

**Academic Affairs Assessment of Student Learning**

**Report for Academic Year 2023 - 2024**

**Department/Program CHEMISTRY**

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1. **Which learning outcomes did you measure this past year?** [Please indicate whether any of these measures were conducted as follow-up to a previous year’s issues or in response to Program Review. Be specific.]

Program Learning Outcomes, PLOs 1 and 3 was measured during the 2023-2024 academic year

• PLO 1. Explain the fundamentals in analytical, biological, inorganic, organic, physical, chemistry.

• PLO 3. Apply problem-solving strategies to scientific questions.

1. **In which course(s) were assessments conducted?**

|  |  |  |
| --- | --- | --- |
| PLOs Assessed | Assessment Point | Assessment tool (Direct or Indirect |
| 1 and 3 | Chemistry 106 General Chemistry II | ACS Second semester General Chemistry Exam (Direct) |
| 1 and 3 | Chemistry 206 Organic Chemistry II | ACS two semester Organic Chemistry Exam (Direct) |
| 1 and 3 | Chemistry 301 Physical Chemistry (Fall Semester) | ACS one semester Physical Chemistry Exam (Direct) |
| 1 and 3 | Chemistry 450 Senior Seminar (Spring Semester) | ACS DUCK\* Exam (Direct) |

\*DUCK: Diagnostic of Undergraduate Chemistry Knowledge

1. **How did you assess the selected program learning outcomes?** (i.e., what did you assess –group project, skills demonstration, presentation, performance, debate, lab experiment, online discussion, etc. *and*- what tool (measure) did you use - rubric, nationally or state-normed exam, item analysis, pre-posttest design, skills inventory, survey, etc.)

The department assessed the PLOs at several stages of a students’ undergraduate education. The freshman, sophomore, Junior, and Senior levels were assessed utilizing the courses CHEM 106, CHEM 206, CHEM 301, and the overall Diagnostic of Undergraduate Chemistry Knowledge (DUCK) exam respectively. All these exams used in these courses are developed by the American Chemical Society(ACS). The ACS is the world’s largest scientific professional society. It has a Committee on Education and a national test center that develops a test for numerous classes in the standard chemistry curriculum. The department decided to use these nationally normed standardized test sequence due to its ability to place students in a national percentile so we can determine how our students stack up against other nationally. Each of the tests can be further broken down to give use data on where our students are struggling in the sub disciplines of general, organic, physical, and chemistry overall Diagnostic of Undergraduate Chemistry Knowledge (DUCK exam).

1. **How many students were included in the assessment(s) of each PLO in a course?**

The number of students who took each examination is broken down in the following table. The Chemistry 106 and 206 had a significant percentage of Biology majors taking the test while the Chemistry 301 and 450 assessment tool was strictly chemistry majors.

|  |  |
| --- | --- |
| Assessment Evaluation | Number of students who completed the assessment tool |
| **Second term General Chemistry test – Chemistry 106** | **40** |
| **Second term Organic Chemistry test – Chemistry 206** | **27** |
| **First Term Physical Chemistry test – Chemistry 301** | **1** |
| **Senior Seminar – Chemistry 450 – DUCK Test** | **1** |

1. **How were students selected to participate in the assessment of each outcome (**Helpful details might include- whether this assessment represents all students, a sample of students in a class, or a sample of students across sections)?

Every student who completed the courses in question were given a copy of the exam the final exam. All graduates for the corresponding survey were sent a copy of the graduate survey and asked to complete the survey. With reminders the surveys were completed and submitted to the College Administrative Assistant until after graduation to protect the anonymity of the graduate submitting the survey. Physical Chemistry, Senior Seminar, and the DUCK test were only given to Chemistry majors. The Organic Chemistry and General chemistry test recipients were mostly students taking the classes as cognates. These majors include biology, engineering, criminal justice, or pre-professional health science majors.

1. **In general, describe how each assessment tool (measure) was constructed** (i.e. in-house, national, adapted).

The course assessment examinations were written by faculty from across the country in their professional service the American Chemical Society’s Division of Chemical Education Examination. These are nationally standardized exams that show the expectations of professional and graduate schools from across the nation.

1. **Who analyzed results and how were they analyzed**

The professor who taught the course is the faculty member who was responsible to do the assessment for the examination. The Assessment Coordinator then compiles the assessment for the Department Reports. The Course examinations were broken down into the content areas to determine where students achieved the poorest scores.

|  |  |
| --- | --- |
| **Assessment examination** | **Faculty responsible for assessment** |
| Chemistry 106 General Chemistry II | Mahinda Ranasinghe & Ernest Sekabunga |
| Chemistry 206 Organic Chemistry II | Micheal Fultz |
| Chemistry 301 Physical Chemistry I | Mahinda Ranasinghe |
| Chemistry 450 Senior Seminar (DUCK) | Mahinda Ranasinghe & Jasmine Porter |

1. **Provide a summary of the results/conclusions from the assessment of each measured Program Learning Outcome.** *Report scores for this assessment, as well as students’ strengths and weaknesses relative to this learning outcome.*

**ACS second semester General Chemistry Exam:** The conceptual chemistry knowledge was accessed by testing the mastery of 9 different areas of chemistry. Generally, some of the areas are considered very challenging for students while other areas are more appealing to students. Specially, concepts covered under Advanced Equilibrium (Acid-Base equilibria and Solubility equilibria), Chemical Thermodynamics (Entropy, Gibbs Energy, and Equilibrium), and Electrochemistry need high level of math knowledge to understand. The student cohort is generally weak in math knowledge. The table 01 shows the 9 different areas covered and the percentage of correct responses.

**Table 01.** Conceptual topics assesses and correct responses.

|  |  |
| --- | --- |
| **Concepts Covered** | **% correct** |
| Intermolecular Forces and Liquids and Solids | 48.31% |
| Physical Properties of Solutions | 40.04% |
| Chemical Kinetics | 56.66% |
| Chemical Equilibrium | 47.35% |
| Acids and Bases | 46.50% |
| Acid-Base Equilibria and Solubility Equilibria | 32.75% |
| Entropy, Gibbs Energy, and Equilibrium | 39.92% |
| Electrochemistry | 28.58% |
| Nuclear Chemistry | 59.11% |

**Table 02.** Comparison of WVSU data with National Norms

|  |  |  |
| --- | --- | --- |
| **Statistical Measure** | **WVSU (40 students)** | **National (6353 students)** |
| Average | 31.2 | 36.5 |
| Median | 28.5 | 35 |
| Standard Deviation | 10.6 | 11.1 |

According to the table 02, WVSU’s cohort of students showed only a minor deviation from the national norms for the same exam. Therefore, it is safer to conclude that WVSU’s students shows learning outcomes comparable with the national level.

During the summer of 2023, Mahinda Ranasinghe attended the ACS leadership workshop organized by the American Chemical Society (ACS). During this workshop, I got to interact with many similar institutions that use ACS standardized exams for their PLO assessment. I was able to learn strategies they employ to improve students leaning outcomes such as more problem discussion session in small group setting, peer-led problem discussion, and real-time feedback about the understanding of the topics discussed using iClicker questions. Some of these measures were implemented for one of the sections and department is in the process of procuring more iClikcer remotes so that all the sections can utilize this technology.

**ACS two semester Organic Chemistry Exam:** Organic Chemistry II is considered one of the Chemistry programs assessment courses. To conduct the assessment all students, complete the nationally standardized multiple choice exam developed by the American Chemical Society for a two semester organic chemistry class. This exam is 70 questions long and broken down into 6 sections. The University had to sign a nondisclosure agreement with the ACS so we cannot go into the specifics of the examination but the 6 sections can be categorized as general knowledge, carbonyls, aromatic, synthesis, spectroscopy, and polymer related areas. The 27 completed were analyzed into these areas with the percent correct in each section. The table 03 shows the percentages of correct responses in different categories;

**Table 03.** The correct responses in different organic chemistry concepts

|  |  |
| --- | --- |
| **Category** | **Percent of the class correct** |
| General | 44% |
| Carbonyls | 39% |
| Aromatic | 39% |
| Synthesis | 38% |
| Spectroscopy | 45% |
| Polymer | 42% |

The spectroscopy section has increased over previous years due to the heavy incorporation of NMR, IR, and MS into the organic labs. Every lab, every week students have to analyze the spectra and prove the laboratory worked.

**ACS First Semester Physical Chemistry Exam:** As a measure of the students’ knowledge assessment, the standard test developed by American Chemical Society (Form 2021) was utilized. This exam consists of 50 multiple-choice questions. This test covers major topics in the areas of Gases, Thermodynamics, Chemical Equilibrium, Phase Equilibrium, an introduction to Statistical Thermodynamic. Students taking this course are expected to have a thorough knowledge of Mathematics at least up to Calculus III level. The topics covered in this course use various mathematical concepts and the deficiency in mathematic knowledge can be difficult for both the students to understand the topics while it can be challenging for the instructor since he has to teach the math concepts while discussing physical chemistry topics. Also, in order to fully understand the concepts, students are encouraged to solve selected end of the chapter problems. Students can work as a group when solving these problems but must submit a separate assignment in the online course module. Unfortunately, this semester only one student took the course. Student never interacted with the instructor to work on problems. Also, student is very unenthusiastic about learning the topics discussed.

**Table 04.** Student’s correct responses breakdown

|  |  |  |
| --- | --- | --- |
| **Topic** | **% Correct** | **# of Questions** |
| Properties of Gases | 0.0 | 7 |
| First Law of Thermodynamics | 35.3 | 17 |
| Second Law of Thermodynamics | 33.3 | 9 |
| Equilibrium, Gibbs Energy, Helmohltz Energy | 75 | 4 |
| Phase Equilibrium | 30.8 | 13 |

According to the table 04, the student got of the many questions wrong. Some of these questions tested the same concepts. It is puzzling to me that student got some of them correct but the others incorrect. This trend suggests that a deep understanding on applications of concepts learned during the lecture was weaker. For example, Questions that covered the concepts related to first law of thermodynamics yet students could not identify that concept in the questions.

Several factors can contribute to deficiency in understanding the thermochemical concepts covered in the course. One of the major reason is the unenthusiastic attitude towards the course in general. The lack of doing homework practice problems that cover the concepts. **I offered additional problem discussion sessions but the student never took the best use of that opportunity.**

**ACS Diagnostic of Undergraduate Chemistry Knowledge (DUCK) Exam:** This exam is given to all students in Senior Seminar at the end of the Spring 2024 semester.  Student scores used to assess the knowledge in chemistry sub-disciplines of Physical, Biological, Inorganic, Analytical, and Organic.

1. **What are next steps?** (e.g., will you measure this same learning outcome again? Will you change some feature of the classroom experience and measure its impact? Will you try a new tool? Are you satisfied?)

While it is the job of every faculty member is to improve the comprehension of their students in the classes they teach. This does not stop, there is always room for improvement. To help with that there are several areas where the department is working to improve.

**General Chemistry (CHEM 106) –** This is a team taught course that is offered as 1 section in the Fall semester and 2 sections in the Spring semester. In order to deliver the course content more effectively and consistently, regular discussions among the faculty teaching the course will be implemented on a more regular basis. Also, keeping student updated with their grades and progress regularly, the use of Myonline course shell effectively will be helpful.

**Organic Chemistry (CHEM 206) –** Since this assessment was done after the Spring 2024 semester and the class is Spring only the plan to increase scores in Spring 2025 include:

1. Inclusion of a polymer synthesis lab that includes an aromatic ring – such as styrene (Improve the polymer, aromatic, and synthesis section)
2. Additional homework in carbonyl and aromatic chemistry (Improve the carbonyl, aromatic, and synthesis section)
3. Introduction of designed collaborative homework to solve more complex synthesis questions (Improve the synthesis section)
4. Post all exams, quizzes, and keys from Organic 1 to allow students to continue reviewing the fundamental basics of organic chemistry. (Improve the general section)

**Physical Chemistry (CHEM 301) –** The faculty teaching in this area will offer more optional recitation periods for additional practice time. Also, will put more emphasis on math concepts needed during the lecture. Optional recitation session will be used to do more problem solving during non-lecture hours. Also, group work will be assigned for extra completion credits. These changes will be implemented in the Fall 2025.

**DUCK test –** Student scores used to assess the knowledge in chemistry sub-disciplines of Physical, Biological, Inorganic, Analytical, and Organic.  The department is looking at whether additional learning opportunities such as recitation sessions, problem discussion sessions, and help session will be possible in inorganic or biochemistry courses.

**Graduate Survey –** This was not administered during the 2023-24 academic year since only 1 student was registered for CHEM 450. But this will be used whenever there are more than 1 student is enrolled in the course so that the anonymity and confidentiality of the survey can be maintained. This will allow us to assess all 6 PLOs.

1. **Please attach an example of the assessment tool used to measure your PLO(s).** These can be added as an appendix, a link to the assessment, or sent separately in email with your report.

We are not able to share a copy of the assessment evaluation exams from the American Chemical Society due to the test security guarantees signed by the Department Chair.