# Assessment Report - 2017/2018 AY

Department of Chemistry & Biochemistry

## Program-Level Assessment Activities

In the Department of Chemistry & Biochemistry, we officially house four majors, which each are technically a separate program. However, the content overlap between them is very high. We use the same PLOs for all four of our programs. As we build an assessment plan over the next four years around our new PLOs, we plan to consider how our expectations for majors in the four programs will differ for each of the PLOs. Therefore, we will use the same measure for all programs, but separate results by the programs in which the student participated and in some cases establish different thresholds for what we consider successful.

|  |  |  |
| --- | --- | --- |
| **Tagline** | **PLO** | **Educational Framework** |
| Know Chemistry Fully | Students will comprehend fundamental chemistry concepts and properly apply them in the five sub-disciplines (Organic, Physical, Inorganic, Analytical, and Biochemical). | Learning |
| Do Chemistry Fearlessly | Students will demonstrate proficiency with safe lab techniques, scientific instruments and computer applications in their implementation of experimental design, measurement, analysis, and interpretation. | Learning and Vocation |
| Speak Chemistry Fluently | Students will communicate effectively—individually and as a team—through written, oral, and visual presentations that demonstrate their capacity to assimilate and convey scientific ideas from experiments and the literature. | Vocation |
| Live Chemistry Faithfully | Students will exhibit scientifically and theologically grounded principles that inform their personal and communal participation in work, worship, service, and stewardship. | Faith and Citizenship |

### 2017-2018 Assessment Activities

**Know Chemistry Fully:**

*Senior Exam*

In the fall semester, we did an analysis of the questions on the current MFT to determine if they covered content that we expected our students to know and thought it was worthwhile for them to know. The results of this analysis are shown in the table below. The department met and discussed these results and decided that the MFT did not cover enough content that was important to the department to make it worthwhile to continue to administer.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Questions** | | **Expect to Know** | | **Care if Know** | | **Is what we teach represented?** |
|  | *count* | *percent* | *count* | *percent* | *count* | *percent* |  |
| Overall | 100 | - | 85 | 85% | 74 | 74% |  |
| Organic | 27 | 27% | 23 | 85% | 20 | 74% | ~1/4 not represented |
| Analytical | 16 | 16% | 13 | 81% | 11 | 69% | No |
| Inorganic | 25 | 25% | 22 | 88% | 17 | 68% |  |
| Physical | 25 | 25% | 21 | 84% | 21 | 84% | Some useful data |
| Biological | 12 | 12% | 9 | 75% | 9 | 75% | No |

The committee decided to try a completely different type of exam this year and then use the results as a platform to discuss what we value in a senior exam and what we would like it to look like in the future. The exam given was adapted from a similar exam given by the faculty at Smith College, where students were asked to review and identify mistakes in a doctored manuscript.[[1]](#footnote-1) The department decided to use Smith College’s exam rather than invest the time in creating our own for the first trial run of this type of exam. For the exam, students first analyzed the paper on their own, then were placed into groups to identify further errors and propose corrections and revisions.

**Summary of Individual Results**

Below is a table reporting the median number of errors identified by student major. Additional comments that were significant but not represented by the current rubric were also noted. The weighted total is the sum of the errors plus half the sum of the additional issues noted.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Major** | **Students** | **Errors** | **Additional** | **Weighted Total** | **GPA** |
| BIOCH | 25 | 1 | 1 | 2 | 3.52 |
| BIOCH+ACS | 4 | 3.5 | 1 | 3.5 | 3.62 |
| CHEM | 4 | 2.5 | 2 | 3.5 | 3.54 |
| CHEM+ACS | 8 | 3.5 | 1.5 | 5 | 3.82 |
| *Total* | *41* | *2* | *1* | *3* | *3.57* |

Below is a scatter plot of student GPA versus number of errors identified.

*Notes on Implementation*

A number of students were distracted by the poor writing and missing experimental components in the paper. If we pursue this model in the future, we should make an effort to put the paper together more carefully than the model used this year. Furthermore, the comments students made about the paper that were not counted in the rubric were insightful and valuable. In the future, we may want to consider a way to systematically count those observations as well.

**Summary of Group Results**

*Overall Performance on the exam.*

After reviewing the rubric and expectations, the committee predicted that on average, students would be able to identify 6-8 errors and that their answers would fall primarily in the fair and good categories.

Below are the results summarized by particular issue. For comparison, performance by students at Smith College were included (format of their exam differed slightly)

|  |  |  |  |
| --- | --- | --- | --- |
| **Issue** | **SLO Mapping and Prediction** | **Team Performance** | **Smith College** |
| **Overall goals of paper** | Speak (2) and (5)  Most students Fair - Good | Poor: 4  Fair: 8  Good: 1  Excellent: 0 | Poor: 4  Fair: 2  Good: 1  Excellent: 0 |
| **Assertion about ion size:** | Do (8) and (11), Know (8a)  Most students Fair - Good | Poor: 1  Fair: 5  Good: 7  Excellent: 0 | Poor: 0  Fair: 1  Good: 4  Excellent: 2 |
| **Emission vs. absorbance**  **intensity** | Know (8)  Most likely Fair category for most | Poor: 9  Fair: 4  Good: 0  Excellent: 0 | Poor: 6  Fair: 1  Good: 0  Excellent: 0 |
| **Assignment of NMR peaks** | Know (8)  Most students Fair - Good | Poor: 6  Fair: 0  Good: 7  Excellent: 0 | Poor: 4  Fair: 3  Good: 0  Excellent: 0 |
| **Expected NMR shifts from anion coordination** | Most students Fair - Good | Poor: 9  Fair: 4  Good: 0  Excellent: 0 | Poor: 2  Fair: 3  Good: 1  Excellent: 1 |
| **Evidence for coordination vs. deprotonation by anion** | Most students Poor - Fair | Poor: 6  Fair: 6  Good: 1  Excellent: 0 | Poor: 4  Fair: 1  Good: 2  Excellent: 0 |
| **Job plot:** 2nd Job plot is too noisy to assert a 1:1  stoichiometry | Most students Fair | Poor: 4  Fair: 3  Good: 4  Excellent: 2 | Poor: 0  Fair: 1  Good: 4  Excellent: 1 |
| **Binding constant for CN- is wrong** | Most students Poor | Poor: 6  Fair: 4  Good: 3  Excellent: 0 | Poor: 4  Fair: 1  Good: 2  Excellent: 0 |
| **Electronic effects on**  **Transition energies** | Know (8)  Few students will pick up on this, most that do will be Fair | Poor: 10  Fair: 2  Good: 1  Excellent: 0 | Poor: 3  Fair: 1  Good: 3  Excellent: 0 |

*Notes on Implementation*

It was really cool to see the students work in groups during the exam – they were looking things up and having good discussions about various issues. Overall, the engagement in the room was strong and student energy seemed to be quite positive. The prizes were a nice addition for motivation for the students to be invested in the product. If this is done in the future, it may be worthwhile to engage with each of the groups early on during the group exam to make sure they are on track and are not getting distracted by minor issues. Student comments related to improving the analysis and data presentation in the paper were also interesting and insightful, we may want to include this in the rubric in future years, it would fit well with the speak chemistry PLO.

*Notes on Department Discussion*

The department met on April 20th to review the results of the exam. On reviewing data, faculty noted the lack of correlation between GPA and score on this senior exam, suggesting GPA is not a complete indicator of ability to apply knowledge to new situations. This highlighted one of the strengths of this exam, which was to test skills beyond simply ‘Know Chemistry’. The department also noted that in the group results, students did not do quite as well as we anticipated in many categories. There are challenges to learning too much from the data in the current format because the focus does not align well with our PLOs. If we write our own exam, in future years it will be easier to determine what changes we would want to make in response to the data. Faculty members also noted that these would be different changes from the ones made based on the MFT. Rather than adjusting the content in one course, we would likely need to think program-wide about how to address various deficits identified by the exam. The advantage of this format, however, is that it can address more than just ‘Know Chemistry’. The department would like to review the new DUCK18 (ACS) standard exam when it is released. Depending on what it covers, it may be a good intermediated between the MFT and then exam tested this year. It would also allow us to compare our results to national standards. Once the DUCK is available, the committee will review the test and report back to the department. If it does not provide the coverage we are looking for, we will likely write our own exam next year.

*ACS National Examinations*

ACS national exams were used in CHEM 103, 104, 105, 262, 230, and 201.

For most courses these results were used by the professors within the course to standardize their grading scales. Last year for CHEM104, we saw the highest averages ever. This made us question what has changed: teaching, cheating or student acumen. The Chem 104 exam was leaked online this past year. This year, we changed exams to eliminate the middle option. The results are shown in the table below:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *Year and population* | Students | ACS Avg | ACS Median | National Average | *Notes* |
| **2016/2017 103** | 277 | 51.2 | 52.0 | 37.1 |  |
| **2016/2017 103 to 104** | 106 | 56.3 | 59.0 | 37.1 | *103 scores of students who went on to take 104 the next semester* |
| **2016/2017 104** | 120 | 54.1 | 56.0 | 39.0 | *test leaked online* |
| **2017/2018 103** | 262 | 44.2 | 47 | 37.1 |  |
| **2017/2018 103 to 104** | 115 | 47.1 | 47 | 37.1 | *103 scores of students who went on to take 104 the next semester* |
| **2017/2018 104** | 130 | 47 | 47 |  | *New ACS exam* |

We will wait another year to see if the dip in 103 scores is an anomaly. Even with the dip, our average remains high above the national average. As part of our core assessment, we will work this year to agree as a department on numerical targets for student scores on the exam.

**Do Chemistry Fearlessly:**

In the past few years, we have primarily focused on how we are equipping students to perform the fundamental skills prioritized in general chemistry. Our goal for the coming year is to look more broadly across our curriculum to understand where students struggle and what we cover well.

*Chemistry 104L Assessment Results from Spring 2018*

Based on previous years data on performance in and anxiety around the 104L practicum, we introduced a practicum at the end of CHEM103L (fall) to prepare students for the more extensive CHEM104L practicum (spring). The fall practicum was focused only on dilutions. Students had to reach a particular target and were allowed to make as many attempts as needed to be successful. Number of attempts to reach the target were recorded. The average number of attempts required to be successful was 1.5.

No correlation was observed between the number of attempts students required to be successful in CHEM103L and their practicum score in CHEM104L. However, the level of anxiety around the practicum was generally lower this year and students overall comfort with making solutions throughout the semester was reported as higher by individual instructors this semester.

Below is the average score of student on the CHEM104L practicum over the past three years. The first row is their total score, the next rows break down specific skills tested on the practicum. Note the jump in score for dilution and choosing the appropriate glassware for the dilution.

|  |  |  |  |
| --- | --- | --- | --- |
|  | 2016 (121 Students) | 2017 (117 Students) | 2018 (125 Students) |
| Total | 64 % | 69 % | 71% |
| Titration | 65 % | 69 % | 66% |
| Dilution | 63 % | 68 % | **79%** |
| Glassware | 53 % | 73 % | **82%** |
| Excel | 71 % | 74 % | 70% |

We used the categories of exemplary, proficient, developing, and remaining to bin our students. Below is the data over the past three years using these categories. The data shown is for all students:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Spring 2016  (121 students) | Spring 2017  (117 students) | Spring 2018 (125 students) |  |  |
| Category | ***%*** | ***%*** | ***%*** | **Grade** | **Notes** |
| Exemplary | 22.3 | 23.9 | 33.6 | 85-100 | within 2% error on titration and dilution |
| Proficient | 22.3 | 28.2 | 22.4 | 70-85 | within 4% error on titration and dilution |
| Developing | 28.9 | 31.6 | 22.4 | 55-70 | within 8% error on titration and dilution |
| Remaining | 26.4 | 16.2 | 21.6 | 0-55 | greater than 8% combined |
| Total | 100.0 | 100.0 | 100.0 |  |  |

We were pleased to see the increased number of students in the exemplary category this year and will repeat the CHEM103L practicum next year to see if this trend persists. We would like to see almost all the students who take the course at least at the developing level. Possible reasons they are not currently there could include lack of exposure to laboratories in high school, and over-crowded labs[[2]](#footnote-2) in 103/104 that are not conducive to learning laboratory skills. Largest challenges noted this year were being able to help all students based on the size of the labs. The department and assessment committee will discuss this year plans whether the role of the labs is primarily skill development or support for classroom concepts. In light of this discussion, revisions will be made to the lab curriculum to prioritize one of these two goals and shape future assessment plans for the lab.

*Analysis of 2016 and 2017 data of students that were declared majors as sophomores*

Below is the 2016 and 2017 data using the categories described in the previous section. Results are shown for all students who took 104L in 2016 and 2017 and were declared chemistry or biochemistry majors in April of 2017 or 2018.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Category | Majors in 2017 | % for Majors | Majors in 2018 | % for Majors | Grade | Notes |
| Exemplary | 5 | 29.4 | 8 | 36.4 | 85-100 | within 2% error on titration and dilution |
| Proficient | 6 | 35.3 | 6 | 27.3 | 70-85 | within 4% error on titration and dilution |
| Developing | 5 | 29.4 | 6 | 27.3 | 55-70 | within 8% error on titration and dilution |
| Remaining | 1 | 5.9 | 2 | 9.1 | 0-55 | greater than 8% combined |
| Total | 17 |  | 22 |  |  |  |

We would like to see 90% of our majors at the proficient level. Currently, this is not what we observe. We would like to see another year of major data before thinking about adjustments. We should also include the students from CHEM105 in this analysis in the future.

*Do Chemistry across the Program*

See section on plan for program-level assessment activities in 2018 – 2019 for a description of how we will assess competencies throughout our program next year

**Speak Chemistry Fluently:**

The focus of this 2017-2018 academic year was on better understand our Speak Chemistry PLO, both in terms of what we actually do related to this PLO and where our students excel and where they struggle. The data collected was collected particularly for this year, in future years we may not look this closely at each particular measure and outcome.

The department as a whole was asked to reflect on the measures and rubrics used and predict what they would expected our students to be able to do. This was done so that along with the data, we could also gauge how well we knew our students abilities and anticipated possible areas of deficiency. The data was discussed during the department retreat in August 2018. The data as well as faculty responses to the data can be found in **Appendix I.**  Below are discussion notes and outcomes from the departmental discussion.

*Discussion Notes from Department Retreat*

* Opportunity to increase student learning by increasing transparency
  + This means providing students with rubrics used to assess their work as well as examples of good and week work
  + It would benefit the department to develop these standards for posters, presentations, and writing projects.
* Now that we have seen some examples of work, we need to agree on department benchmarks for what constitutes appropriate levels of performance.
  + Current PLO as written doesn’t provide any benchmarks/targets
* Challenging to assess the data with different rubrics that have different standards of performance. It would be better to have one rubric (used outside of class grades) that would work at various levels. Assessment would focus on a fewer number of samples of student work.
  + Inclusion of common language/images/branding to help students track across the curriculum and align the departmental message in individual courses.
* Equipping students for scientific writing is different than for non-scientific writing, but both are important. Can we do this by leveraging courses and content to which we already have access rather than by adding another course?
* We don’t do anything with team training. It would be helpful for the department to clarify what it defines as teamwork and what teamwork skills it really values. If we could describe a level 1, 2, and 3 performance, we could ask students to self-assess on tasks they are already completing. We should find ways to better use opportunities that already exist in the department.
* Not all classes have to meet all components of the PLO or even all sub components. We could strategically think about pairing different courses and assigning them different lines of focus.

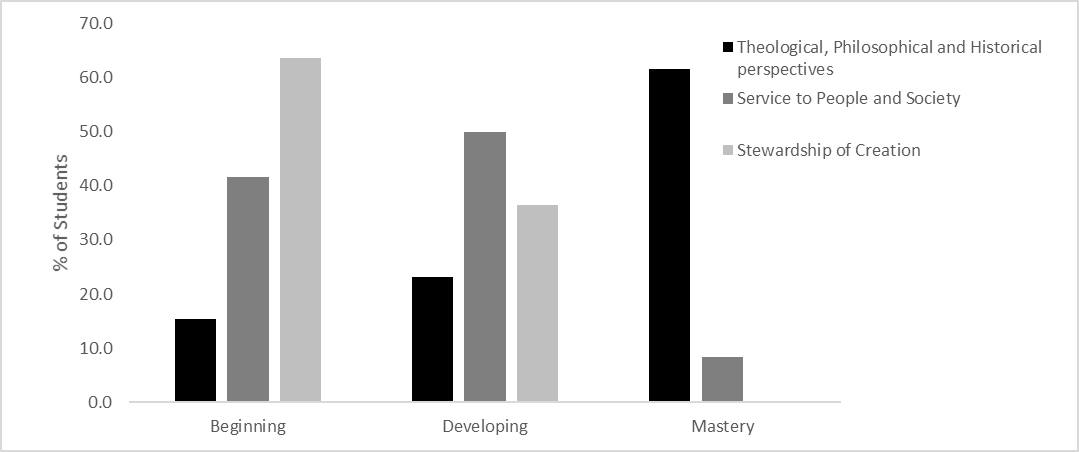
*Outcomes*

The department plans to develop a rubric with clear benchmarks for each subcategory of the Speak Chemistry PLO that can be used across courses to map student progress through our major and determine how well our seniors (through our capstone course and seminar course) are meeting this PLO.

**Live Chemistry Faithfully:**

IDIS310 has been recast as “Science in Society” and was co-taught by R. Baker and M. Walhout this year. Below are the reports of assessing the ‘Live Chemistry’ component of this course. The ‘Speak Chemistry’ component assessment is included with the Speak Chemistry report above. This year, 18 of our junior and senior majors enrolled in the course. Over the course of the semester, they were asked to explore a current scientific advance from a historical, societal, philosophical, ethical, and Christian perspective. A summary of the results relevant to the Live Chemistry PLOS are shown in the table below.

Students were scored as (1) beginning, which was identified as simplistic statements, no integration of ideas throughout discussion , (2) developing, where there was some recognition of nuance and an attempt to integrate the discussion with other ideas and (3) mastery (at this level), which included a complex and nuanced exploration of multiple aspects of topic integrated throughout the project.



Instructors noted significant growth in the areas of understanding historical and philosophical perspectives on chemistry, which was the purpose of the course and was evidenced by the number of students obtaining a 2 or 3 in this category by the end of the semester. However, students consistently struggled with how to discuss and understand their topics within a Christian framework. While some students showed significant growth in this area over the semester, a significant number of others struggled to move past statements that were simplistic and naïve. In the next few years as we think about how to prepare students in the Live Chemistry SLO category, it will be important to think about how we tackle difficult topics and meaningfully make a Christian framework explicit in those discussions. One semester is not enough time to develop this type of thinking from the ground up. Below are some examples of the types of ideas that scored high and low in the faith integration categories. Note that their scores in this category came not just from these sentences, but from how they continue to integrate and explore these ideas throughout their writing.

|  |  |  |
| --- | --- | --- |
| **Topic** | **Score** | **Example text** |
| Acceptability of Naturopathy in the US | 3 | Christians have a unique responsibility to enter in these ethical considerations due to our calling to care for each other. Just as medical practitioners are under oath to provide the best care possible, we too should take up our responsibility to make sure that those around us are receiving optimal care. Looking at the historical aspects to the acceptability of naturopathy has also shown us how intertwined science and religion are, indicating that perhaps people of faith are more connected to these scientific discussion than we originally thought. |
| Renewable Energy Technologies | 3 | A religious approach to energy follows closely with a religious perspective on climate change in general. The religious perspective considers the moral responsibility people have toward other people and the moral responsibility they have toward the environment. The debate about these responsibilities stems from different interpretations of God's mandate to humans in Genesis. |
| Stem Cell Research | 2 | Scripture does not give any very clear indication of whether embryos are people. However, it does strongly promote the Christian principle of loving our neighbor. Therefore, one of the most important questions to ask is whether or not the embryo is our neighbor. |
| Phage Therapy | 2 | Christians should be at the forefront of harnessing technology for ethical purposes by leveraging the dizzying speed of technological advances in phage therapy. We abused antibiotics; hopefully, we can learn from our mistakes to better and bodly extend stewardship to all of creation - even the microbial world. |
| Opioid Crisis | 1 | In conclusion, America's opioid crisis is a serious, multi-faceted problem that cannot be easily solved. It can be attributed to pharmaceutical companies who falsely advertised their products as non-addictive, but also to the phenomena of declining religion in the U.S. Moving forward, we must be careful not to destroy the bond of faith in Christ that this nation was founded upon...Let us hope that the problem of opioids is solved before we start singing hymns about opiates instead of Christ. |
| Vitamins | 1 | God gave us this life and he sacrificed his only son for us. The least we can do is honor God by showing him we are thankful by giving him the best physical temple we possibly can. We can do this by honoring God with your body and giving your body the right nutrients to thrive. |

**Senior Survey (Covering Aspects of Know, Speak, and Live Chemistry)**

All senior students were surveyed before taking the senior exam this year. Some of the results we would like to pay attention to in the future are shown below.

*Number of Students that worked with the Career Center*

19/41 responded with a Yes

*Mapping of Courses Choices to Major or Program*



*Gains in particular areas*

Rate your ability when you started at Calvin and now:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Then | Now |  | Example Comments |
| **Ability to write clearly and efficiently** | 3.15 | 4.71 | 1.56 | * "Efficiently" is always a struggle * Better "science writing" skills now * Better understanding of scientific writing * writing clearly and efficiently looks different in different disciplines * I would have liked more experience with writing scientific papers * I have learned a lot more about scientific writing here at Calvin |
| **Oral communication skills** | 3.05 | 4.51 | 1.46 | * Better research presentation skills * Had to give a lot of presentations over the 4 year which increased my oral comm. Skills * I now have more of the vocab I need to talk about the concepts * I really struggled at the beginning of college and now I've presented to the chem department on my research |
| **Ability to organize and present data visually** | 2.98 | 4.76 | 1.78 | * Research and lab courses help immensely |
| **Ability to evaluate the quality of information sources** | 2.98 | 4.80 | 1.82 | * Became much more comfortable looking at scientific literature and interpreting what it says * Could still use more practice in this area * Especially aided by Looyenga's Biochem II and Baker's biochem lab * Journal club great for this |
| **Ability to collaborate with others** | 3.71 | 4.85 | 1.14 | * Especially on research/lab-style papers and reports * In advanced classes, always had competent and motivated students to work with |
| **Ability to articulate strategies for stewarding the creation** | 2.68 | 4.29 | 1.61 | * Chem 295 and Prof Sinniah * Documentaries on the topic were quite helpful and 304 as well |
| **Understanding of theological, philosophical, or historical perspectives on chemistry** | 2.24 | 4.00 | 1.76 | • Could have been more thorough  • I didn't take the history of science capstone  • I've gained a lot here, and IDIS 310 has been great. |
| **Articulating the role of chemistry in service to people and society** | 2.37 | 4.39 | 2.02 | * Not touched much except in 304 |

Rate the following (very satisfied=4, satisfied=3, dissatisfied = 2, very dissatisfied = 1):

No students were very dissatisfied with anything. 7.7% dissatisfied.

|  |  |  |
| --- | --- | --- |
|  | **Score** | **Comments** |
| Major as a whole | 3.4 | * looking back, I wish I had majored in biology * I wish more bio classes were an option or a molecular bio major * I wish I took more advantage and asked more questions * I know I had neuroscience as a concentration, but I wish I had more bio classes |
| Advising | 3.5 | * Did not connect that well with my advisor, only saw him twice a year for advising break * he wasn't my best fit advisor but he was very helpful * I did most of the work, which was easy * I wish they would have pushed me harder in my freshman and sophomore years * majority of my advising came from biology * the one problem was the unknown independent research I didn't know I had to do |
| Courses | 3.5 | * add advanced organic synthesis * disappointed that instruments wasn't offered when it worked for me * much better than biology major * you really have to plan things out in order to take the classes you want even then they may not be offered or you might not get in |
| Engagement | 3.6 | * demolished other departments in terms of difficulty |
| Connections | 3.4 | * everyone is easily accessible * faculty is very approachable, and I'm glad I got to know some well over the years * liked all the instructors I had * Wish I had spent more time to connect with one or two faculty on a closer level, and that I had been more involved outside of just class for my own personal growth in science |
| Career Options | 3.1 | * all of my jobs and grad school plans came from faculty connections * focuses on very traditional paths and not much else outside of med and grad school * it only comes through email, and our email is wonky * most info came from pre-med advisors but department was still helpful |
| Other Students | 3.2 | * got to work with a lot of different people * harder to connect with students as a transfer * I didn't do summer research and feel I don't know many of them * I never really felt a sense of community within Biochem. Maybe having a common space that is fairly appealing to study in would help? * I'm a transfer and never really made any friends * other than summer research it’s hard to meet people in other years |

The department doesn’t plan to do much with this information as it is the first year of the survey, but we will implement the survey again next year and begin to look for trends between years. This data will not replace direct measures of student learning but is meant to complement the direct measures and keep us attentive to the overall culture of the department and community and support students perceive to be available.

***Overall Summary of Data and Plan***

The department collected data in a number of areas this year. The major outcome from the data was a recognition that we should work on improving some of our measures (developing new rubrics) and setting a few clearer benchmarks to help with decisions about where interventions are warranted. The department will work on those rubrics over the coming year and continue to collect data where warranted. We have decided to hold off on any major curricular changes until we have carefully assessed each of our four PLOs and have a better handle on major areas that need to be addressed and how they might be related. Individual faculty have been encouraged to make changes within their own courses in response to the data as they see fit, and we are pleased to report that data informed decisions are being made. For example, students in Chemistry seminar are now provided with the rubric that is used for assessment to make the features of a quality presentation more transparent to all students. The faculty teaching Chem 317 have also revised how the present and implementing their writing project after the Speak Chemistry PLO assessment report discussion that happened at the department retreat.

### Review of Previous Action Plans

Our goals after reviewing the data from last year’s assessment were to:

1. Evaluate the MFT for effectiveness and consider an alternative senior exam
2. Run a senior survey for the first time
3. Add a short practicum to Chemistry 103
4. Evaluate the Speak Chemistry PLO

We completed each of these goals in the past year. Outcomes are discussed in detail throughout the report and are briefly summarized here:

1. Evaluate the MFT for effectiveness and consider an alternative senior exam – *we completed this, determined it was not effective, and did a trial run of an alternative senior exam.*
2. Run a senior survey for the first time – *this was completed while also implementing the new senior exam*
3. Add a short practicum to Chemistry 103 – *this was done and data analysis suggests it positively impacted student performance on the Chemistry 104 practicum as well.*
4. Evaluate the Speak Chemistry PLO – *data was collected and discussed by the committee throughout the year. The department met in August and discussed the data as a whole and then developed and approved a plan to increase our ability to measure and target specific areas of this PLO in future years.*

### Plan for Program-Level Assessment Activities in 2018 - 2019

## Measures of Student Learning

There are a number of measures of student learning we plan to collect each year. Each year, we will also focus on one PLO in particular (see schedule below). In the year that we focus on a particular PLO, we will make choices for additional direct measures of student learning to include. At the end of that year, we will decide which, if any, will be included in our yearly cycle moving forward and revise our plan accordingly.

|  |  |  |
| --- | --- | --- |
| Measure | Assessment | PLO Alignment |
| Senior Exam (yearly) | Do our students perform above the national average in each sub-category (if a national exam is chosen)? | Know Chemistry |
| Senior Survey (yearly) | Identify areas of consistent strength to continue and weaknesses (across multiple years) to improve. Set benchmarks for what want to see. | Do, Speak, and Live Chemistry |
| Capstone Papers | Integration of faith in topic, scored by rubric with review of individual student statements. Set benchmarks for what want to see. | Live Chemistry |
| Speak Chemistry PLO | *Develop department-wide rubric for PLO* | Speak Chemistry |
| Lab Practicum Data (particular focus for this year) | Measure whether students reach a particular level of mastery (developing/proficient), determined by a grading rubric and standard grading scale. | Do Chemistry |

## A Process for Responding to the Results

Data will be gathered by the Curricussessment committee from the sources of interest. The department has assembled a new document of all the approved SLOs for each course the department teaches. This document also contains notes for each course on what material they are expected to contribute towards departmental assessment efforts over the course of the semester. A report of the results will be assembled by the committee and disseminated to the department at the end of the spring semester. When the department meets for its yearly retreat in August, the results will be discussed and any necessary decisions about course changes will be made. This timeline will allow decisions to be made early enough that they can be implemented in the upcoming academic year cycle. The Curricussessment committee will be responsible for following up with individual instructors on implementation.

## A Regular Schedule of Activities

In a 5-year cycle, we will focus on one PLO each year. In the year the PLO is the focus, we will collect additional data on that PLO, and at the end of the year consider if any revisions are needed for the PLO and associated curriculum mapping. We will also discuss as a committee which measures related to that PLO will be standard for collection moving forward and which we can collect in a 5-year cycle. In the 5th year, we will focus on the department as a whole rather than an individual PLO. We will choose the particular questions we want to investigate the spring before this 5th year.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **PLO** | **2017 - 2018** | **Aug 2018** | **2018-2019** | **Aug 2019** | **2019-2020** | **Aug 2020** | **2020-2021** | **Aug 2021** | **2021-2022** |
| **Speak** | Collect and assemble data | review results (dept.) | Identify possible changes and data to continue to collect |  |  |  |  |  |  |
| **Do** |  |  | Collect and assemble data | review results (dept.) | Identify possible changes and data to continue to collect |  |  |  |  |
| **Know** |  |  |  |  | Collect and assemble data | review results (dept.) | Identify possible changes and data to continue to collect |  |  |
| **Live** |  |  |  |  |  |  | Collect and assemble data | review results (dept.) | Discuss program wide changes to prioritize |
| **Meta** |  |  |  |  |  |  |  | Determine focus of year review | Collect data and discuss throughout year and at end of year, including results from changes over past 4 years |

## Course-Level Assessment Activities

## Core Curriculum Assessment (& Plan)

**Course Names:** CHEM 101, 103, 105, 115, & 103/104

**Core Category:** Natural World

**SLO’s**: Students will

1. Demonstrate understanding of the natural world through the concepts and methods of at least one of the natural sciences.

2. Demonstrate preparedness for scientifically informed citizenship.

3. Reflect critically on the processes and findings of natural science, including the relationship between natural science and Christian faith.

**Assessment Plan**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Year** | **SLO** | **Assessment Methods** | | | |
| CHEM 101 | CHEM 115 | CHEM 103, 103/104, 105 |
| 2017-2018 | 1 | Assessed through final exams using pre- and post- questions. | Assessed through pre- and post-questions on key chemical concepts. | Assessed through a common standardized national ACS exam is given to all students.  Also assessed through a short chemistry content pre-test assessment of chemical knowledge parallel to the final exam. |
| 2018 - 2019 | 2 | Assessed through a reflective essay exam question focusing on a societal issue dealt with in the course.  *Target: 80% of students achieve a 2 in each category.* | Assessed through a pre- and post-math test.  *All students either score an 8/10 or show gains of 3 points.*  Assessed through a series of short answer questions on exams throughout the semester.  *Target: 80% of students achieve a 2 in each category.* | Assessed through a pre- and post-math test.  *All students either score an 8/10 or show gains of 3 points.*  Assessed through a reflective essay assignment focusing on a societal issue dealt with in the course.  *Target: 80% of students sampled achieve a 2 in each category.* |
| 2019-2020 | 3 | Assessed through a reflective essay exam question focusing on a societal issue dealt with in the course. | Assessed through a series of short answer questions on exams throughout the semester. | Assessed through a reflective essay assignment focusing on a societal issue dealt with in the course. |

**Summary of Outcomes**

*Full data and rubrics in Appendix*

|  |  |  |  |
| --- | --- | --- | --- |
| **Course** | **Measure** | **Target\*** | **Students that met Target≠** |
| Chem 101 | Pre-post questions | All students score an 80% or above on the post test | 28/30 (93%) |
| Chem 103 | ACS Exam | 75% above or within the confidence intervals of the national average | 242/327 (74%) |
| Pre-Post Questions | 90% score at least an 8/10 OR show gains of 3 points | 49% of students scored 8 – 10  39% of students <8 gained 3 points  12% of students gained 0-2 points |
| Chem 103/104 | ACS Exam | 80% above or within the confidence intervals of the national average | 117/130 (90%) |
| Pre-Post Questions | All students score a 7/10 OR within 1 point of their score at end of CHEM 103 | Students as a whole showed losses in 7/10 questions, target not met |
| Chem 105 | ACS Exam | 95% at or above national average | 32/32 (100%) |
| Pre-Post Questions | Student gains on target with those observed for Chem 103 | Met as a class |
| Chem 115 | Pre-Post Questions | 75% of students answer questions correctly | Met for 4 of 8 topics (116 students total) |

\*Targets will be revisited and possibly adjusted in the coming years when we have multiple years of data

≠See discussion of results and next steps, particularly for areas where we fell short of initial targets

**Discussion of Results and Next Steps**

*Chemistry 101*

The average score on the final exam was 93%. A good overall average generally speaking. Students were still weakest on the mass-to-mass problem, but they did decidedly better. This sort of problem is reportedly on the MTTC exam for elementary education, so I need to continue to include this topic. I will try to interleave it more next year (on daily quizzes and homework).

*Chemistry 103, 104, and 105*

ACS exams are standard for these courses and have been administered consistently. We noted that we did not quite hit the desired mark Chemistry 103, likely due to the significant breadth of preparedness and motivation we observe in this particular course. We also noted that our average score was much lower than last year, even though we did not change exams. In the future, we will have pre-math and pre-chem scores to be able to determine if this difference is related to the preparedness of the students from a particular year. Unfortunately, we do not have pre-math data from 2016 that can be compared to our 2017 data.

This is the first year the department implemented the additional chemistry pre-test and post-test model. Alongside standardized exams (where available), it gave good insight into student learning and what topics could use more attention. In response to this data and general concerns about preparedness for Chemistry 103, the department created a general chemistry committee that worked on redesigning some features of the course and consistently implementing research-based pedagogical practices across sections. We are also working closely with tutoring to improve tutor preparation and student experience in chemistry help sessions. We look forward to collecting this data again this coming year to determine if these practices improve student learning.

In Chemistry 104, we noted significant losses when the same post-test from Chemistry 103 was administered in Chemistry 104. This suggests that (1) we are not reinforcing key chemistry concepts through Chemistry 104 as they learn new material, (2) that they are not transferring key chemical concepts from Chemistry 103 to Chemistry 104, or (3) that they are memorizing the material in Chemistry 103 rather than really understanding it, leading to the significant drop in scores by the end of Chemistry 104. The General Chemistry committee will discuss ways to improve retention of these key concepts through Chemistry 104 as they meet this year.

*Chemistry 115*

A pre- and post-test similar to that used in Chem 103/104/105 was also administered in Chem 115. Here, students did not meet the initial target set in all categories. These areas will be given increased attention in the coming year. However, we also noted that in topics where students did not meet the goal, there were still significant gains throughout the semester, which suggests that learning in these areas was still occurring. This year, the data was not collected in a way that would allow us to track individual student gains. In future years, we will track student gains to determine if it some of the students who are not meeting the 80% correct mark that are still making significant advances in their learning.

*Plan for Next Year*

Next year, the focus will be on SLOs 2 and 3. Our pilot assignments this year in Chem 103 helped us to identify areas we would like to improve for the coming year. The writing assignment revealed that we have important work to continue in the material with which we engage students and how we challenge them to engage. We will continue to explore the best way to integrate material and discussion related to faith and chemistry in each course while balancing that with the time required to master the challenging chemistry concepts. This fall, the Chemistry department will be leading a series of chapels throughout the year related to sustainability and chemistry. We hope this will create at least one additional faith and chemistry touchpoint that can be used by the chemistry instructors. We plan to keep the measure for engagement with faith and chemistry the same and look for improvement in scores with additional and more intentional content.

**APPENDIX: detailed results from individual courses**

**Chemistry 101 Data (Spring 2018)**

*SLO1: Demonstrate understanding of the natural world through the concepts and methods of at least one of the natural sciences.*

Plan: Final exam (pre/post comparison)

*I used a 6-question pre-test administered during Week 1. The questions are below:*

1. An atom is identified as carbon-13. The atomic number for carbon is 6. Use this information to describe the counts of subatomic particles in this atom.

2. An atom is radioactive. What does this mean?

3. What is a mole to a chemist?

4. Is the equation below balanced? If so, how do you know? If not, balance this equation.

CH4 + O2 → CO2 + H2O

Molar masses:

CH4 16 g/mole

O2 32 g/mole

CO2 44 g/mole

H2O 18 g/mole

5. 50.0 g of methane reacts with excess oxygen gas to form carbon dioxide gas and water. How many grams of carbon dioxide are produced in this case? (You do not need to calculate an answer here. Just show how you would setup the problem.)

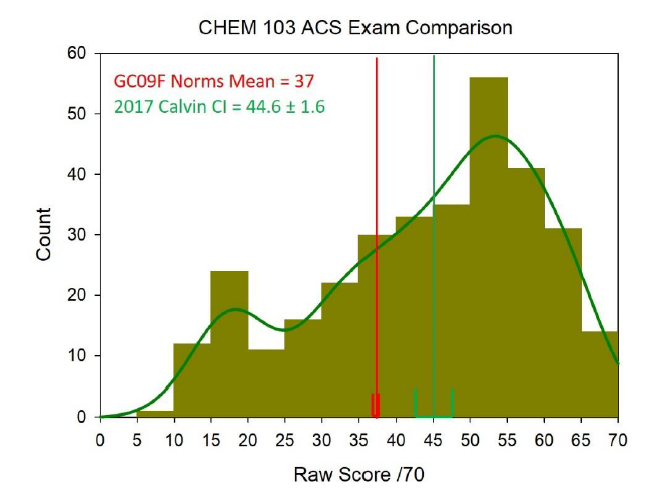
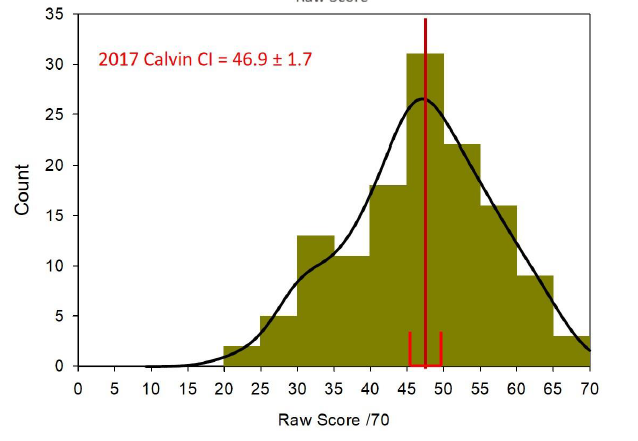
6. Describe one way that ionic bonding is different from covalent bonding.

I scored the pretest (2 points per question) and the average percentage on this pretest was 33%. Note: I asked students to self-report if they did the pretest on their own and without access to outside materials, such as Google. Many reported they “phoned a friend” or googled. 33% is a low score, but the actual score is even lower. It is good to see students don’t know what is about to be taught! Students were not strong on any content area, but if I were to pick a stronger area, it would be balancing equations. Students were weakest on the mass-to-mass calculate (not surprisingly).

Each concept on the pre-test appeared on the final exam. The average score on the final exam was 93%. A good overall average generally speaking. Students were still weakest on the mass-to-mass problem, but they did decidedly better. This sort of problem is reportedly on the MTTC exam for elementary education, so I need to continue to include this topic. I will try to interleave it more next year (on daily quizzes and homework).

**Chemistry 103 Data (Fall 2017 and Spring 2018) and Chemistry 104 (Spring 2018)**

*SLO 1: Demonstrate understanding of the natural world through the concepts and methods of at least one of the natural sciences.*

Measure 1: ACS final exam scores

**CHEM104**

**CHEM103**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *Year and population* | Students | ACS Avg | ACS Median | National Average | *Notes* |
| **2016/2017 103** | 277 | 51.2 | 52.0 | 37.1 | *2009 Test* |
| **2016/2017 103 to 104** | 106 | 56.3 | 59.0 | 37.1 | *103 scores of students who went on to take 104 the next semester* |
| **2016/2017 104** | 120 | 54.1 | 56.0 | 37.2 | *test leaked online* |
| **2017/2018 103** | 262 | 44.2 | 47 | 37.1 | *2009 Test* |
| **2017/2018 103 to 104** | 115 | 47.1 | 47 | 37.1 | *103 scores of students who went on to take 104 the next semester* |
| **2017/2018 104** | 130 | 47 | 47 | 38.9 | *New 104 ACS exam* |

Our students consistently score at or above national norms. A minimum grade of C is required to progress from Chemistry 103 to Chemistry 104, which is one of the reasons the ACS scores for first semester students continuing to second semester are higher. Calvin student distributions are not normal, particularly for Chemistry 103. Our distribution is left skewed and we do have a sizeable distribution at the lower end. If we look at the bimodal averages, we have two modes at 53 and 18. Overall, we look for maintenance of scores between 103 ACS exam and 104 ACS exam. Additional data that allows us to make pedagogical decisions is in the pre- and post-chemistry assessment shown below.

Measure 2: pre- and post-chemistry assessment

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | students | **Isotopes** | **Pure Compound** | **Empirical Formula** | **Lewis Structure** | **Limiting Reagent** | **Gas Law** | **Periodic Properties** | **Hybridization** | **Hess' Law** | **Bond Enthalpy** | **Total Score** |
| pre | 308 | 35.4% | 46.1% | 24.4% | 48.1% | 27.9% | 18.5% | 49.0% | 31.8% | 32.1% | 20.8% | **3.3** |
| post | 205 | 47.3% | 68.3% | 56.6% | 78.5% | 79.5% | 66.3% | 69.3% | 68.3% | 88.8% | 68.3% | **6.9** |
| *gain* |  | *11.9%* | *22.2%* | *32.2%* | *30.5%* | *51.6%* | *47.8%* | *20.2%* | *36.5%* | *56.6%* | *47.5%* | ***3.6*** |
| post 104 | 111 | 60.4% | 51.4% | 44.1% | 76.6% | 47.7% | 69.4% | 49.5% | 45.9% | - | 21.6% | **5.2** |
| *gain* |  | *13.1%* | *-16.9%* | *-12.5%* | *-2.9%* | *-31.8%* | *3.1%* | *-19.8%* | *-22.4%* | *-* | *-46.7%* | ***-1.7*** |

The same exam was given at the beginning and end of 103 and then again at the end of 104. For Chemistry 103, gains were observed in every area. One question was dropped from the analysis for re-administering the question in 104 due to an error in the question. Significant losses between 103 and 104 were observed in topics that are not expanded in Chemistry 104. This suggests students would benefit from more interleaving of topics (likely through homework sets) throughout the Chemistry 104 course. Students may also be compartmentalizing their learning and viewing CHEM103 in isolation from CHEM104.

*SLOs 2 & 3: Demonstrate preparedness for scientifically informed citizenship. Reflect critically on the processes and findings of natural science, including the relationship between natural science and Christian faith.*

Measure 1: writing assignment

Prompt Provided:

Describe one of the sustainability challenges discussed in class. What is the underlying scientific basis of or evidence for the problem? What is the responsibility of a Christian citizen as an individual and society (globally) in response to the chosen issue?

Rubric Used:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Not Present (0)** | **Beginning (1)** | **Developing (2)** | **Proficient (3)** |
| **PLO 2: Demonstrate preparedness for scientifically informed citizenship** | | | | |
| Awareness of problem and description of the scientific basis | Student does not identify an issue discussed in class | Student does not discuss key findings of the particular issue highlighted in class or does not demonstrate an awareness of the scientific basis of the issue | Student identifies the issue and lists key findings about the issue, but does not connect how the scientific data informs our understanding of the issue and possible solutions | Student identifies the issue discussed in class, identifies the key findings related to the issue, and makes a connection to why it is helpful to understand the scientific basis |
| **PLO 3: Student can reflect critically on the process and findings of natural science, including the relationship between natural science and Christian faith** | | | | |
| Critical thinking related to the process and findings of natural science | Student proposes that there is not actually a problem or no action is necessary | Student identifies problem and some type of response, but response is not strongly connected to problem | Student identifies both the issue and reasonable responses, but does not clearly articulate the connection between the knowledge and the action | Student describes the issue, what we know about it, and what reasonable responses or actions informed by data might entail |
| Relationship between natural science and Christian faith | No discussion of Christian faith is present or student proposes no action is necessary | Christian faith is discussed, but student cannot articulate a clear connection between actions or choices and a Christian framework | A clear Christian framework is presented, but its role informing particular responses to a chose issue is not fully articulated | A clear Christian framework is presented and student discusses how the framework would inform response to a particular issue. |

Results:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **Awareness of problem** | **Scientific understanding** | **Relating Science and faith** |
| Students Scoring… (Total = 244) | 0 | 9 | 9 | 28 |
| 1 | 29 | 96 | 69 |
| 2 | 97 | 74 | 70 |
| 3 | 109 | 65 | 76 |
| % 2 or above | | 84 % | 57 % | 60 % |
| median | | 2 | 2 | 2 |
| maximum score | | 3 | 3 | 3 |

This was the first pilot of this type of assignment, and our primary goal was to develop a baseline understanding of our students that we could use to design, implement, and monitor future assignments. Things to note about the data on the previous page:

* The assignment itself was a challenge to design because we are dealing with about 300 students across different sections and instructors. We have to consider what is reasonable for faculty to implement in a large classroom and what is reasonable to assess.
* Based on how we chose to engage the material in class and the rubric parameters we designed, we expected our students to score on average a 2 in each section of the rubric. The students scored about where we expected. This does not necessarily mean that we are happy with this outcome, but it shows that we do have a handle on how well students can engage these ideas based on how we currently engage the material in class.
* Creating this pilot assignment and rubric initiated a good conversation in our department about dissatisfaction with the way we engage faith content now in the class. We are in the process of revisiting engagement for the future. The content and assignment will likely look different when we assess these SLOs next year.
* A similar assignment was completed in CHEM104. The project was specifically focused on the flint water crisis, and after engaging the content through class lecture and discussion and a homework set, a prompt similar to the one for CHEM103 was used for a short writing assignment. The writing assignment was graded as its own homework set and then assessed using the same rubric shown above. A few outcomes from this assessment were:
  + The two faculty grading using the above rubric had significantly different interpretations of the categories and thus it was difficult to compare between the two sections or to compare individual students between CHEM103 and CHEM104. This shows that we need to improve the rubric design as we continue to revise and refine the assignment.
  + Student scores between CHEM103 and CHEM104 were compared for one CHEM104 section. The faculty teaching this particular section had also reviewed a number of the CHEM103 reports and thus the scores between 103 and 104 were better calibrated. There were no clear gains between CHEM103 and CHEM104, which is not surprising considering the amount of time allocated to these topics in class. This again highlights the importance of focusing on integration of and engagement with material into the class.

**Chemistry 105 Data (Fall 2017)**

*SLO 1: Demonstrate understanding of the natural world through the concepts and methods of at least one of the natural sciences.*

Measure 1: ACS final exam scores

32 students. Mean: 56.3; Median: 56; A-student mean: 61; B-student mean: 50.

National Norms: Mean: 38.90; Median: 37.7, Std Dev: 12.78

As expected, students in the accelerated CHEM105 section score consistently higher than CHEM103 as they are the students who have had the most chemistry before arriving at Calvin.

Measure 2: pre- and post-chemistry assessment

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Isotopes** | **Pure Compound** | **Empirical Formula** | **Lewis Structure** | **Limiting Reagent** | **Gas Law** | **Periodic Properties** | **Hybridization** | **Hess' Law** | **Bond Enthalpy** | **Total Score** |
| pre | 65.6% | 46.9% | 40.6% | 68.8% | 53.1% | 28.1% | 46.9% | 37.5% | 50.0% | 25.0% | 4.6 |
| post | 71.9% | 65.6% | 75.0% | 90.6% | 90.6% | 90.6% | 65.6% | 96.9% | 93.8% | 62.5% | 7.9 |
| *gain* | *6.3%* | *18.8%* | *34.4%* | *21.9%* | *37.5%* | *62.5%* | *18.8%* | *59.4%* | *43.8%* | *37.5%* | *3.3* |

CHEM105 consists of students that had significant experience in chemistry before coming to college and are ready to move at an accelerated rate. As expect, the pre- and post-chemistry assessment scores for these students were higher than that of the population in CHEM103. Overall, however, students in CHEM105 showed similar gains in total score to students in CHEM103.

*SLOs 2 & 3: Demonstrate preparedness for scientifically informed citizenship. Reflect critically on the processes and findings of natural science, including the relationship between natural science and Christian faith.*

An assignment similar to the one for 103 was given and scored according to the same rubric. Student performance was similar or slightly better than that of the students in Chemistry 103. Changes made to the faith engagement for Chemistry 103 can also be integrated into the Chemistry 105 curriculum where appropriate.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Students Scoring… (Total = 32) | 0 | 3 | 0 | 2 |
| 1 | 3 | 13 | 9 |
| 2 | 4 | 7 | 15 |
| 3 | 22 | 12 | 6 |
| % 2 or above | | 81.3% | 59.4% | 65.6% |
| median | | 3 | 2 | 2 |
| total score | | 3 | 3 | 3 |

**Chemistry 115 Data (Fall 2017)**

*SLO 1: Demonstrate understanding of the natural world through the concepts and methods of at least one of the natural sciences.*

A pre-test and post-test were administered in CHEM115 similar to the one given in CHEM103/104 but with topics appropriate to this particular course.

|  |  |  |  |
| --- | --- | --- | --- |
|  | % Students Answering Correctly (116 Total Students) | | |
| **Topic** | **Pre- correct** | **Post- Correct** | **Gain** |
| Lipid in membrane | 60.3% | 87.1% | 26.7% |
| Formula for MgO | 39.7% | 73.3% | 33.6% |
| Biochemical Energy transfer | 9.5% | 43.1% | 33.6% |
| part of atom in bonding | 75.0% | 93.1% | 18.1% |
| liquid to gas | 22.4% | 62.1% | 39.7% |
| protons, neutrons, electrons | 25.0% | 81.9% | 56.9% |
| atom forms most covalent bonds | 23.3% | 84.5% | 61.2% |
| hydrophobic biomolecules | 57.8% | 69.8% | 12.1% |

The preliminary goal was that 80% of the students would answer the questions correctly in the post test. This goal was met in four of the eight topics tested.

However, we noted that in topics where students did not meet the goal, there were still significant gains throughout the semester, which suggests that learning in these areas was still occurring.

**Chemistry 101 Data (Spring 2018)**

*SLO1: Demonstrate understanding of the natural world through the concepts and methods of at least one of the natural sciences.*

Plan: Final exam (pre/post comparison)

*I used a 6-question pre-test administered during Week 1. The questions are below:*

1. An atom is identified as carbon-13. The atomic number for carbon is 6. Use this information to describe the counts of subatomic particles in this atom.

2. An atom is radioactive. What does this mean?

3. What is a mole to a chemist?

4. Is the equation below balanced? If so, how do you know? If not, balance this equation.

CH4 + O2 → CO2 + H2O

Molar masses:

CH4 16 g/mole

O2 32 g/mole

CO2 44 g/mole

H2O 18 g/mole

5. 50.0 g of methane reacts with excess oxygen gas to form carbon dioxide gas and water. How many grams of carbon dioxide are produced in this case? (You do not need to calculate an answer here. Just show how you would setup the problem.)

6. Describe one way that ionic bonding is different from covalent bonding.

I scored the pretest (2 points per question) and the average percentage on this pretest was 33%. Note: I asked students to self-report if they did the pretest on their own and without access to outside materials, such as Google. Many reported they “phoned a friend” or googled. 33% is a low score, but the actual score is even lower. It is good to see students don’t know what is about to be taught! Students were not strong on any content area, but if I were to pick a stronger area, it would be balancing equations. Students were weakest on the mass-to-mass calculate (not surprisingly).

Each concept on the pre-test appeared on the final exam. The average score on the final exam was 93%. A good overall average generally speaking. Students were still weakest on the mass-to-mass problem, but they did decidedly better. This sort of problem is reportedly on the MTTC exam for elementary education, so I need to continue to include this topic. I will try to interleave it more next year (on daily quizzes and homework).

**APPENDIX**

**Speak Chemistry PLO Assessment Report for 2017-2018**

*Context:* The assessment committee focused on the Speak Chemistry PLO to better understand where we engage with our students on this content, how well our students do, and how well this aligns with our expectations of how our students do.

**Speak Chemistry PLO and Content for Course SLOs**

Students will communicate effectively—individually and as a team—through written, oral, and visual presentations that demonstrate their capacity to assimilate and convey scientific ideas from experiments and the literature.

*Specific Content for Course SLOs*

1. Information Literacy
   * proficiency in searching the Hekman library and electronic databases.
2. Reading for understanding & retention
   * understanding of chemical concepts and data obtained from independent reading.
3. Visual data presentation
   * ability to use standard data analysis & graphic presentation software to create tables, graphs, mathematical relationships, and structural representations of chemical data.
4. Oral presentation
   * fluency with scientific language
   * ability to logically explain a scientific problem, method or solution to different audiences.
5. Scientific writing
   * ability to summarize or explain chemical concepts and data to diverse audiences.
6. Teamwork/collaboration
   * ability to work as a team member, both to learn from and benefit other members of a team.

**Assessment Plan**

Our goal was to collect evidence of communication that covered each category of the specific content for the SLOs. For each data source, we wanted to consider what content it covered, but also what population of our students we would be assessing since not all students would be covered under each measure.

|  |  |  |  |
| --- | --- | --- | --- |
| **Data Source** | **Content** | **Population** | **Measurement** |
| Chem 295 talks | 3, 4 | ACS majors (research) | Rubric, available to all faculty at seminar |
| Poster Session | 4 | Research students | Rubric, all faculty evaluate within subdiscipline |
| IDIS 310 project & presentation | 1, 2(?), 4, 5 | Most graduating seniors | Rubrics for writing project and presentation |
| Chem 323/324 | 2(?), 5 | Many majors | Rubric for methods study guide (323) and writing assignment (324) |
| Lab reports from 304/317 | 5 | Majors | Rubric with same categories as 323/324 above |
| 200 and 300 labs | 6 | Most upper-class majors | Student survey: what percent did you contribute to experiments and reports? |

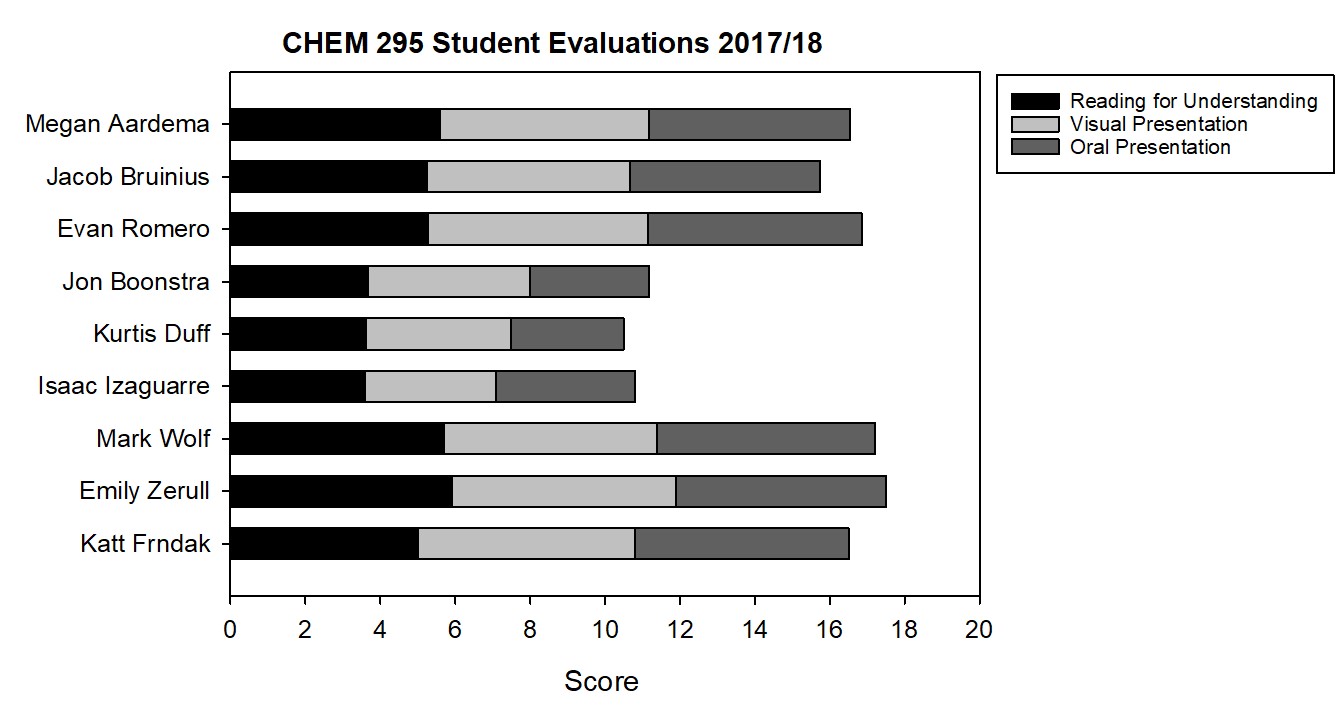
\*Note: assessment committee found it difficult to find assignments to assess to cover all SLO content

**Results**

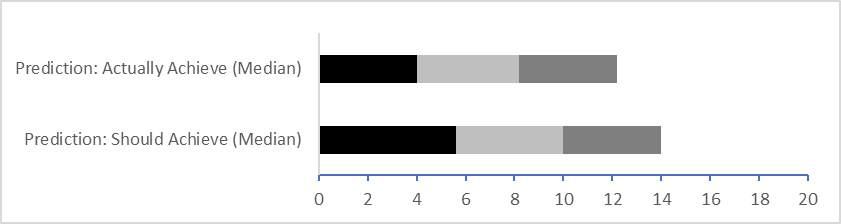
1. ***Chem 295 Student Talks*** *(ACS or Honors Students who have done research)*

Appendix II – Rubric for Assessment

Each bar represents one student and the average score they received based on the faculty that were present at the talk and turned in the rubric.



*Anticipated by the Faculty*

**

*Reflections on why ‘should’ and ‘actual’ may differ*

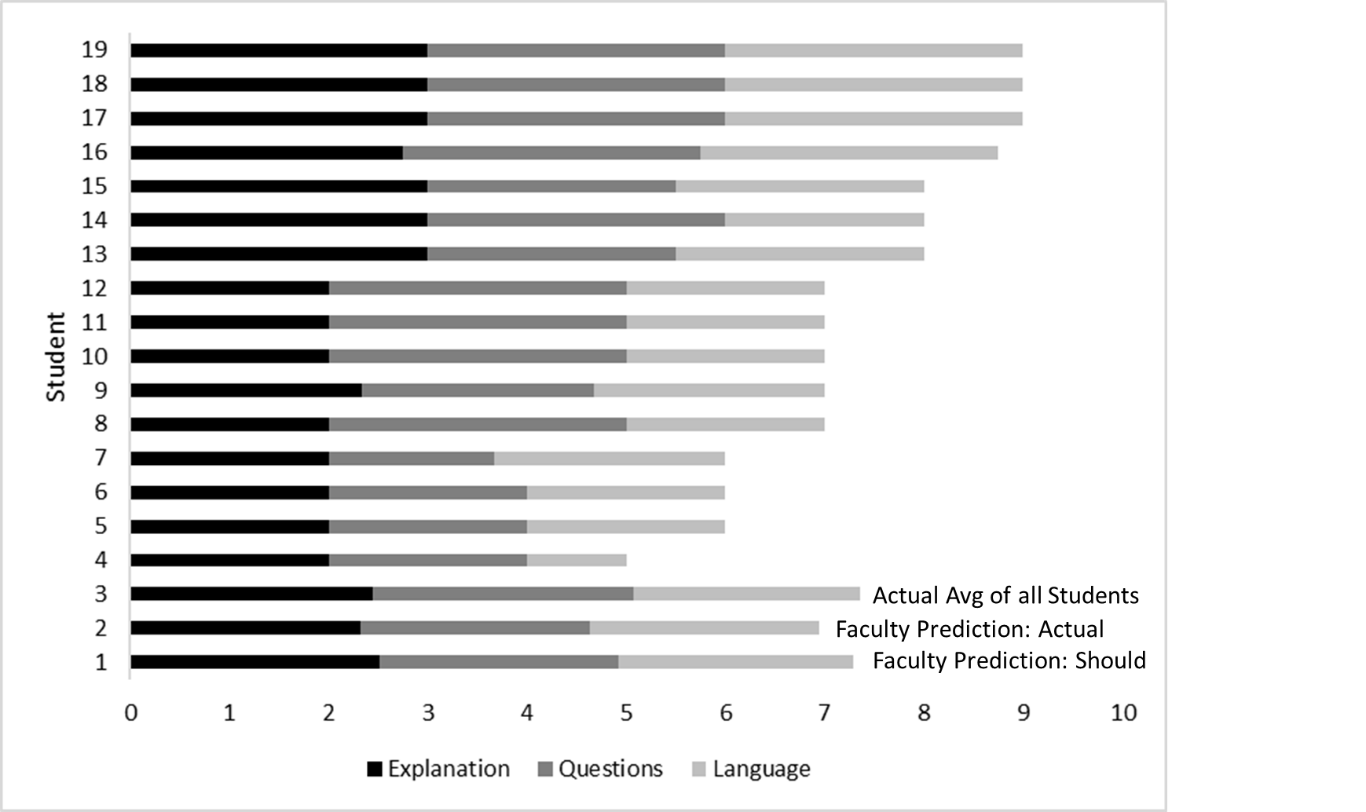
* I believe students averaged about 0.4 less than what we would feel good about because they don't get much training in these areas.
* I don't think we necessarily give the students targeted coaching for each of these items.
* For reading, my experience was that students exceeded my expectations, For Oral, we had a wide range of quality and we should do something to bring up the weakest students

*For faculty reviewing data:*

1. Are you happy with this level of performance for this student population? Would other student populations likely perform at the same level?
2. If not happy, are there small changes that could be made to improve outcomes (for these students or for other student populations)?
3. Are there any large changes that would be necessary (for these students or for other student populations)?
4. ***Poster Session*** *(students who have done research)*

Appendix III – Rubric for Assessment

Each bar represents one student and the average score they received based on three faculty interacting with them at their poster. The first three bars are averages from data analysis as indicated



*Reflections on why ‘should’ and ‘actual’ may differ*

* None of mine differed, but I'll make a comment anyway. By the time students make a poster, they know pretty well what they are talking about. And, because of the casual nature of a poster discussion, they aren't exposed as easily as in a talk. Our rubric is pretty easy too (more general than the one for talks). Maybe that's fine?

*For faculty reviewing data:*

1. Are you happy with this level of performance for this student population? Would other student populations likely perform at the same level?
2. If not happy, are there small changes that could be made to improve outcomes (for these students or for other student populations)?
3. Are there any large changes that would be necessary (for these students or for other student populations)?
4. ***IDIS 310 Projects*** *(Junior and Senior Majors)*

Students were asked to write three essays, two to a scientific audience and one to a general audience (all on the same scientific topic). Two faculty scored each essay in the four categories described below. Each essay was scored for complexity and organization, the first two essays were scored for scientific communication, and the last essay was scored for non-scientific communication. Even though the original plan to explore SLO builders (1), (2), (4), and (5) using this course, the actual assignment and available data best spoke to (5) Scientific writing: ability to summarize or explain chemical concepts and data to diverse audiences.

Each student was scored in each category on a scale of 1 to 5 that aligned with a letter grade scale where 1 is equivalent to a F in this category and 5 is equivalent to an A.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Category** | **Description** | **Avg. Score (StdDev)** | Prediction: Should Achieved | Prediction: Actually Achieved |
| Complexity | Category includes the quality, complexity, originality of reasoning, argumentation, observation. A score of 5 would include arguments that are complex and connect ideas to make new conclusions or identify novel trends/influences. | 3.3 (0.5) | 3.7 | 3.5 |
| Organization | A score of 5 indicates that the paper is clearly organized around key ideas, sentences support main argument in each paragraph | 3.8 (0.2) | 3.7 | 3.6 |
| Scientific Communication | Proper syntax, diction, and mechanics for the chemistry field is used throughout the paper. | 3.1 (0.6) | 3.7 | 3.4 |
| Non-scientific Communication | Proper syntax, diction, and mechanics for a general audience is used throughout the paper. | 3.4 (1.7) | 3.6 | 3.5 |

*Reflections on why ‘should’ and ‘actual’ may differ*

* I think students are just a little behind our expectations on this.
* Our students aren't as good of writers as they should be. It's not the fault of this course or even of the program, though we should continue to work on it.
* Our students should be able to get a C. But we tend to construct and grade things so that the average is more like a B.
* Based on writing I see in P Chem, I expect the students need to work on logical organization and in using scientific chemical language

*For faculty reviewing data:*

1. Are you happy with this level of performance for this student population?
2. If not happy, are there small changes that could be made to improve outcomes?
3. Are there any large changes that would be necessary?
4. ***Writing Projects from Chem 323/324*** *(Biochemistry Majors)*

Appendix IV – Rubric for Assessment of 323 projects

In CHEM323, students completed a project to help them engage with methods used to answer biochemical questions. The project included creating a study guide as an individual, then partnering with others to combine them into one succinct study guide. The scores shown below are for the individual study guides complete by students in both sections of CHEM323.

In CHEM324, students were asked to write (as a group) a research proposal. The instructions were as follows:

“Your proposal should take the form provided on the “Strategy” handout and must not exceed a single page of writing (1 inch margins; 11 pt font or larger; spacing 1.15). It should essentially be comprised of 2 paragraphs plus 2-3 specific aims describing what you are going to test experimentally.”

Groups were graded on the following categories:

1. Format: how closely was the format of the provided example and the language provided in the instructions followed.
2. Creativity: how creative is the experimental design to cleanly answer the proposed questions.
3. Logic: does the group present a solid, testable hypothesis that makes sense based on class content.

The other CHEM324 section did a different assessment where they presented on and then wrote a summary of a primary literature article. Overall, students gave reasonable presentations and summaries of the papers. The professor of this section noted that the area where students struggled most in this assignment was in transitions between major ideas and the logic behind performing various experiments.

*Reflections on why ‘should’ and ‘actual’ may differ*

* We don't always provide a good model for citing sources for everything we use. Sometimes our students get too bogged down in details to recognize the purpose of a technique
* Really a shot in the dark here -- I don't know how pointed the instructors were in their training of the students. So I'm falling back on the rationale that we tend to design and grade things so that our students get better grades than the grade that they "should" get.
* I think we should expect a level of competence and I predict that they fall short in directly addressing an issue and having their writing style meet our expectations as scientists.

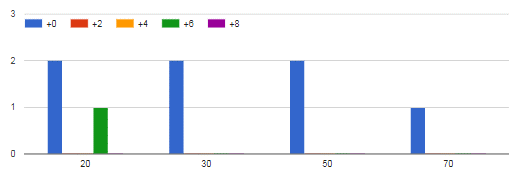
*For faculty reviewing data:*

1. Is this data informative? Would we learn more by looking at examples of student work?
2. Are you happy with this level of performance for this student population?
3. If not happy, are there small changes that could be made to improve outcomes?
4. Are there any large changes that would be necessary?
5. ***Survey of Participation for 200 and 300 Level Labs*** *(All Majors)*

Appendix V – Lab Teamwork Survey

|  |  |  |  |
| --- | --- | --- | --- |
|  | Fall (201L, 253L, 317L, 383L) | Spring (262L, 271L, 318L, 383L) | Predicted by Faculty |
| Gender | male (54.1%), female (45.9%) | male (63.5.1%), female (36.5%) | - |
| Partner Gender | same (77.3%), other (22.7%) | same (68.6%), other (31.4%) | - |
| **What percent did you and your partner contribute to each of the following aspects of your work:** | | | |
| Planning (self) | 50.9 (high: 80, low: 30) | | 60 % |
| Bench work | 52.9 (high: 90, low:40) | |
| Problem solving | 51.6 (high:90, low:20) | |
| Writing | 55.6 (high:100, low:10) | |
| **Please rate the followings statements for yourself only by selecting one box for each statement:** | | | |
| Enjoyed teamwork | 4.3 | 4.3 | 3 |
| Team worked effectively | 4.4 | 4.3 | 3 |
| Improved individual mastery | 4.0 | 4.1 | 3.5 |
| Teamwork as a skill | 4.6 | 4.6 | 5 |
|  | | | |
| Received training: | yes (37.1%\*), no (62.9%) | yes (47.1%\*), no (52.9%) | (see graph below) |

\*Primarily obtained through engineering courses, team sports, employment, other labs, research, misc.



*For faculty reviewing data:*

1. What do we learn from this survey?
2. Are you happy with this response for this student population?
3. If not happy, are there small changes that could be made to improve outcomes?
4. Are there any large changes that would be necessary to better address the data or the category?

**Guide for Department Discussion During August 2018 Retreat**

1. What did we learn/see in the data? What big picture trends, strengths, or weaknesses did you note (either with student performance, number or type of assignments, or preparation for assignments)?
2. Does our current PLO and mapping (see below) align with what is actually happening in our courses?   
   If not, do we want to adjust the PLO or SLO categories or change what we actually do?

Departmental Map of SLO Content

*Summary of how various aspects of this PLO are targeted throughout the departmental curriculum for majors*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | General | | | Organic | | | Analytical | | Inorganic | | Physical | | | Biochemical | | | |  |  |  |  |
|  | 103 | 104 | 105 | 253 | 261 | 262 | 201 | 329 | 230 | 330 | 304 | 317 | 318 | 303 | 323 | 324 | 383 | 271 | 295 | 310 | 39x |
| Literature interrogation | **-** | **-** |  | **-** | **-** | *2* | *1* | **3** | **2** | **3** | **3** | **3** | **3** | **2** | **3** | **3** | *2* | **-** | **0/3** |  | **3** |
| Reading | **1** | **1** | **1** | **1** | **1** | **1** | **-** | **3** | **2** | **3** | **3** | **3** | **3** | **2** | **3** | **3** | *2* | **-** | **-** |  | **3** |
| Visual data presentation | **1** | **1** | **1** | **-** | **-** | **2** | **2** | **3** | **2** | **3** | **2** | **2** | **2** | **1** | **2** | **2** | *3* | **2** | **-** |  | **2-3** |
| Oral presentation | **-** | **-** | **0-1** | **-** | **-** | **-** | **-** | **-** | **2** | **-** | **-** | **-** | **-** | **-** | **0/2** | **-** | *3* | **2** | **-** |  | **3** |
| Scientific writing | **1** | **1** | **1** | *1* | *1* | *2* | **1** | **3** | **-** | **3** | **3** | **3** | **3** | **1** | **2** | **3** | *3* | **3** | **0-1** |  | **3** |
| Teamwork/collaboration | **1** | **1** | **1** | *1* | *1* | *2* | **2** | **2** | **-** | **2** | **-** | **1-2** | **1-2** | **1** | **2** | **2** | *3* | **-** | **-** |  | **3** |

Key:1: introduction, 2: expansion, 3: mastery, **Bold: in class,***Italics: in lab*

|  |  |  |  |
| --- | --- | --- | --- |
|  | **1** | **2** | **3** |
| **Literature interrogation** | general scientific literature | discipline-specific literature; discernment of resource relevance | sub-discipline-specific & primary research literature; discernment of resource integrity & quality |
| **Reading** | Textbooks & general interest science articles | published or informal review articles; advanced textbooks | primary research articles & sub-discipline specific reviews |
| **Visual data presentation** | graphing data with basic programs such as Excel | manipulating the data for analytical or derivative purposes | applying field-specific or instrument-specific programs for high-level analyses |
| **Oral presentation** | oral communication of chemical concepts during in-class exercises | oral reporting of small datasets or presentation of research articles during in-class exercises | oral presentation of extended research projects from laboratory research |
| **Scientific writing**  **(*audience)*** | other students & faculty through informal reports, short answer test questions or essays | the general public through non-technical science articles | chemistry experts through technical manuscripts (review or research) & grant |
| **Teamwork/ collaboration** | lab partnerships & reports | extended group projects/presentations | team research and technical writing |

1. What are some programmatic changes that the department might want to consider?
2. As we move forward, what data do we want to collect over the next few years to help inform decisions?

**Appendix I *- Rhetoric Projects in the Chemistry Department***

1. CHEM103 – Doug Vander Griend: “Sustainability Project”

*Purpose*: To develop social & environmental awareness as well as skills to participate in group decision making. To gain experience in group oral presentations.

1. CHEM201L – Kumar Sinniah: “Laboratory Reports”

*Purpose*: To develop the skills for displaying & interpreting primary scientific data obtained in the lab.

1. CHEM230 – Doug Vander Griend: “Elemental Project”

*Purpose:* To develop awareness of the sources of important elements we use in modern society, and to learn how to effectively display this information with a common software platform used in academia.

1. CHEM230 – Doug Vander Griend: “Resource Mapping”

*Purpose:* To develop awareness of how limited our natural resources are, and to learn how to effectively communicate this information in both visual/written and oral formats.

1. CHEM262L – Mike Barbachyn/Carolyn Anderson/Chad Tatko: “Multi-week Organic Chemistry Lab Report”

*Purpose*: To develop the ability to plan & execute a multi-week set of experiments in organic synthesis, and to learn how to effectively display & interpret primary scientific data.

1. CHEM303– Larry Louters:

*Purpose*: To expose students to emerging research techniques by having them interrogate the primary research literature and to develop their science writing skills by communicating their findings in a formal report.

1. CHEM317 – Herb Fynewever/Mark Muyskens: “Scientific Formal Report”

*Purpose*: To learn how to write a complete scientific report using your own primary data.

1. CHEM323 – Rachael Baker: “Journal Club Assignment”

*Purpose:* This assignment has three specific goals: (1) Develop skills necessary to read journal articles, (2) Improve presentation skills both by presenting and assessing others’ presentations, (3) Learn about current methods and approaches used to answer biochemical questions

1. CHEM323 – Brendan Looyenga: “Vocational Thought Essay”

*Purpose*: To help students ground their career goals in a sound theological basis using a brief essay.

1. CHEM323 – Brendan Looyenga: “Methods Presentations”

*Purpose*: To learn how to present scientific data & methods to a group of peers.

1. CHEM324 – Brendan Looyenga: “Journal Club Presentations”

*Purpose*: To learn how to present a scientific article to your peers in a comprehensive, yet concise, fashion.

1. CHEM324 – Brendan Looyenga: “Writing a Grant Proposal Aims Page”

*Purpose*: One of the key skills that is important to develop is the ability to frame a scientific question or problem in terms of a logical answer (hypothesis) that is experimentally “testable.” This is the sort of exercise that researchers go through every time they write a grant proposal for funding or other support.

1. CHEM324 – Eric Arnoys: “Protein of the Year”

*Purpose*: To gain skills in literature interrogation, bioinformatics, visualization of protein structures and scientific writing on the biochemistry of proteins/enzymes.

1. CHEM383L – Eric Arnoys/Rachael Baker/Brendan Looyenga: “Scientific Formal Report”

*Purpose*: To learn how to write a complete scientific article using your own primary data.

1. CHEM383L – Eric Arnoys/Rachael Baker/Brendan Looyenga: “Biochemistry Independent Project Presentation”

*Purpose*: To learn how to present a concise summary of a scientific project to a peer audience.

**An initial survey of the assignments shows that (1) they are more faculty-specific than course-specific, (2) there is no sequencing of the assignments, and (3) some assignments assume skills that may not have been explicitly taught in earlier classes.**

**Appendix II – CHEMISTRY 295 Rubric**

**Reviewer: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Student:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Grand Total: \_\_\_\_\_\_\_\_\_\_\_\_\_**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Not Present (0)** | **Beginning (1)** | **Developing (2)** | **Accomplished (3)** | **Score** |
| **(2) Reading for Understanding and Retention** | | | | | |
| Content | Does not adequately cover the topic, lacks references | Closer to 0 than 3 | Closer to 3 than 0 | References primary literature; places their research in the larger context of their scientific sub-discipline |  |
| Conclusions | Missing or poor conclusion. Not well-tied to analysis | Closer to 0 than 3 | Closer to 3 than 0 | Conclusions are well-supported by data and analysis, future research proposed |  |
| **(3) Visual Data Presentation** | | | | | |
| Tables, graphs, schematics, and structures | Visual representations are not used in the talk | Closer to 0 than 3 | Closer to 3 than 0 | Appropriate visuals are chosen, representations are pleasing, readable, and informative |  |
| Use of visual slides | Students reads text directly from slides | Closer to 0 than 3 | Closer to 3 than 0 | Student discusses visuals on slide, including describing how to interpret the visuals |  |
| **(4) Oral Presentation** | | | | | |
| Fluency with scientific language | Student does not use clear scientific language and provides unclear answers to questions | Closer to 0 than 3 | Closer to 3 than 0 | Student uses appropriate scientific language, both during the presentation and in answering questions |  |
| Delivery | Poor audience engagement, very uncomfortable | Closer to 0 than 3 | Closer to 3 than 0 | Engages audience, comfortable delivery, good pace |  |

**Appendix III – Rubric for Poster Session Assessment**

*Instructions: please ask students to give you a* ***2 min*** *summary of their poster and research, then ask at least one follow up question related to their research. Circle the best description for the student for each category.*

**Student Name: Research:** On Campus / Off Campus

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Beginning (1)** | **Developing (2)** | **Accomplished (3)** |
| **Ability to logically explain a scientific problem** | Student does not provide clear explanation of research project | Student discusses data/results with some reference to poster, may struggle to situate project within the field or existing literature | Student explains scientific problem and how project fits, walks through data and results, making reference to poster |
| **Ability to answer questions** | Student not sure about questions or not able to provide reasonable answers | Student can provide an answer, may struggle with supporting information | Student answers questions clearly, providing support from data or knowledge of the literature |
| **Fluency with scientific language** | Student does not consistently use appropriate scientific language | Student mostly uses scientific language, may struggle to maintain consistency throughout | Student consistently uses scientific language, both during the presentation and in answering questions |

**Appendix IV – Rubric for Assessment of 323 Projects**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Beginning (1)** | **Developing (2)** | **Accomplished (3)** | **Score** |
| **Question answered with method** | Does not clearly or correctly articulate the question | Question is correctly described, may not be stated clearly or may miss a key element | Describes question clearly and correctly |  |
| **Approach** (x3) | Exhibits a weak understanding of how the method works, schematics may be unclear or not relevant to the discussion | Describes most of the approach well, missing some key details or not providing appropriate or clear schematics | Accurately describes the approach for the experiment, identifying key details and providing clear schematics where appropriate |  |
| **Limitations of Method** (x2) | Does not identify all the major limitations, no discussion of experimental advances or alternative approaches | Identifies major limitations but misses relevant experimental advances or alternative approaches | Identifies all major limitations of the method and points to experimental advances or alternative approaches that overcome those limitations |  |
| **Example Data and Interpretation** (x3) | Exhibits a weak understanding about how to interpret results or does not provide supporting images | Accurate description of how to interpret data, may not be written clearly, supporting images unclear or not appropriate for description | Chooses clear representative data to show that is accompanied by text and annotations that clearly describe how to interpret the data |  |
| **Overall style and clarity of writing** | Writing hard to follow, includes grammatical errors, does not use appropriate scientific language | Writing mostly clear, some grammatical errors, does not always use appropriate scientific language | Writing and logic can be followed throughout, minimal grammatical errors, uses scientific language where appropriate |  |
| **References** | References only the textbook, does not include references for images used | References additional sources, but does not choose reputable sources | Cites all pictures used in study guide, uses at least two valid sources (textbook, website, article) in description of method. |  |
| **Total** | | | | /33 |

**Appendix V – Lab Teamwork Survey**

**General Information**

Course and Section:

|  |  |  |
| --- | --- | --- |
|  | Major | Gender |
| Myself |  |  |
| Partner 1 |  |  |
| Partner 2 (where applicable) |  |  |

**What percent did you and your partner contribute to each of the following aspects of your work:**

*Note: the percentages in each row should add up to 100 %. If you do not remember or a particular component is not applicable to your situation, you may leave the cell blank.*

|  |  |  |  |
| --- | --- | --- | --- |
|  | Myself | Partner 1 | Partner 2 |
| Planning |  |  |  |
| Doing bench work |  |  |  |
| Generating ideas and problem solving |  |  |  |
| Writing up the work |  |  |  |

**Please rate the followings statements for yourself only by selecting one box for each statement:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree |
| Overall, I enjoyed working in a team |  |  |  |  |  |  |
| My team worked together effectively |  |  |  |  |  |  |
| Working in a team improved my individual mastery of the material or technique |  |  |  |  |  |  |
| Teamwork is an important skill for my chosen career. |  |  |  |  |  |  |

Have you received training or instruction on how to work well in a team? *Circle one: yes / no*

If so, where?

1. J. Chem. Educ., **2016**, *93* (12), pp 2058–2062 [↑](#footnote-ref-1)
2. ACS accreditation regulations require no more than 16 students per faculty in lab. We place over 30 students in labs using the fact we have TAs in the lab. Hope has 22 students in a Gen Chem lab, while GVSU has at most 24 students in a Gen Chem lab. They do this with TAs as well. Furthermore, our TAs are not trained or skilled to help students other than babysitting, crowd control, and grading lab reports. Instructors have no time to spend developing skills of students in the lab. If we are serious about labs, then we will bring this number down to 24 per lab. Until then, much of what is done to improve lab skills at the 103/104/105 level may well prove ineffective. [↑](#footnote-ref-2)