I. Learning Objectives

Our learning objectives, and the visual representations of them, evolved over the 2009-10 year. As our discussions ensued, learning objectives moved around between larger categories and new learning objectives moved onto the scene, including effective independent learning, use of quantitative reasoning/skills, and what we came to call "mastering complexity". Preparations for our 2010-11 Department review also helped us converge. We have included below a version that represents best where we are right now (**Figure 1**). This is still a work in progress.

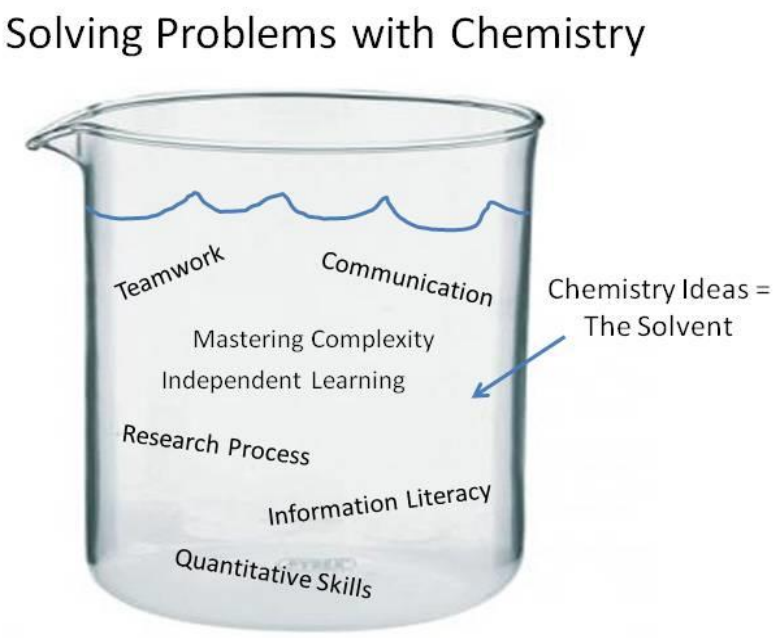

Figure 1: Carleton Chemistry Department Learning Objectives for Majors

All our learning objectives relate to one overarching goal for graduating Chemistry majors. **We want students to be able to solve a wide variety of problems (disciplinary, interdisciplinary, practical, real-world, research, etc…) that require a chemical perspective.** The title of

Figure 1 reflects this. Finding this "center of mass" was encouraged by Mary Savina and Cherry Daniels in early discussions, and we have found it to be quite helpful.

At the moment, we view chemistry content ideas as the "solvent" in which all other learning goals "swim". Chemistry content is ubiquitous; it is present regardless of the skill-based learning objective we are assessing. The content present in a given learning activity varies hugely. We have yet to sort out the implications for assessment that is largely focused on chemistry ideas, but we know this lies ahead. However, it is likely that we will end up assessing chemistry content with "big ideas" categories ideas in the discipline that include: structure/function relationships, dynamics (kinetics), macro/micro thinking, energy thinking, and chemical reactivity. Please note that the "disciplinary skills" are also liberal arts skills for life-long learners.

Finally, we note that concrete and specific learning outcomes must emerge from the framework and categories in **Figure 1** above. Some of these are more currently developed, and some are not. For example, a list of learning outcomes for communication is contained in **Document 2** and includes attention to issues of purpose, organization, clarity, audience, and visuals. This rubric is working pretty well for us right now, though it lacks precise definition for the novice-expert scale. We typically struggle with precise scale definitions on rubrics. We have also articulated more specific learning outcomes for comps (**Document 1**), many of which are apply outside of Chemistry and appear in our **Figure 1** categories. We acknowledge that we have much work to do in the area of rubric design and scale definition. We would appreciate help on this now that we have areas for learning outcomes better defined.

II. Department Assessment Plan

Table I: Chemistry Department Plan for a Decade of Assessment

Academic Year	**Learning Outcome Area**	**Learning Activities to Use in Assessment**
2009-10 Year 1	1. Communication, Mastering Complexity, Independent Learning	1. Comps: • Group Comps Talk Rubric • Group Question List Bloom Analysis • Instructor Assessment of Individuals on Independent Learning
2010-11 Year 2 ***Department Review Year***	1. Communication, Mastering Complexity, Independent Learning 2. Research Process	1. Refine/use group talk and instructors rubrics from last year (see above). Decide on changes in teaching practice. 2. Team Research Lab Projects • Chem 301 Kinetics Project • A 200-level lab project (Orgo Chem)

2011-12 Year 3	1. Research Process 2. Chemistry Content I	1. Team Research Lab Projects (as above). Refine/use rubric(s) from last year. Decide on changes in teaching practice. 2. Invent rubric(s) we can apply at 2 points in curriculum. Use existing assessments (exams, assignment, projects, etc...)
2012-13 Year 4	1. Chemistry Content I 2. Quantitative Skills	1. Refine/use rubric(s) from last year (see above). Decide on changes in teaching practice. 2. Invent rubric(s) we can apply at 2 points in curriculum. Use existing assessments.
2013-14 Year 5	1. Quantitative Skills 2. Teamwork	1. Refine/use rubric(s) from last year at 2 points in curriculum. Decide on changes in teaching practice. 2. Invent rubric(s) we can apply at 2 points in curriculum. Use existing assessments.
2014-15 Year 6	1. Teamwork 2. Information Literacy	1. Refine/use rubrics from last year at 2 points in curriculum. Decide on changes in teaching practice. 2. Invent rubric(s) we can apply at 2 points in curriculum. Use existing assessments.
2015-16 Year 7	1. Information Literacy 2. Chemistry Content II	1. Refine/use rubrics from last year at 2 points in curriculum. Decide on changes in teaching practice. 2. Invent rubric(s) we can apply at two points in curriculum. Use existing assessments.
2016-17 Year 8	1. Chemistry Content II 2. Mastering Complexity, Independent Learning	1. Refine/use rubrics from last year at 2 points in curriculum. Decide on changes in teaching practice. 2. Revisit these important areas, revise rubrics and use at 2 points in curriculum.
2017-18 Year 9	1. Mastering Complexity, Independent Learning	1. Refine/use rubrics from last year at 2 points in curriculum. Where have we come in a decade? Decide on changes in teaching practice.
2018-19	1. Communication	1. Revisit this area. Create new rubric(s) that are more compelling to us and apply at 2 points in

Year 10	2. Draft of new Decade Plan for Department Assessment	curriculum. 2. Take time to reflect on a decade of work and build a plan for the next decade. Refined areas for learning outcomes. Progress made? What is compelling to us now? What is most problematic today in current student learning?

Document 1: Chemistry Comps Learning Outcomes

Independent Learning (attitudinal & behavioral)

- Takes positive attitude toward independent learning; stretches to become a more independent learner.
- Has the confidence that learning will progress if time/effort and effective learning practices are used.
- Demonstrates accountability and responsibility for drawing actively/often on prior learning.
- Takes ownership of, initiative for, and responsibility for own learning.
- Takes the initiative to connect comps learning to prior chemistry learning.
- Takes the initiative to learn alone and/or outside the group (info literacy in here too?)
- Understands and uses ability to self-assess (individual and group level) in the learning process (metacognition). Keeps own learning on track.
- Copes effectively with ambiguity and confusion, both in forefront scientific knowledge and in individual learning process.

Communication – Verbal & Written

- Ability to "talk like a scientist" – clear articulation of ideas (group meetings, visit with chemist, public talk).
- Ability to articulate ideas and questions clearly in written form.

Problem Solving & Inquiry

- Effectively applies chemistry to the problem at hand (*application*).
- Makes connections to chemistry learning (connection to prior knowledge); actively draws from all areas of chemistry (*integration, synthesis*).
- Effectively navigates the tension between context of research topic and deep learning about the content (literature papers) (*context vs. content*)

- Develops and uses strategies for deep reading of the scientific literature, in service of understanding the comps research topic. (*deep reading/learning process)*

Teamwork

- Transitions between working independently and working collectively towards a particular goal.
- Articulates ideas accurately and carefully to the group, as an individual.
- Plays various roles that help the entire group move forward with their learning.

Document 2: Assessment of Chemistry 2010 Group Comps Talks

Group: _____ **Talk Date: _____**

Features present in talk: **infrequent** **frequent/sometimes** **very consistently**

Effective Oral Communication			
Clear purpose and goals for the talk			
Clear organization			
Clarity of explanations			
Appropriate voice and use of language (audience)			
Effective and creative use of visuals			
Apply Problem-Solving & Inquiry to Topic			
Effective narrative - "telling your own story" about the research			
Clear articulation of research questions addressed by the field/chemist			
Framing a larger context for the research field			
Accuracy and depth of scientific ideas			
Synthesis and integration of topic with chemistry			
Effective use of evidence and examples			

Please write comments on the back of this form.

DOCUMENT 3: CHEMISTRY COMPS EVALUATION SCHEME

June 3, 2010

Fill out this evaluation for each student in each group, then the results will be pooled and distributions will be obtained. This should be done:

1. For students at the end of the comps experience, focusing more on the activities other than the talk
2. Once per student in each group (i.e. co-leaders complete this together)
3. Without names of students attached

THE STUDENT IS CAPABLE OF…	*DEPENDENT ON FACULTY (1)*		*SOME DEPENDENCE ON FACULTY* →		*INDEPENDENT OF FACULTY (5)*
Learning on their own, outside of the structure of a course **(Independent Learning)**	1	2	3	4	5
Learning as part of a team, outside the structure of a course **(Teamwork)**	1	2	3	4	5
Using the chemical literature **(Information Literacy)**	1	2	3	4	5
Building upon courses in the major to master a complex set of ideas **(Mastering Complexity)**	1	2	3	4	5
Holding themselves to an appropriate level of rigor **(???)**	1	2	3	4	5

We have also labeled how each learning outcome relates to our **Figure 1 categories**.