UW-Green Bay Curricular Assessment Plan and Report - Year Three

CHEMISTRY PROGRAM

Review your Plan for Year One and your Year Two Status Update.

Which, if any, course-level interventions did you implement as a result of your baseline assessment results? This could be anything from content to modality to periodicity to additions to the curriculum.

- Lessons learned from Year One and Two assessments: Assessment interventions.

To begin with, in year one there were several flaws identified in the assessment questions. I will go into some details here:

One of the questions deigned to assess the knowledge of rate laws required that they correctly determine the overall order for two reactants in a second order rate law (the overall order is the sum of each individual reactant order). If either of the individual orders is incorrect, then the overall order would be incorrect. This question required students to get multiple parts correct to get the correct answer. If a student got one order correct but not the other, the exam result would have been incorrect. Here a partial scoring system should have been used (0.5 for each correct order) in a multiple step problem. This was corrected in year three assessment.

Second, the question to assess how well they understood the mechanism and collision theory of kinetics was flawed in year one. The students were asked to determine which of several mechanisms were consistent with a given rate law. Again, a situation where a student might have gotten two out of three correct, but still be marked incorrectly. More importantly with this question, it was flawed (in a sense) because all the shown mechanisms were correct. Some students mistakenly thought that is the mechanism steps added up to the overall balanced equation (which must be true of any mechanism) then it was a consistent rate law. All the mechanisms provided happen to be consistent, so some students could have gotten this question correct through incorrect reasoning (so we weren't testing what we thought we were).

This year to prevent any of these issues from occurring, the assessment questions were slightly adjusted to be more singularly focuses on a specific topic rather than having several ideas combined into a single question. The revised assessment questions will test the same knowledge and in addition provide more granular detail about the student's knowledge then the questions from year one. The year three assessment exam questions, along with the rationale and scoring points) are given in the Appendix A:

- Course level Interventions:

As a result of the baseline assessment, several changes were implemented. More practice problems involving Kinetics were placed in their discussion sheets. Also, problems that used to given as extra credit were moved into the lecture to do as an additional "in class" example.

Have you made any changes to your Programmatic Learning Outcomes as a result of the baseline assessment?

No

Have you included a signature assignment/s for the assessment of Programmatic Learning Outcomes? If so, how are you using it/them? Cut and paste it/them here.

The assessment was carried out through in-class exam questions. Although, I believe that a homework assessment might be a more accurate measure of student's knowledge since the students would be singularly focused on one topic rather than an exam which is timed and has students trying to remember things from three chapters. Future assessments might include signature assignments. Signature assignments could also help assess more outcomes each semester.

What new courses are most strategic to assess?

After CHEM 211 and CHEM 212 the chemistry majors naturally progress into upper-level courses of Organic Chemistry I (CHEM-302) and Organic Chemistry II (CHEM 303). These would be most strategic to assess. Additionally, CHEM 302 and CHEM 303 are traditionally where most chemistry majors (at all universities) struggle. Assessing these courses will be key to student retention within the major.

Detail any changes that you intend to make to your Cycle of Assessment, the Outcome Assessment Procedure or your program's Participation in the Assessment Process. Why are you making those changes? If none, leave blank.

What questions will this re-assessment answer in regard to your curriculum or program forward?

The main question that this assessment was designed to test is whether our chemistry major students are getting the proper and sufficient introduction to chemical principles to be successful as they move through our program. To retain students, we must ensure that we successfully educate in the lower-level core courses ensure that students have set up for success in higher level courses. This chain of success shows that all courses must be designed properly to have a successful program. With this, upper-level teachers can be confident in the depth of topics and knowledge that upcoming major students have previous been exposed to. Making sure students have the basic core principles down is essential to student **success and retention** (area we are always striving to improve).

This is the end of the Assessment Plan for Year Three. Please complete the information above (and include the information from Part One and Two) and post in the UWG B Curricular Assessment site under your program's folder. This is due by September 30.

YEAR THREE FINAL REPORT:

Results:

Based on the scoring rubric discussed in the assessment report. The students are performing a 78.1% efficiency for the program learning outcome 4,

- PLO 4: Have knowledge of atomic and molecular structure, thermodynamics, kinetics, quantum mechanics and spectroscopy.

specifically testing kinetics.

Question	Correct (1)	Incorrect (0)	Half-correct* (0.5)	Score
6	44	5	—	44
7a	38	11	—	38
7b*	32	7	10	37
8	34	15	—	34

Sample Size, N=49
Proficiency: (44+38+37+34)/(49*4) = **78.1% proficiency**

Please detail the results of your re-assessment.

The details of the assessment report as well as the detailed scores can be found in Appendix A and B.

General Education:

<u>Scientific Methods & Inquiry</u>
SMI 1: Students will cultivate scientific information of the appropriate depth from a variety of relevant sources.
SMI 2: Students will properly demonstrate their use of the scientific method and theoretical framework.
SMI 3: Students will skillfully evaluate and organize scientific evidence and formulate logical conclusions while discussing any relevant limitations.

<u>Quantitative Reasoning</u>
QR 1: Students will develop competency in working with numerical data.
QR 2: Students will develop the ability to solve quantitative problems in different contexts.

QR 3: Students will understand, create, and communicate arguments supported by quantitative evidence.

Institutional Learning Outcomes:

ILO 1: Demonstrate the specialized knowledge, skills and perspectives in their chosen field or fields of study.

ILO 2: Develop a variety of practical and intellectual skills, including inquiry and analysis, critical and creative thinking, oral and written communication, quantitative literacy, information literacy, and teamwork and problem-solving.

Programmatic Learning Outcomes:

PLO 4: Have knowledge of atomic and molecular structure, thermodynamics, kinetics, quantum mechanics and spectroscopy.

PLO 8: Have the ability to perform experiments to obtain fundamental thermodynamic and kinetic data on chemical systems.

What do you see as strengths of your program, based upon the above assessment results?

There are several strengths we see.

- Commitment to the educational outcomes of its students.

  Assessment has enabled the department to identify any areas of improvement for students. By implementing relatively simple strategies (additional problems and focused test questions) we have increased learning proficiency in this particular learning outcome as well as confidence in the questions.

- Commitment to the retention, persistence, and degree completion of its students.

  In order the be successful in upper-level class, students must have a firm understanding of lower-level principles (such as kinetics). The results outlined above demonstrate that our current students should be setup nicely for success in future chemistry courses.

What do you see as challenges, based upon the above assessment results?

As with most program studies, to become good and be successful at it you usually must have a sufficient knowledge of other fields as well. Chemistry is no different. To be successful in any science program students must also be sufficiently competent in mathematics. We have prerequisites of mathematics classes for most of our chemistry courses to ensure student success, but I would dare say this is the area where most students struggle. Understanding the chemical principles may be relatively easy to teach, but expressing the principle in mathematical language can be difficult for students. As our student's climb the degree ladder, the math gets increasingly difficult. To some extent this mathematics competency is out of our control, but we can move some lessons into the lecture (if needed). Additionally, the program does have discussions with the mathematics department regarding the outcomes that they assess in various courses.

Data Analysis

· Discuss the process for reviewing, aggregating and analyzing the assessment results.

The details of the assessment report as well as the detailed scores can be found in Appendix A and B.

· How are the results aligned to targets/benchmarks from your Year One Plan?

The department wanted to achieve a 75% proficiency in this program learning outcome. We updated the questions to ensure that we were testing what we wanted to test. The new questions are designed to give us a more granular data about student knowledge.

Question6 is still pretty much identical to what we still use (the definition of rate)

Year 1 result = 84.1%, Year 3 result = 89.8%

Questions 7,8 have undergone a change to yield more insightful data. The comparison is not as straight forward as with question 1.

Question 7 Year 1 = 52.4%, Year 3 = 76.5%

Question 8 Year 1 = 30.2%, Year 3 = 69.4%

The changes implemented after Year 1 (more precisely focused questions and additional practice problems in discussion, homework and lecture) have resulted in an increase of overall proficiency by From 55.6% to 78.1%.

· What did you learn from these results?

Students are comprehending the basics of kinetics. Very few tried to make the balanced equation coefficients equal to the exponents of the rate law. The students have an excellent handle on how to define the rate of a given reaction. The students were successful at reading the data in the initial rate table and solving the corresponding exponential equations. Finally, there was proficiency with understanding the rate law for elementary reactions. More emphasis on this topic is planned for future semesters.

· How will you disseminate the results to your unit. When will you discuss them?

At a department group meeting in Spring 2024.

· **How is your assessment information made available to the public?**

Assessment report will be published to the UW-GB assessment website:

https://www.uwgb.edu/assessment/undergraduate-programs/chemistry/

Using Assessment Results for Continuous Improvement

How will you use the result to maintain current performance and/or ensure continuous improvement? For example, how will the results be used to make programmatic changes? How will the results be used to make curricular changes?

In terms of programmatic changes, we are satisfied with the assesment scores for the lower-level classes.

In terms of curricular changes, because the improved questions provided more granular data on student knowledge, we can see that students generally do very well with the definition of rate, so maybe we can shift more focus onto the area of mechanism and rate laws.

Please include any materials that may be pertinent to your plan as Appendices.

Please submit your Final Report to the UWGB Curricular Assessment TEAMS site by July 31.

Programs are encouraged to consult with the University Assessment Program.

Contact information: uac@uwgb.edu

Post all Plans, Status Updates and Final Reports to the UWGB Curricular Assessment TEAMS site.

Appendix A: Year Three 2024 Assessment: Exam Questions and their rationale for testing PLO: Knowledge of Kinetics

The first question (number 6 on the exam) deals with the most basic question of what we mean when we talk about the "rate" of a chemical reaction. The rate is defined as the change in chemical concentration divided by the change in time. To ensure that our definition of rate is independent of which reactant or product we monitor, the ratio of change in concentration divided by change in time must be divided by the balanced equation coefficient (positive if the species is a product and negative if it is a reactant).

***6.** In class we considered the reaction,*

$$BrO_3^- \; + \; 5\,Br^- \; + \; 6\,H^+ \; \rightarrow \; 3\,Br_2 \; + \; 3\,H_2O$$

Which of the following expressions would serve as a suitable definition of rate?

(a) $\frac{\Delta[BrO_3^-]}{\Delta t}$ *(b)* $-\frac{1}{3}\frac{\Delta[Br_2]}{\Delta t}$ *(c)* $3\frac{\Delta[H_2O]}{\Delta t}$

(d) $\frac{\Delta[Br_2]}{\Delta t}$ *(e)* $-\frac{1}{6}\frac{\Delta[H^+]}{\Delta t}$

Scoring Question 6:
The students were given 1 point for question 6 if there answer was correct and a zero if they were incorrect.

The second question (number 7 on the exam) involves several different knowledge checks. The students are provided a balanced chemical reaction and an initial rate table and asked to determine the rate law. The rate law tells us how the rate depends on the concentration of reactants, among other things as well that we discussed. We only look at reactant concentrations since we focus on the initial rate data, and initially very little to no products are formed. We go over the form of the rate equation as rate = $k[R_1]^X[R_2]^Y[R_3]^Z$...
The value of the exponents must be determined experimentally, that is the purpose of providing the experimental initial rate table. The students must find the exponents by utilizing the data in this table. For example, let's say I triple the concentration of R1 (with corresponding exponent X) while holding all other reactants constant and I observe the rate to increase by a factor of 9 then I know X=2 since 3^2=9. Another common mistake is for students to think that the exponents are equal to the balanced equation coefficients. So in this problem I tested that by adding balanced equation coefficients that were different from the rate law exponents (very important not to make the coefficient the same as the exponent!).

7. The following initial rate table was constructed for the reaction

2 A(g) + 3 B(g) → Products.

Experiment	[A]	[B]	Relative Rate
1	1	1	1
2	2	1	4
3	1	2	2

If the rate law is assumed to have the form $Rate = k[A]^x[B]^y$, determine the exponent values of x and y.

x = __________ y = __________

Scoring Question 7:
The students were given 1 point if they did not assume the balanced equation coefficients were the rate law coefficients. The students were given 1 point for each correct rate law exponent derived from the rate table.

Finally, the third question is a simple test of the students understanding of mechanisms and rates of elementary steps. The collision theory of kinetics says that the rate at which products form is proportional the concentration of the colliding species. This provides the basis for proposing a reaction mechanism. The students are given a reaction mechanism consisting of a single elementary step $NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g)$ and asked if this mechanism is consistent with the observed rate law. Students should know that (since the mechanism is always written in elementary reactions) the given elementary step has a rate law of $k[NO_2][CO]$.

8. You and your lab partner are asked to propose a valid mechanism for the reaction,

$$NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g)$$

which you are told has the experimentally determined rate law of $Rate=k[NO_2]^2$. Your partner suggest that the mechanism could be the simple single step mechanism of

$$NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g) \qquad \textbf{\textit{Elementary Step}}$$

Is this a valid mechanism for this reaction?

(a) This mechanism is *VALID* (b) This mechanism is *NOT VALID*

Scoring Question 8:
The students were given 1 point if they were correct with the consistency of the reaction mechanism with the observed rate law.

Appendix B: Raw Exam Scores

N	49

	Question				
Student ID	**7a**	**6**	**7b**	**8**	**Score**
410735	1	1	1	1	4
812774	1	0	0.5	1	2.5
812531	1	0	1	0	2
505032	1	1	1	0	3
716329	1	0	1	1	3
569232	1	1	1	0	3
818825	1	1	1	1	4
362953	1	1	1	0	3
163440	1	0	0.5	1	2.5
713054	1	1	1	1	4
812546	1	1	1	1	4
378031	0	0	0	1	1
812714	1	1	1	0	3
812806	1	1	1	1	4
802292	1	1	1	1	4
812614	1	1	1	1	4
812471	1	0	1	1	3
812360	1	1	1	0	3
812486	1	1	1	0	3
812348	1	1	1	1	4
716904	0	0	0	1	1
749601	1	1	1	0	3
676571	1	1	1	1	4
812311	1	1	1	1	4
792248	1	1	0.5	1	3.5
409971	0	1	0	1	2
513806	1	1	0.5	1	3.5
540853	1	1	1	1	4
813803	1	1	1	1	4
812185	0	1	0	0	1

	Question				
Student ID	**7a**	**6**	**7b**	**8**	**Score**
813789	1	0	1	1	3
515965	1	1	0.5	0	2.5
510434	1	1	1	1	4
812271	1	1	0.5	0	2.5
677411	1	1	0.5	1	3.5
665836	1	1	0.5	0	2.5
666152	1	1	1	1	4
235605	1	1	1	1	4
513421	1	1	0.5	1	3.5
812882	1	1	1	1	4
814083	1	0	0	1	2
666149	1	1	1	1	4
822725	1	1	1	0	3
812356	1	1	1	1	4
801743	1	1	0	0	2
830167	1	0	1	1	3
812283	1	1	0.5	0	2.5
363548	1	1	1	1	4
594581	0	0	0	1	1
	0.898	0.776	0.755	0.694	3.122
				% effic	0.781