Departmental Mission Statement

Our major goal is to provide our students with the most rigorous education in the core concepts of chemistry. We strive to provide a meaningful and relevant education in which the core concepts are framed in the most exciting science topics of today, including materials and energy research, nanotechnology, computational chemistry, natural products, drug design and protein research. We strive to provide our students with a broad range of interdisciplinary learning and research opportunities. At the same time we provide our students with a solid foundation in the core traditional areas of chemistry.

Assessment Loop #1: Research Methods in Chemistry

Learning Goal
Students will understand and apply basic research methods as used professionally in chemistry, including research design, data analysis, and interpretation.

Specific Student Learning Objectives
1. Identify, describe, and demonstrate research methods used to probe chemical reactions.
2. Design and articulate an independent research project.
3. Critique conclusions presented in the primary literature.

Comments on Learning Objectives.

1. **Identify and describe research methods used to probe specific chemical motifs.**
   This Learning Objective involves the correct use various instrumental analyses in the full characterization of different reaction types. This Learning Objective most likely fits into Superlab.

2. **Design and articulate an independent research project.**
   This Learning Objective is designed to probe a student’s ability to digest the chemical literature, formulate new ideas and articulate them clearly. This objective will take the form of an independent research proposal that is based upon the primary literature and includes new ideas and directions. This would serve a few purposes. First, it would provide preparation for senior thesis experience in that they need to be able to propose future experiments in current projects. Second, it would provide another source for the evaluation of their critical thinking skills.

3. **Critique conclusions presented in the primary literature.**
   This Learning objective is designed to measure a student’s ability to analyze and critique the primary literature. This is performed routinely in the advanced level courses offered by the chemistry department.
The Measures

Direct:

1. **Rubrics.** We will develop a consistent rubric for the evaluation of fixed Superlab components related to instrumental analyses (objective 1). Also, if all students are asked to write a research proposal in Chem 301 (objectives 2 and 3), a common rubric that does not change from year to year will be used (some revisions are, of course, fine). We will also develop rubrics for 36x, senior research grades in order to better assess the development of research skills in the senior year. Emphasis will be placed on critical problem solving skills and not necessarily on advancement of the project.

2. **Standardized tests.** We could give our students old versions of the GRE chemistry tests, focusing on items related to research methods, research project design and critique of literature (objectives 1, 2, and 3). Most who enter graduate school will be given these tests.

3. **Experiment design.** Evaluation of the first objective will take the form of student driven reaction procedures in which students will be required to design methodologies for specific reactions. They will be given terse experimental sections from the primary literature and charged with successfully conducting the experiment.

Indirect:

1. **Alumni Surveys.** We will target alumni who are either employed as professional chemists or are graduate students in chemistry. The surveys will be designed to focus on the skills used by chemists, not necessarily those used in health fields. Some questions would relate to their preparation at Haverford for the research world related to the three learning objectives.

Linked Planning

The Chemistry department will use the outcomes to measure student learning and to further refine our curriculum at the junior and senior levels. This could take several forms:

1. Student – research mentor interactions during the senior thesis experience could reflect a student’s strengths or weaknesses, as determined in junior level assessments. This would allow the Chemistry department to feed such data back into improved student learning.

2. The use of standardized tests and rubrics in our programs will allow for the determination of longitudinal correlations between program design and student performance.

3. Student performance in the first semester of senior research should reflect past experience in writing an independent research proposal in junior level Superlab. The Chemistry department will probe the effectiveness of this added requirement by comparing current and past student performance. We will focus on the use of the primary literature, formulation of ideas and articulation of research goals.
4. The results of the alumni surveys will be used to assure that our curriculum provides sufficient coverage of modern chemistry. As graduate school and industrial research areas evolve more quickly than most undergraduate programs, we will use this information to ensure that our curriculum remains current.
Assessment Loop #2: Evaluation of the Introductory Curriculum

Learning Goal
Students will understand the fundamental basis for the structures and reactivities of atoms, molecules and non-molecular solids and the analytical techniques used for their determination.

Specific Student Learning Objectives
1. Demonstrate the strengths and limitations of different models for bonding.
2. Identify characterization tools to probe bonding motifs.
3. Collect, analyze and interpret spectra using various forms of instrumentation.
4. Access and search the primary literature for examples of functional molecules.

Comments on Learning Objectives.

1. This learning objective is designed to probe student understanding of the different models of chemical bonding, with focus on the strengths and weaknesses of each. This objective will be targeted in first semester general chemistry and first semester organic chemistry. A strong foundation in chemical bonding is critical for the understanding of molecular reactivities and structures.

2. As the Chemistry department revises the introductory curriculum, we plan to create a laboratory program that is more focused on connections between chemical structure, reactivity and methods of characterization. We plan to completely reconstruct the first laboratory experience such that characterization tools are integrated into discussions of structure. For example, UV-Vis spectroscopy is used to observed electronic transitions and it will be described and implemented as the courses discuss the electronic structure of molecules. We have identified several techniques to introduce, each of which probe a different structural motif. These include UV-Vis spectroscopy (electronic transitions), IR and Raman Spectroscopy (bond strengths), atomic absorption (electron structure), NMR spectroscopy (molecular connectivity and nuclear structure) and X-ray diffraction (solid state structure).

3. As described above, we plan to create a series of laboratory experiments that will give students hands on experience with a wide range of instrumentation. These techniques are currently not integrated into the lab program or the lecture courses. They tend to be taught as a ‘Spectroscopy’ unit in which many are described. We believe integrating them into the lecture courses and creating a new laboratory sequence will strengthen the connections between techniques and the chemistry.

4. The primary literature will be used to demonstrate the breath of molecular structures and to further develop correlations between structure and reactivity. The primary focus of the learning objective is to introduce standard portals used to search the literature, including SciFinder Scholar and the Web of Knowledge.

The Measures
Direct:

1. American Chemical Society Standardized tests (objectives 1 and 2). Questions from established standardized tests will be incorporated into the final exams of our introductory courses. These questions
will be designed to cover a wide range of topics. We will track student performance on these questions in a longitudinal fashion. We believe that the effectiveness of our curriculum will be reflected in student performance on these questions.

2. **Laboratory performance (objective 3).** The Chemistry department’s ongoing reorganization of our introductory curriculum includes significant changes to our first and second year lab sequences. We will develop a series of experiments to probe student understanding of the use of different spectroscopic techniques. Emphasis will be placed on the analysis and interpretation of collected data.

3. **Poster presentations (objective 4).** The Chemistry department routinely asks second year students to research, create and present posters on independent topics. This exercise provides an introduction to the chemical literature and the methods used to search the literature. A standard rubric will be developed to evaluate these posters.

**Linked Planning**

The Chemistry department will use the outcomes to further refine our curriculum at the introductory level to improve student learning. This will take several forms:

1. The degree to which we have made the primary literature accessible to students in our introductory courses will be evident from their posters. We will use the quality of the citations to understand student use of SciFinder Scholar.

2. Student performance of the standardized tests should reflect the quality of the curriculum. We will collect data from class to class to see the effects of course structure variations. The results will be used to elucidate the strengths and weaknesses in our curriculum and will feed back into course revisions.

**Institutional Support**

The Chemistry department will require institutional support in a number of initiatives. These include:

1. The creation, distribution and analysis of alumni surveys. We plan to use established social networking sites to collect current contact information. Specifically, Facebook and LinkedIn groups will be created and populated with our alumni. Administrative assistants will be able to invite alumni to these groups by using past lists of majors. In addition, we will ask each senior class to join these groups before graduation.

2. The science library staff has been very helpful in the past with introducing standard search mechanisms for the primary literature. We will continue to require this assistance.

3. The collection of scores from direct measures (standardized tests or common questions on different exams) could result in the construction of a small database. This database would contain longitudinal data and allow for the comparison time dependent data. The set up and maintenance of this database would require institutional support.