CHEM 104 Spring 2021 Learning Outcomes Assessment Report 

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| Date of report: | **June 3, 2021** |
| Course: | Chemistry 104 Spring 2021 |
| Materials used: | Cumulative Final Exam, Online Evaluations, Lab reports |
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# Purpose and Justification

The purpose of this assessment is to identify and qualify strengths and challenges in students’ accomplishment of learning outcomes in CHEM 104, General Chemistry II, using rubric data collected from final exam performance and lab reports.

# Course Overview

This course is the second of a two-semester sequence and provides an in-depth introduction to the fundamental laws and techniques of chemistry for majors in science and engineering. Topics include: intermolecular forces, solutions and their physical properties, chemical kinetics, equilibrium, acids and bases, solubility and complex ion equilibria, thermodynamics, electrochemistry, and nuclear chemistry. It consists of three components (lecture, laboratory, and recitation), which are integrated to provide a comprehensive but thorough introduction to the principles of chemistry. The laboratory component introduces students to common laboratory methods including visible spectroscopy and titration. The recitation aims to show how the concepts covered in lecture are applied in practice in solving problems. The course allows STEM major to receive credit in the **Life and Physical Sciences category** **(LPS)** of Pathways General Education requirements. It is taught as a large lecture (200+ students) with lab and recitation sections (up to 25 students each). It typically has ~8 sections. The syllabus (see Appendix 1) is included in this report.

# Assessment Findings

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| **General Education LPS Learning Outcomes** | **Chemistry 104 concepts** | **Quantitative result\*** | **Brief Description of Findings** |
| Identify and apply the fundamental concepts and methods of Chemistry | The nature of intermolecular attractive forces in relation to states of matter and phase changes. | 83.17% | Conceptual, non-quantitative material that students do not generally find extremely challenging, thus very strong result.  |
| The basic properties of solutions, principles of solubility, vapor pressure effects, colligative properties and associated laws.  | 75.32% | More strongly quantitative material than preceding, student must confront increasing level of difficulty and more complex material. |
| The principles of kinetics and rates of reaction, with specific attention to the development of rate laws and reaction mechanisms.  | 73.56% | Good outcome for complex subject that requires synthesis of different approaches to analyze rates of reaction. |
| Chemical equilibria and reaction outcomes in terms of equilibrium constants, changes in initial concentrations and arrival at dynamic equilibrium; le Chatelier's principle.  | 73.37% | Good result for a challenging topic that students often find difficult both conceptually and quantitatively. |
| Acid/base definitions, acid/base equilibria, pH calculations, strong vs. weak acids/bases, buffer behavior, and acid/base titrations. | 64.32% | Students fare well in certain aspects of this material, but it becomes substantially more difficult with the titration material. Learning outcomes reflects this challenge. |
| Thermodynamics: entropy, system vs. surroundings, and spontaneous vs. non-spontaneous physical and chemical processes; Gibb's free energy. | 56.25% | Known to be one of the more difficult topics of 2nd semester chemistry; worth noting this material falls at the end of the exam where time may be running short.  |
| The electrochemistry of galvanic and electrolytic cells; cell potential and redox reactions; electromotive force and Nernst equation. | 56.85% | Again, extremely challenging material that requires cumulative knowledge and the ability to synthesize many different chemistry topics. As above, time pressure near end of exam.  |
| **Average for learning outcomes for all topics above:** | **70.47%** | Overall excellent result; would like to see less of a decline in learning outcomes over material progression.  |

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| **General Education LPS Learning Outcomes** | **Chemistry Activity Alignment** | **Brief Description of Findings** |
| Apply the scientific method to explore natural phenomena, including hypothesis development, observation, experimentation, measurement, data analysis, and data presentation. | Engage in a series of virtual labs during remote instruction in real time led by teaching assistants; follow videos of procedure prepared by CCNY staff. Prior to the lab they are asked to answer a series of pre-lab questions that help them understand the experiment and develop a preliminary hypothesis. They use a lab manual that outlines the experimental procedure and are given a set of data prepared by staff to analyze for a lab report and present their findings.  | Students successfully completed 12 experiments conducted online under the guidance of experienced teaching assistants. For each lab students completed advance preparation to orient them to the experiment and assist in hypothesis development. Students followed detailed instructions and experimental protocols to learn about the labs and make connections with lecture material. Ultimately students had to analyze supplied data and present it in the form of lab reports. Student performance on these lab reports was excellent, an analysis of all sections revealed a grade average of 93% with robust attendance and very few students who drop the lab.  |
| Use the tools of chemistry to carry out collaborative laboratory investigations. | Follow the procedure and principles of a variety of experiments (kinetics, equilbrium, acid-base, etc.) in a virtual learning space and use provided data for experimental analysis. Work as part of a problem solving team to solve chemistry problems in a lab oriented setting. Students are encouraged to use secondary online resources for data analysis and problem solving.  | Students were introduced to an array of experimental techniques of importance. In the virtual setting students were routinely assigned to breakout rooms to recreate the experience of working in lab teams when in person. Questions that students had difficulty answering individually were typically mastered in group settings with minimal input from teaching assistants. Students also learned how to be resourceful by using secondary material such as open-source textbooks, lecture slides and other internet resources to promote self-guided learning outcomes. |
| Gather, analyze, and interpret data and present it in an effective written laboratory or fieldwork report. | Complete laboratory report as outlined in lab manual. In ‘traditional’ online labs students analyze data and make extensive use of excel to analyze and report on supplied data, in addition to addressing selected questions. In virtual (phet simulation) labs students change experimental conditions and analyze graphical (or other) results.  | For each lab students were required to create a detailed lab report with supporting calculations and graphical analysis. This semester an emphasis was placed on students learning how to present experimental data in Excel for data presentation and to support their experimental conclusions. Many students came into the course with little knowledge of Excel and by conclusion of the lab were skilled in presenting their data in this program, using an array of graphs and charts, calibration curves, and linear regression analysis. |
| Identify and apply research ethics and unbiased assessment in gathering and reporting scientific data. | In the virtual setting students are provided with data and do not collect their own. Students are alerted to the necessity or making sure that all work is their own, in terms of analyzing and reporting on their data. They are also made aware that manipulation of data is strictly not allowed.  | Individual teaching assistants were in charge of educating students on the ethics of unbiased reporting. Teaching labs online meant that students were not generating their own data. It was made clear to the students that they were being given data that was more ‘perfect’ than what they would likely achieve if conducting the labs in person. Student lab reports were monitored for independent work and a lack of plagiarism, with the consequence of a poor grade if guidelines not followed.  |

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| *Briefly summarize overall findings by identifying strengths and challenges in students’ accomplishment of learning outcomes.* |
| The students of General Chemistry 104 in the spring semester 2021 achieved an extremely high success rate. Notably, 200 students passed the course with a grade of C or better, while the remaining 12 either officially withdrew from the course, withdrew unofficially, or obtained a grade of D or below. An analysis of learning outcomes was performed using the cumulative final exam (n=205), administered through the online learning program ALEKS. Students demonstrated an overall success rate based on comprehensive learning outcomes of 70.5%. Other components of the course allow students to bring up their final grade, including lab, recitation, online homework, and in class problem solving. The final exam was designed to be rigorous and incorporated a significant degree of time pressure in combination with algorithmic questions to deter academic dishonesty in an online setting without proctoring. The above learning outcome data shows a sustained decrease in learning outcome success over the course of the semester, which can likely be attributed to several factors. The trajectory of the material is such that it becomes increasingly difficult over the course of the semester, culminating in thermodynamics and electrochemistry, which along with certain aspects of acid base chemistry, are traditionally by far the most challenging for students. It is also probable that the time pressure of the final led students to perform more poorly on the topics that are positioned near the end of the exam. Students are allowed to move around freely within the questions of the exam, but they tend to proceed in a linear fashion. More accurate data about learning outcomes may be obtained upon a return to in person learning in supervised setting incorporating less time pressure. Going forward, it will be worth addressing how to avoid a decline in learning outcome success over the duration of the semester as the material becomes substantially more difficult. |
| *How useful are the text and other resources assigned to this course?*  |
| The learning resources provided to students for the lecture portion of the course are the OpenStax Chemistry 2e textbook (free and open source), detailed lecture slides, online lecture recordings, selected online learning videos, and ALEKS online homework. Pandemic learning has shifted heavily towards the use of ALEKS for both online homework and exams. Informal polling has revealed a low use of the textbook for learning the assigned material, while students appear to make good use of the lecture slides, which have many worked problem examples, and the lecture recordings, both of which are made available on blackboard. Students also rely heavily on the “ALEKS explanations” which accompany the online homework and provide detailed explanations for how to tackle a given problem both conceptually and quantitatively.  |
| **Already implemented “Closing-the-loop” efforts to improve student learning/success:***Since teaching this course, including this current semester, have you made changes in course content, course delivery or other pedagogy? If yes, please explain.* |
| A positive strategy for improving learning outcomes in general chemistry focuses on a partially “flipped” approach to learning. It is possible to deliver learning resources to the students for them to assimilate prior to the lecture, so that they come in more prepared, and we dedicate approximately 25% of class time to problem solving and question answering via iclicker polling. Students are encouraged to work together and actively engage with the lecture. This is a particularly important approach with respect to online learning, since it tends to prevent students from succumbing to the inherent distractions present when in front of their personal computers or other electronic devices. Each semester I attempt to refine my approach to partially flipped learning so that it works as effectively as possible. Challenges include finding the right balance between lecture time and problem-solving exercises within the constraints of a comprehensive survey course, while also encouraging students to do the requisite work prior to coming to lecture.  |
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| *How exactly have the changes that you have implemented impacted student learning/student success? Please provide specific examples.*  |
| For the past two semesters success rates for students passing the course (Chemistry 103 and 104) have been extremely high and very few students have withdrawn from the course or failed. There is some reason to be cautious about these results since pandemic learning, and in particular exam administration, has been marred by the lack of supervised testing, although efforts have been made to deter cheating through deployment of algorithmic questioning and other strategies. Student attendance and engagement have been robust, and student enthusiasm has been made clear through positive feedback from course evaluation. For example, students have made the following comments in the course evaluation from spring 2021:*I learned how to review for exams on the material by consistently practicing on ALEKS as it helps you prepare for exams and boosts homework grade. I learned how to solve specific ALEKs problems with the help of TA and studying effectively through ALEKs problems and lecture power points in areas I would struggle in.**I learned important topics within the field of chemistry that greatly connected to my current studies in engineering such as thermodynamics. I was also able to achieve a concise and thorough understanding of acids and bases through the lectures provided by the Professor, as well as the specific and rigorous homework that had been assigned to us weekly. Finally, I also learned how to effectively analyze chemistry questions which was beneficial in understanding the questions asked during class that counted towards our grade.**I learned how to manage my time when it came to a lot of work. I learned how to seek help from peers to help me understand certain questions. I learned a better way of studying for certain types of course.**I appreciated the professor's teaching style and how approachable they were to answer any questions unlike other professors. They made learning during lectures very fun and interacting along with other students. The engagement between students was also great. I also appreciated the TA and the lab instructors for helping out with material pertaining to outside lectures like ALEKs homework and lab assignments.**I really appreciated the Professor's passion for chemistry and care for her students. She was always open to questions and improvements to the class in order to make our experience less stressful. She also developed a safe space in which people can express their thoughts on not only chemistry, but when the coursework had been applied to real-life scenarios, which made the class not only enjoyable, but comfortable*. |
| **Future “Closing-the-loop” plans to improve student learning/success***Based on your assessment of student learning, what changes do you plan to implement at instructional level to improve student learning? Specify topics and pedagogical changes, if applicable.*  |
| Continue with the partially flipped learning approach to maximize engagement with the material and improve learning outcome success rates. Address how students learn best, i.e. understanding the best way to communicate the material and providing the most effective teaching resources for different kinds of learners. Finally, helping students manage their time and efficiency with study habits to avoid decline in learning outcomes as the semester progresses.  |
| *Provide suggestions, if any, to be done on a departmental or institutional level to support student learning/success in this course.*  |
| The large enrollment of general chemistry courses makes it very difficult to provide personal attention to students who are struggling. While the recitation is very effective in providing students with additional assistance, more robust tutoring services would be helpful. the City Tutors program through Colin Powell is a useful resource, but there is always room for improvement to provide students with assistance in mastering a difficult subject.

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| *Any suggestions for improving the assessment strategy for this course?*  |

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The use of the cumulative final exam for evaluating learning outcomes was informative and useful, but a more comprehensive analysis could be performed combining this analysis with other components of the course such as online homework performance or mid-semester exams.