83%)</u> **Number of Students Not Achieving the Benchmark Score:** Originally: <u>21/86 (24%)</u> Modified: <u>15/86 (17%)</u> **Chem 203's Average Score:** <u>36/70 (51%)</u> **National Average Score:** <u>38/70 (54%)</u> **Number of Students Achieving the National Average:** <u>39/86 (45%)</u> **Number of Students Not Achieving the National Average:** <u>47/86 (55%)</u> Note: Spring 2013 data presented in tabular and graphical formats can be found at the conclusion of this report. Furthermore, a summary of Chemistry 203 Exit Exam and ACS data for the past 10 semesters is also included.

Action Plan Based on Results and Analysis Based on what was learned, what additional steps will be taken to improve student learning?	The Physical Science Department attempted to merge the Exit Exam concept, a set of questions used to verify that students have attained a minimum of essential skills from the course, and the nationally standardized American Chemical Society Examination used to gauge the skills of Wright College student against students nationwide. Although the merging of these two types of student learning assessments is not ideal, one clear benefit for students is that this format requires students to take only one exam not two during the already exam-heavy final week of the semester. Overall, the analysis of the data generated indicates that this merger was not only efficient but successful. Students averaged 36/70, which is above the original benchmark score of 30/70 and the modified benchmark score of 28/70. Furthermore, 83% of the 86 Chemistry 203 students met the modified benchmark score and passed the Exit Exam. Finally, of the 15 students failing the ACS Exit exam and not only qualifying but also sitting for the Departmental Appeals Exam, 11 students passed with a minimum score of 10/20. (Note: All 15 students opted to take the Departmental Appeals Exam. Thus, four students failed the departmental exit exam.) The 59/70 questions which relate to Chemistry 203 student learning outcomes covered the majority of Chemistry 203 topics and varied in the level of difficulty (see Tables 1 and 2). 41/59 questions were correctly answered by 46% or more of the students. Although the data indicates that the majority of students demonstrated competency with regard to the student learning outcomes for Chemistry 203, students appeared to have attained the strongest understanding of topics dealing with equilibrium and acid-base equilibrium, but a much weaker understanding of chemical kinetics and chemical thermodynamics. Therefore, Chemistry 203 instructors should be encouraged to provide ample time for the instruction of chemical kinetics and chemical thermodynamics as well as ample problem-solving opportunities which span the realms of conceptual, computational, visual, and word problems. Furthermore, Chemistry 203 instructors should require students to memorize the Gibbs-Hemholtz equation ($\Delta G = \Delta H_{system} - T\Delta S_{system}$) as it is not given on the ACS exam. In addition, Chemistry 201 instructors should be reminded that thorough coverage of net ionic equations, enthalpy, and the dissolution of salts is necessary to prepare students adequately for Chemistry 203. Finally, although Chemistry 201 has a thermochemistry lab activity, Chemistry 203 does not. An experiment that not only reviews the enthalpy changes associated with neutralization reactions and dissolution processes, but also incorporates the aspects of entropy and free energy changes should be introduced into Chemistry 203. As evidenced by the data in Table 7 and Figure 2, 39/86 (i.e. 45% of the) Chemistry 203 students scored at or above the national average. In fact, four students scored above the 90th percentile. Likewise, 47/86 (i.e. 55% of the) students scored below the national average with six students scoring below the 10th percentile. Figure 3 illustrates the Chemistry 203 Student Score Distribution from Spring 2013.

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Part 1: Exit Exam Analysis

Table 1: Summary of 59 Questions by Topic and SLOs

Topic	**Student Learning Outcomes** Students will solve qualitative and quantitative problems which involve:	No. of Quest.
Kinetics	1. Recalling definitions and terms relating to chemical kinetics. 3a: Predicting the impact of certain factors (concentration, temperature, catalysts, activation energy) on the rate of chemical reactions. 3b: Calculating the reaction rate given concentration and time. 3c: Relating the formation of products to the rate of disappearance of reactants given a balanced equation. 3d: Formulating rate laws from exp. data or a proposed mechanism. 3e: Recognizing the differences between first & second order reactions.	9
Equilibrium	1. Recalling definitions and terms relating to chemical equilibrium. 3f: Writing the equilibrium-constant expressions for reactions. 3h: Manipulating the equilibrium constant to reflect changes in the chemical equation. 3i: Calculating an equilibrium constant from given concentrations or pressures (or vice versa). 3j: Predicting the outcome of disrupting a system at equilibrium by changing concentrations, volume or pressure, or temperature using Le Chatlier's principle. 3s: Calculating K_{sp} from molar solubility and molar solubility from K_{sp}.	9
Acid-Base Equilibrium	1. Recalling definitions and terms relating to acid-base chemistry. 2. Applying previous knowledge of acid-base chemistry in aq. soln. 3k: Defining and identifying Arrhenius, Bronsted-Lowry, and Lewis acids and bases. 3l: Defining, identifying, and relating (strengths) of conj. acid-base pairs. 3m: Relating (mathematically) the $[H^+]$, the $[OH^-]$, the pH and pOH of aqueous solutions using K_w and pK_w at 25°C. 3n: Calculating the pH of a strong acid, strong base, weak acid, weak base, salt, or buffer solution given initial concentrations and equilibrium constants, K_a or K_b, when appropriate. 3o: Calculating the K_a or K_b from an initial concentration and pH or from K_w for conjugate acid-base pairs. 3q: Defining and identifying buffer solutions. 3r: Interpreting and extracting the information revealed by an acid-base titration curve.	12
Solubility	3s: Calculating K_{sp} from the molar solubility (or vice versa).	1

Thermodynamics	1: Recalling definitions and terms relating to thermodynamics. 2: Apply previous knowledge of chemical reactions in aqueous solution (acid-base, precipitation, redox) to provide a foundation for topics focusing on chemical equilibrium and thermodynamics. 3u: Recalling the three Laws of Thermodynamics. 3v: Defining, predicting (via sign designation) and calculating (via Hess's Law or tabulated standard state values) the enthalpy, entropy, and free energy changes for reactions. 3w: Relating (mathematically) the enthalpy, entropy, and free energy changes for reactions using the Gibbs-Hemholtz equation. 3y: Relating (mathematically and theoretically) the standard free energy change and equilibrium constant for a reaction.	12
Electrochemistry	3aa: Defining and identifying oxidation, reduction, oxidizing agents and reducing agents. 3bb: Assigning oxidation numbers to isolated atoms or atoms within molecules or ions. 3dd: Identifying and defining the anode, cathode and salt bridge as applicable to voltaic/galvanic and electrolytic cells. 3ee: Ranking oxidizing agents and reducing agents by strength given standard reduction potentials. 3ff: Calculating standard cell potentials from standard reduction potentials and nonstandard cell potentials using the Nernst equation. 3hh: Relating (mathematically) the amounts of products and reactants in redox reactions to electrical charge.	11
Nuclear Chemistry	3ii: Defining the properties of alpha, beta, and gamma radiation. 3jj: Constructing and balancing nuclear equations using nuclide symbols. 3ll: Calculating the ages of objects or the amounts of radioactive nuclei remaining given the initial amount and half-life.	3
Coordination Chemistry	--	0
Laboratory Concepts	4: Draw logical conclusions from laboratory activities using the scientific method and knowledge of chemical kinetics, chemical equilibria, acid-base chemistry, selective precipitation/qualitative analysis and electrochemistry.	2

Table 2: Summary of 59 Questions by Difficulty Index

Difficulty Index*	No. of Questions	Question Difficulty
0.60 or above	19	Least Difficult
0.55 - 0.59	13	--------------
0.50 – 0.54	8	-------------
0.49 or below	19	Most Difficult

*The difficulty index is the percentage of students who responded correctly to an item.

Table 3: Questions Answered Incorrectly by 55% or More of Students (Overview)

Question No.	Topic	% of Students with Incorrect Responses		Difficulty Index
		Wright	Nation	
1	Kinetics	59%		
2	Kinetics	61%	63%	0.37
3	Kinetics	68%	62%	0.38
5	Kinetics	74%	47%	0.53
14	Thermodynamics	75%	79%	0.21
24	Solubility Equilibrium	60%	53%	0.37
28	Thermodynamics	70%	56%	0.44
33	Acid-Base Equilibrium	65%	46%	0.54
38	Acid-Base Equilibrium	63%	53%	0.47
40	Acid-Base Equilibrium	58%	46%	0.54
45	Thermodynamics	84%	67%	0.33
46	Thermodynamics	83%	59%	0.41
48	Thermodynamics	59%	52%	0.48
52	Thermodynamics	55%	74%	0.26
54	Electrochemistry	88%	81%	0.19
58	Electrochemistry	66%	53%	0.47
62	Electrochemistry	66%	42%	0.58
64	Nuclear Chemistry	55%	33%	0.47

Note: Only questions from the original set of 59 are included in Table 3 and are eligible for further analysis.

Table 4: Summary of Questions Answered Correctly and Incorrectly* by Topic

	No. of Questions	Number Correct	Number Incorrect
Kinetics	9	5	4
Equilibrium	9	9	0
Acid-Base Equilibrium	12	9	3
Solubility Equilibrium	1	0	0
Thermodynamics	12	6	6
Electrochemistry	11	8	3
Nuclear Chemistry	3	2	1
Lab Safety	2	2	0

***Questions answered incorrectly by 55% or more of students. Questions answered correctly by 46% or more students.**

Part 2: ACS Exam Analysis (Comparison to Composite Norms)

Table 7: Summary of Chemistry 203 Student Achievement

Score	National Percentile	Number of Chem 203 Students
53 - 70	90 - 100	4
48 - 52	80 - 89	7
45 - 47	70 - 79	5
41 - 44	60 - 69	11
38 - 40	50 - 59	12
35 - 37	40 - 49	13
31 - 34	30 - 39	12
28 - 30	20 - 29	7
24 - 27	10 - 19	9
0 - 23	0 - 9	6

Figure 2:Chemistry 203 Student's National Percentile Rankings - Spring 2013

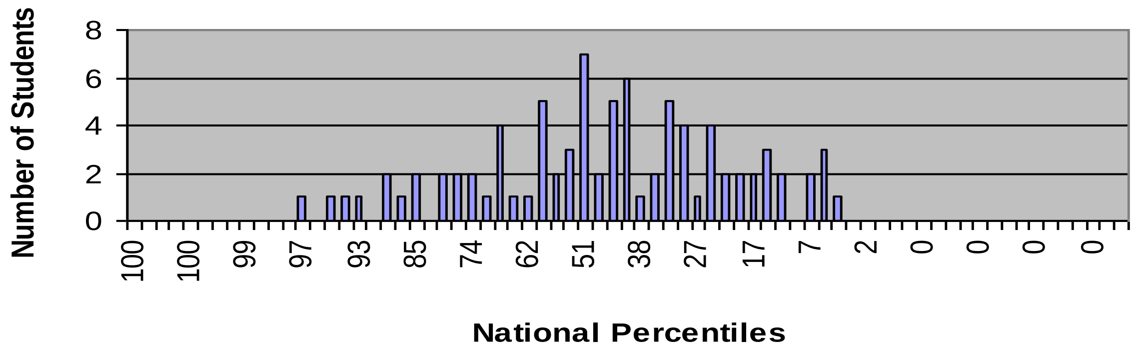
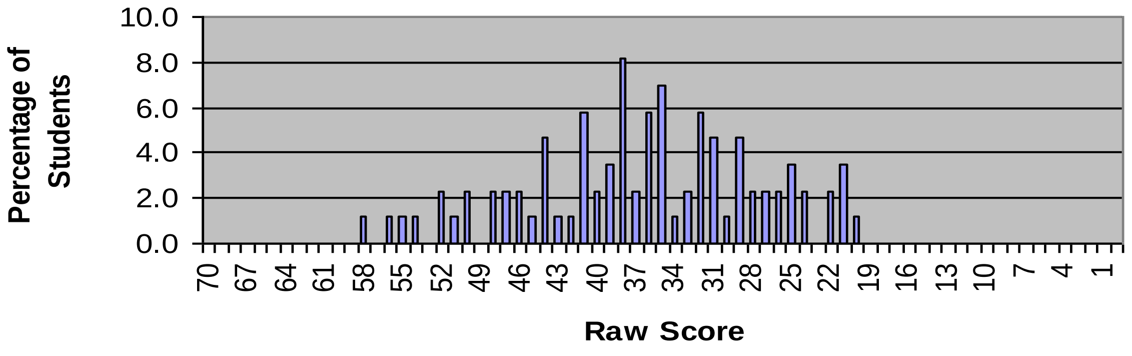


Figure 3: Chemistry 203 Student Score Distribution - Spring 2013



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Chemistry 203 ACS-Exit Exam Summary

Chemistry	Coordinator	Semester	Passing Score	Total # of Students	% Students Passing ACS Exit	Avg. ACS Exit Score
203	T. Mitchell	Spring '10	16/40*	80	88%	24/40
203	T. Mitchell	Summer '10	16/40*	30	100%	29/40
203	T. Mitchell	Fall '10	30/70 (suggested) 26/70 (modified)	58	79% 88%	37/70
203	T. Mitchell	Spring '11	30/70 (suggested) 27/70 (modified)	73	63% 78%	34/70
203	T. Mitchell	Summer'11	30/70 (suggested)	54	85% 89%	39/70
203	T. Mitchell	Fall '11	30/70 (suggested) 29/70 (modified)	87	67% 72%	34/70
203	T. Mitchell	Spring '12	30/70 (suggested) 28/70 (modified)	62	79% 82%	36/70
203	T. Mitchell	Summer '12	30/70 (suggested) 27/70 (modified)	38	82% 87%	37/70
203	T. Mitchell	Fall '12	30/70 (suggested) 28/70 (modified)	65	62% 71%	34/70
203	T. Mitchell	Spring '13	30/70 (suggested) 28/70 (modified)	86	76% 83%	36/70

*Note: In Spring 2010 and Summer 2010, 40 of the 70 questions were selected to assess the students' understanding of fundamental skills in Chemistry 203 as well as to serve as each course's Exit Exam. <u>However, in Fall 2010, the passing score for Chemistry 203 will be 30/70 questions (i.e. a 43%).</u> As an aside, only 60/70 questions pertain to the student learning outcomes for Chemistry 203. The national average is 38/70.