Physical Science Department
Unit-Level Assessment Liaison Report
Spring 2019

Liaison Project Start Date: Spring 2015
Liaison Report prepared by Allan Wilson

With this report, I complete eight semesters of work on assessment with the physical science department. In the fall, I will pass the assessment torch on to the capable hands of Prof. Samar Ayesh, and I look forward to seeing the new directions she takes it in. So I will use this final liaison report as an opportunity to reflect on my time in this role, with its challenges, its (possible) successes, and its (many and definite) rewarding experiences. And I will try not to be *too* maudlin in the process!

Phase 1:
When I started in this role, there was no departmental assessment plan. A big focus of my first year in the role was what our committee calls "department buy-in", which I took to mean "persuading possibly skeptical faculty that assessment is not a secret Fascist plot by the administration to spy on them in their classrooms," But this task turned out to be surprisingly easy, not due to any skills on my part, but because I had drastically underestimated my colleagues' enthusiasm for assessment. This will not be the last time I say this – I have been extremely fortunate to have a department which so thoroughly supports the role of assessment in improving student learning – they are awesome!

Phase 2:
So I was able to begin research on possible assessment tools right away. In consultation with fellow faculty, we chose CHEM 201 (Gen. Chem. I) as the course we were most interested in – it has many sections and serves as the foundational course for students hoping to further study chemistry and its related disciplines.

The American Chemical Society (ACS) has created standardized exams for all of the courses traditionally offered to chemistry undergraduates, and in fact some of our faculty were using these exams in their own classes. They were attractive possibilities as assessment tools, but we were not sure exactly how well any of these tests lined up with what was being taught in HWC chemistry courses. This prompted a deeper question – exactly *what is* being taught in HWC chemistry courses?!

Of course we have a master syllabus with student learning outcomes, but when 128 hours of in-class time is condensed into 8 student learning outcomes, a few things are inevitably left out! So I designed a survey that went through each chapter of our textbook, asking if *this* topic or *that* concept was being taught, and I distributed it to every full- and part-time professor who routinely taught CHEM 201. I was delighted to get a 100% response rate (as I said, my department is awesome!), and the results were quite interesting. There was unanimity about all of the "big" topics traditionally taught (stoichiometry, gas laws, etc.), but in the “corners” of the curriculum, there was more variety. Some professors taught molecular orbital theory, for instance, but most did not.

The results of this survey were two-fold. First, the results of the survey were tabulated and a report created; this report is now given to new adjuncts when they begin teaching CHEM 201. It shows them what topics all the current faculty are teaching (and which they should probably cover too!), and which topics are optional. Secondly, by comparing the results to the topics tested on ACS exams, we concluded that these ACS exams would make appropriate assessment tools.

Phase 3:
For the next several years, we gave ACS exams in all of our classes. In fact, we usually gave two – a pretest and a posttest. Comparing the posttest results in CHEM 201 to national averages revealed that our scores are slightly lower, but not by much (our students answered, on average, 19 questions correctly out of 40, compared to 24 nationally). It was more interesting to look at the specific questions that our students struggled with. Topics that I would have expected students to struggle with (such as resonance) were not difficult, whereas a question about what happens when glucose dissolves in water, which I expected to be *very* easy, was in fact the third most commonly missed question on the entire test.

Pretest results were also interesting. In contrast to *many* anecdotal reports of students complaining that they understand the chemistry, they just don’t understand the math, the pretest for CHEM 201 revealed that students actually understand basic math concepts relatively well. The pretest for CHEM 203 (Gen. Chem. 2) revealed that while students do forget some of the material they learn in CHEM 201, the effect is not large (17 correct questions out of 40 at the beginning of CHEM 203, compared to 19 correct by the end of 201).

Phase 4:
Despite some interesting reports, and some stimulating conversations among the faculty that these reports generated, nothing that we did as a result of these tests seemed to improve overall student performance. Semester after semester, the average number of correct responses out of 40 was stubbornly hovering in the 18-20 range. We began to feel that we had learned everything there was to learn from the ACS exams, and that we needed an assessment that would give us more detailed information about student thought processes on a particular topic.

After several conversations with fellow faculty, the topic that was chosen was stoichiometry – definitely the biggest and arguably the most important topic in CHEM 201. With the help of many faculty (again, huge thanks to my awesome department!), I designed a new assessment that focused on stoichiometry questions with a range of difficulties.

We first gave this assessment in both CHEM 201 and CHEM 121 (Basic Chem.) at the end of Fall 2017. After grading the assessments in the spring, I was initially struck by the poor performance of our students on the final question, which was the most difficult. This was a “real world” question, which gave students a balanced chemical equation but then asked them to perform a stoichiometric calculation not by mentioning chemicals by name (“silver” or “sulfur”) but by their role in the described scenario (“necklace” or “tarnish”). This change stymied many of our students, and they produced correct stoichiometry calculations, *but started from the wrong substance.* As a result, I concluded that our students might benefit from more practice with such real-world problems, which are actually challenging for professors to write. After extensive searching for such questions through textbooks and online resources, and supplementing the results with a few questions that I wrote myself, I was able to distribute a small collection of such questions to faculty at the end of the spring semester 2018.

The second time we gave this assessment, at the end of Fall 2018, I was instead struck by student performance on the second question, which was a "typical" question of a kind that they had certainly seen before. While students did much better on this question than the harder real-world question that came later on the exam, there was still a sizable portion of our students who tried to solve this problem by the wrong algorithmic procedure. In particular, even though this question did not mention the mass of any substance, many students felt the need to shoehorn the molar mass for at least one substance somewhere into their calculations, even if it added extra unnecessary steps. I talked about these puzzling results with my colleagues, and we concluded that many of our students do not truly learn *why* certain calculations are performed when solving a problem, and instead try to memorize a series of rote mathematical steps. Since many typical problems require using a molar mass, students get into the habit of using them even when they are not necessary.
The implication is that students might benefit from more conceptual stoichiometry questions – questions that they cannot solve mathematically and must use a conceptual understanding instead. These questions are also somewhat hard to find, and those that are commonly encountered are usually of a certain type (molecular "pictures" that show ratios of various reactants and/or products). I was able to put together a small packet of other conceptual questions after much searching, supplemented with helpful suggestions from several of my colleagues. (Have I mentioned that my department is awesome? Yes? Several times? Ok then.) My colleagues have been particularly enthusiastic about these questions; I think they perceive them to be both slightly easier and more important than the real-world questions they received last year. This packet has been included in the appendix.

Final Thoughts:
These reports typically end with a discussion of "success factors" and "recommendations". In many ways I still feel like a novice in the huge task of departmental assessment, and such talk seems premature, if not presumptuous. But there are opportunities that I am thankful for, and there are experiences that I hope will present themselves as Samar takes the wheel of this car and drives it to new locations. Looking back over the past 8 semesters, I am thankful for the opportunity to examine student learning in a context larger than my own classroom, and I hope that my colleagues found the results to be as interesting and helpful as I did. I am thankful that those results prompted me to create learning materials that I would never have envisioned otherwise, and I hope that my colleagues find them useful. I am thankful for the opportunities to discuss chemistry and education with my colleagues, and I am thankful for the improvements to my teaching that were inspired by those conversations. I hope that my colleagues also benefited from those conversations. I am thankful for invaluable advice and encouragement from Erica and the other members of the assessment committee, and I hope that the administration continues to provide the committee with the resources it needs to continue its mission effectively. And, of course, I am thankful for the support and participation of the rest of my (awesome!) department, and I ***know*** that the Physical Sciences, under Samar's leadership, will make great strides in the semesters ahead.

Appendix:

Conceptual Stoichiometry Problems

Iron, over time, combines with oxygen in the air to form rust (iron oxide), according to the reaction below.

$4\ Fe\ (s)\ +\ 3\ O_2\ (g)\ \rightarrow\ 2\ Fe_2O_3\ (s)$

Imagine you had a sample of iron which rusts completely over time. Which statement below is most accurate?

A) The mass of iron oxide rust that results will be **greater than** the mass of iron that was originally present.

B) The mass of iron oxide rust that results will be **less than** the mass of iron that was originally present.

C) The mass of iron oxide rust that results will be **equal to** the mass of iron that was originally present.

D) We cannot determine which mass is greater without knowing the starting mass of iron.

Tin forms two different stable compounds with bromine, and both can be decomposed to elemental tin and bromine (a process called electrolysis), as shown in the two equations below.

$SnBr_2\ \rightarrow\ Sn\ +\ Br_2$

$SnBr_4\ \rightarrow\ Sn\ +\ 2\ Br_2$

If you have separate samples of each reactant, and both samples have the same total mass, which one would yield the larger amount of tin product?

A) The $SnBr_2$ will yield the greater mass of tin.

B) The $SnBr_4$ will yield the greater mass of tin.

C) Both samples will yield the same mass of tin.

D) We cannot determine which will yield more product without knowing the exact mass of our starting materials.

A student has a solution of silver nitrate and she wishes to precipitate the silver ions using chloride ions according to the equation below.

$Ag^+\ (aq)\ +\ Cl^-\ (aq)\ \rightarrow\ AgCl\ (s)$

She has two solutions that she could use, a 1.0 M solution of NaCl and a 1.0 M solution of $CaCl_2$. She decides to use the NaCl solution and observes that it required 10 mL of the NaCl solution to completely precipitate the silver. If she had instead chosen the $CaCl_2$ solution, what volume would she have needed to use?

A) 5 mL

B) 10 mL

C) 20 mL

D) We cannot answer this question without knowing the volume and concentration of the silver nitrate solution.

A student tears off a piece of aluminum foil that she wishes to react with HCl according to the reaction below.

$$2\ Al\ (s)\ +\ 6\ HCl\ (aq)\ \rightarrow\ 2\ AlCl_3\ (aq)\ +\ 3\ H_2\ (g)$$

What is the most accurate statement about the moles of HCl that she will need?

A) She will need 3 moles of HCl.

B) She will need 6 moles of HCl.

C) She will need 12 moles of HCl.

D) We cannot answer this question without knowing the mass of aluminum foil.

Ozone (O_3) decomposes into molecular oxygen according to the equation below.

$$2\ O_3\ (g)\ \rightarrow\ 3\ O_2\ (g)$$

If you had a sample of ozone which decomposes into oxygen, which of the following statements is true?

A) The mass of the oxygen at the end is greater than the mass of the starting ozone.

B) The volume of the oxygen at the end is less than the volume of the starting ozone.

C) The total number of molecules does not change during the reaction.

D) The total number of atoms does not change during the reaction.