Assessment of General Chemistry Course

Samar Ayesh, Ph.D.
Unit Level Liaison for Dept. of Physical Science

Previous Assessment for Chemistry in the Department

I remember when I first joined the Physical Science department as an adjunct in fall of 2009, I was asked by the Chair at that time to use one of the ACS (American Chemical Society) Standardized Exam as a Final Assessment for my CHEM 201 course. I was told to leave the Scantrons and all the scratch paper in a folder in his office. I wasn't sure what, if anything, was done by the data collected.

Two years later, I joined as a full time and I kept using the same assessment. I was giving the exam, using the grades as a final exam and putting them aside. Unfortunately, I never examined the results in detail nor did the department. Sometimes I would quickly glance at the results to check which question was missed the most. I always wanted to dig deeply but never seemed to have the time.

Fast forward to 2017, when Allan Wilson became the first Assessment Liaison for the Physical Science Department. He was able to analyze the data of this ACS assessment from several semesters. The results showed that our students' scores are slightly lower than the national averages (our students answered, on average, 19 questions correctly out of 40, compared to 24 nationally). The results also showed us in detail the topics that students struggled in the most.

This led Allan to design a new assessment that focused on stoichiometry. It consisted of 3 stoichiometry questions with a range of difficulties. Results of this new assessment were not very encouraging since a big portion of students used the wrong algorithmic procedure to solve a "typical" question. It implied that students might benefit from more conceptual stoichiometry questions – questions that they cannot solve mathematically and must use a conceptual understanding instead.

Motivation for a New Plan, 2019-2020

In fall 2019, I took over the Assessment Liaison role for the Chemistry courses within the Physical Science department. Based on all the great work that Allan did, it was clear to me and others teaching CHEM 201 that student learning seems to be missing some important component. The results of the ACS assessment clearly indicated the areas that students are challenged. So I designed several "Learning Activities" which were meant to engage students in exploring the big ideas and concepts in order to develop the desired understandings, knowledge, and skills that they should come away knowing by taking CHEM 201. These activities were meant to be used in the classroom, so I am hoping to use them once we go back to face-to-face instruction. In the meantime, they will be share them with all faculty teaching CHEM 201 in order to use them in their classroom and get initial feedback.

Establishing Goals, 2020-2021

It is clear to us faculty teaching Chemistry 201, that student learning seems to be missing some important component. I decided to examine the course SLOs more closely. The first steps towards an effective assessment plan is to establish goals and develop specific measurable learning outcomes. It is very important to first determine what we faculty expect students to learn. The master syllabus for the course shows only 16 student learning outcomes. So this semester I used the survey that Allan designed earlier, in which he went through each chapter of our textbook, asking if this topic or that concept was being taught, and created a specific SLO for every topic that faculty taught. This came to 56 SLOs covering 13 chapters. I e-mailed the list to the faculty who typically teaches the course (a total of 6 faculty, both FT and adjuncts). I asked them to read the entire list and tell me which of those 56 they do not teach.

Using Wiggins and McTighe's "Understanding by Design", I asked the faculty to classify the SLOs as critical, important, or desirable, based on the following definitions.

- Critical outcomes (CRO) are considered to be vital and of fundamental importance. They are outcomes in which an enduring understanding is needed, such that students will remember them long after the details have faded.

- Important outcomes (IMO) are more specific and pertain to ideas or skills that the student must know or be able to do. Student learning is incomplete without mastery of these essentials.

- Desirable outcomes (DO) are recognized as worth knowing, but the aim is exposure, not mastery.

The table below shows a few of these SLOs from different chapters. The first column is based on the survey conducted by Allan Wilson in 2017. It shows the number of faculty teaching a specific topic.

Topic	Student Learning Outcome	SLO Classification
Unit conversions involving units in the denominator (for instance, converting m/s to m/min)? **Yes__6__ No____**	**1. Apply derived units, such as volume and density, to perform calculations.**	**CRO**

Unit conversions involving units raised to a power (for instance, m^2 to cm^2)? **Yes__6__ No____** **Do your students memorize SI prefixes *other than* kilo, centi, milli, and micro?** **Yes__3__ No__3__**	**2. Utilize conversion factors to conduct unit conversions.**	**CRO**
	3. Apply dimensional analysis toward solving problems with multiple steps or conversions.	**CRO**
	4. Utilize SI unit prefixes.	**CRO**
Relating atomic weights to isotope abundances? **Yes__6__ No____**	**Calculate the average atomic mass of an element given the atomic mass and relative abundance of each of its naturally occurring isotopes.**	**DO**
Calculating empirical and molecular formulas? **Yes__6__ No____** **If yes to the above, do your students learn to solve combustion analysis problems?** **Yes__4__ No__2_**	**1. Determine the empirical formula of a compound from percent composition or from combustion analysis data.**	**CRO**
	2. Determine the empirical formula of a compound using combustion analysis data.	**DO**
	3. Utilize the empirical formula and molar mass to determine the molecular formula of a compound.	**IMO**

Do your students memorize strong/weak acids and bases? **Yes__4__ No__2__**	**Identify weak and strong acids and bases.**	**DO**
Calculating oxidation numbers? **Yes__5__ No__1__**	**Apply oxidation number rules toward determining the oxidation number of each element in a compound or polyatomic ion.**	**IMO**
Calculating the molarity of electrolytes (for instance, the sodium of sodium sulfate)? **Yes__6__ No____**	**Calculate the molarity of a solution and molarity of ions in solution.**	**CRO**
Bohr model of the hydrogen atom? **Yes__6__ No____**	**Apply Bohr's theory of the hydrogen atom to calculate energy levels.**	**CRO**
Do your students memorize the ideal gas law? **Yes__4__ No__2__** **If yes to the above, do your students memorize relationships such as Charles's Law, etc?**	**1. Use the ideal gas equation to determine the pressure, volume, moles, or temperature of a given all of the other values.**	**CRO**

Stoichiometry involving the ideal gas law? **Yes__6__ No____**	**2. Use the ideal gas equation in stoichiometric calculations.**	**IMO**

Designing and Conducting the Assessment

Since we were able to classify our SLOs for CHEM 201, I believe now we have a better understanding of what exactly we want our students to learn. We should be able to design an assessment that is tailored to our own department and students. The main purpose of this is to build as assessment tool based on these SLOs. Using these measurable SLOs, and based on their importance, we need to design an assessment that should help us determine the extent of student knowledge. The questions should be written to measure specifically each (or most) of the SLOs and should be able to determine what students learned. The results of this assessment should help us answer questions such as: "What should students come away understanding, knowing, and be able to do?", "What evidence can show that students have achieved the desired results" and "What would count as evidence of successful learning?"

Work in Progress

We were able to come out with 27 SLOs that we deemed as "Critical Outcomes" (CRO); i.e. SLOs that are considered to be vital and of fundamental importance. The plan was to prepare an assessment that is about 20-25 questions based on these CRO outcomes. A pilot is planned to be given during spring/summer 2021, and data analysis to be performed in the fall.