

Chemistry

CWSEI Department Summary

This document summarizes the Chemistry Department's activities as part of the Carl Wieman Science Education Initiative over the years 2007-2017. In this initial version, it replaces a series of web pages that were updated over the lifetime of the CWSEI. It may be updated in future with more detail on impact.

For questions, please contact:

Jackie Stewart (jstewart@chem.ubc.ca) or Warren Code (warcodes@science.ubc.ca)

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Overview

The Chemistry Department began work on CWSEI course transformations in 2008. Initially, the work focused on evaluating and redesigning the Chemistry 123 lab (Physical and Organic Chemistry).

In spring 2013, the second phase began, which focused on 1) analytical chemistry courses (CHEM 211 and 311), 2) third-year integrated laboratories (CHEM 315/325/335/345), and 3) Global Challenges, a Chemistry Perspective (CHEM 341).

The third and final phase of course transformations, beginning in spring 2016, will address Chemistry 208 (Coordination Chemistry), 218 (Fundamentals of Reactivity in Inorganic Chemistry), 233 (Organic Chemistry for the Biological Sciences), 300 (Communicating Science), and 327 (Introduction to Materials Chemistry).

In addition to CWSEI teaching initiatives, the department underwent an independently funded external review of our 1st year chemistry program. Mike Wolf, Derek Gates and Jackie Stewart have developed improved course support materials for CHEM 121 (tailored in-house textbook, homework sets, power point notes for instructors, etc.) independently supported by TLEF and Skylight. Additionally, seven interactive online tutorials have been developed and implemented over the past eight years to complement existing CHEM 121 lab experiments as part of an ongoing co-operative between Sophia Nussbaum and the ChemCollective of Carnegie Mellon University. Funding from Skylight was used to develop yet another interactive tutorial and refine two existing tutorials with Carnegie Mellon. In fall 2014, activities supported by UBC's Flexible Learning Initiative were implemented in CHEM 121.

People

CWSEI Department Director: Jackie Stewart (2010-2017), Laurel Schafer (2007-2010)

STLFs: Elizabeth Gillis, Jane Maxwell, Kerry Knox, Jennifer Duis

Faculty: R. Algar, D. Bizzotto, M. Blades, G. Bussiere, G. Dake, E. Grant, P. Kennepohl, A. Lekhi, J. Love, V. Monga, J. Rodríguez Núñez, C. Rogers, R. Stoodley, M. Thachuck

Students: Chad Atkins, Claire Chatalova Sazepin, Eugene Chong, Caitlyn Grypma De Jong, Ravina Binning, Zachary Nevin, Armandeep Sidhu, Merrill Isenor, Nicholas Mah, Samantha D'Souza, Ainge (Y. C.) Chang, Aalia Sachedina, James Zhou, Michael Carlson, and Yuri Samozvanov

Activities

Overview of Activities

Course Evaluation & Redesign Phases

PHASE I (2008-2010):

Focused on the evaluation and redesign of the CHEM 123 lab – Physical and Organic Chemistry and CHEM 121 lab - Structural Chemistry, with Application to Chemistry of the Elements.

PHASE II (2013-2015):

Focused on 1) analytical chemistry courses (CHEM 211 and 311), 2) third-year integrated laboratories (CHEM 315/325/335/345), and 3) Global Challenges, a Chemistry Perspective (CHEM 341).

PHASE II (2016-2017):

Will address Chemistry 208 (Coordination Chemistry), 218 (Fundamentals of Reactivity in Inorganic Chemistry), 233 (Organic Chemistry for the Biological Sciences), 300 (Communicating Science), and 327 (Introduction to Materials Chemistry).

Additional Undergraduate Program Activities


- We identified interdisciplinary science lab skills that other science streams consider to be important and/or are expecting students to get from 1st year chemistry to inform our curriculum. Additionally, seven interactive online tutorials have been developed and implemented over the past nine years to complement existing CHEM 121 lab experiments as part of an ongoing co-operative between Sophia Nussbaum and the ChemCollective of Carnegie Mellon University. Funding from Skylight was used to develop another interactive tutorial and refine two existing tutorials with Carnegie Mellon. In fall 2014, activities supported by UBC's Flexible Learning Initiative were implemented in Chemistry 121 and currently work is underway to implement flexible learning activities in Chemistry 123.
- We surveyed Co-op employers to aid in focusing efforts of optimization and determining impact on upper level laboratory revitalization.
- The Department modified course curriculum for CHEM 415/425 to expand research opportunities to chemistry majors.
- In 2015 the Department started rolling out an entirely [new curriculum](#). A new required course for chemistry majors (CHEM 300) "Communicating Chemistry" will be designed with the assistance of CWSEI to best achieve the course goals of improving students' communication skills and their awareness of the process of science.


TA Development



Anka Lekhi and Sophia Nussbaum have been offering yearly TA training since 2009, with support from the TA Training Program of the Provost and Vice-President Academic Office and the Chemistry Department. This training has emphasized the skills needed for incoming graduate students to teach first-year labs. Elizabeth Gillis has started a TA peer-mentoring program for students working in the third-year labs, which complements a start-of-term workshop.

Courses



Status as of May 2016:



Course	Learning goals	New Assessments	Improved Methods
<p>CHEM 121: Structural Chemistry, with Application to Chemistry of the Elements (Lab component) (Oct '08 start)</p> <p>Faculty: Sophia Nussbaum STLF: Jennifer Duis</p> <p> Paper (JCE 2013): A Process for Developing Introductory Science Laboratory Learning Goals To Enhance Student Learning and Instructional Alignment</p>	<p>Course-level goals: Outline from CHEM 123, focus on transferable skill acquisition</p> <p>Experiment-level goals: process for development established</p> <p>Course-level outline and experiment-level development process appropriate for the entire lab program</p>	<p>Attitudes survey (C-LASS CHEM) given 3 Terms</p> <p>Development and implementation of end-of-term technique assessments:</p> <p>— Year 1: TA visual assessment of technique with provided guide</p> <p>— Year 2: Visual assessment guide refined and technique questions added to the end-of-term quiz.</p>	<p>Alterations made to increase alignment with 1st-year lab goals:</p> <p>— Marks re-allocated to increase emphasis on maintaining a lab notebook.</p> <p>— Directions on maintaining a lab notebook expanded in lab manual.</p> <p>— Brief "taking observations" module developed and added during check-in.</p> <p>— Peer marking of observations using supplied templates added to each experiment</p> <p>— Technique modules will be expanded to include choosing glassware for analytical vs. non-analytical purposes.</p> <p>— A new experiment was piloted</p> <p>— "Pair-technique-ing" (ala comp. sci. pair programming) was piloted with a</p>

			small subset of students.
<p>CHEM 123: Physical and Organic Chemistry (Lab component) (July '08 start)</p> <p><u>Faculty:</u> Sophia Nussbaum, Laurel Schafer, Jackie Stewart <u>STLF:</u> Jennifer Duis</p> <p>The First Year Assessment sub-committee of the Chemistry Lab Committee oversaw this project. The sub-committee members were: Brian Cliff (chair), Guillaume Bussiere, Ed Grant, Laurel Schafer, Vishakha Monga, Sophia Nussbaum, John Sherman, Robin Stoodley, Nancy Vered, Peter Wassell, and Dana Zendrowski.</p> <p> Poster (CWSEI EOY 2009): Instruments for assessing practical skill development in a first-year chemistry laboratory course</p>	<p>Course-level goals: working version, inspired by Rice University's interdisciplinary science lab learning objectives, approved by Chemistry Lab Committee</p> <p>Experiment-level goals: (developed from existing course materials) 4 of 4 experiments complete and approved by Chemistry Lab Committee</p>	<p>Chemistry background and demographics survey developed and given 2 Terms.</p> <p>Attitudes survey (C-LASS CHEM) given 2 Terms.</p> <p>Pre-/Post-Lab skills survey (written) developed & given 4 Terms. "LG use" questions added.</p> <p>Refined hands-on lab skills assessment implemented 2 terms.</p> <p>Assessment of experiment specific learning goal achievement (surveys, observations, interviews); 3rd round of refinement based on expert & student validation</p>	<p>Learning Goals incorporated into lab manual (under refinement).</p> <p>Alterations made to increase alignment with learning goals:</p> <ul style="list-style-type: none"> — Marks re-allocated to increase emphasis on maintaining a lab notebook. — Directions on maintaining a lab notebook expanded in lab manual. — Expanded quizzes will be introduced to test technical skills. — Addition of manual dilutions to electrochemistry experiment to increase technical experience and conceptual understanding of the effect of dilution on voltage. — Lab final modified to test students' "solo" completion of an experimental design, recording of observations and data, and evaluation of skills using a pipet and weighing by differences.

<p>CHEM 211: Analytical Chemistry (Spring 2013 start)</p> <p><u>Faculty:</u> Russ Algar, Anka Lekhi, José Rodríguez Nuñez</p> <p><u>STLF:</u> Jane Maxwell</p> <p> Poster (Science Education Open House 2016): Pilot implementation of an online homework system for practice and feedback on decision-making skills</p> <p> Talk (CSC 97th Canadian Chemistry Conference, June 2014): Development of a Concept Inventory for Measuring Learning Gains in Analytical Chemistry</p>	<p>Course-level learning goals developed in consultation with current and previous instructors of both CHEM 211 and 311</p> <p>Topic-level learning objectives have been revised through an iterative process, with slight modifications each term. There now appears to be consensus that the current learning goals meet the needs of all instructors.</p>	<p>Mid-term survey of student perceptions of instructional activities and tools.</p> <p>End-of-term surveys probing student perceptions of the course and the discipline of analytical chemistry</p> <p>Ongoing: Development of an analytical chemistry concept inventory</p>	<p><u>Lecture:</u> Fall 2013: Introduction of concept questions and clickers, and increased use of team-based-learning (TBL) activities.</p> <p>Winter 2014: Introduction of clickers to support new and existing concept questions and class activities. Continued use of TBLs. Short, in-class writing assignments connecting topics to big-picture learning goals.</p> <p>Winter 2015: Continued use of iclickers. Introduction of in-class worksheets for problem solving related to the equilibrium unit.</p> <p><u>Lab:</u> Increased emphasis on lab skills via an early-term lab skills test (including a remedial intervention) and TA grading of lab skills based observation</p> <p>Fall 2013: Introduction and evaluation of a new guided-inquiry experiment in which students design, build, and test a simple photometer</p> <p>Fall 2014: Introduction</p>
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			of a new guided-inquiry experiment based on comparing instrumental and classical methods of analysis.
<p>CHEM 311: Instrumental Analytical Chemistry (Spring 2013 start)</p> <p><u>Faculty:</u> Dan Bizzotto <u>STLF:</u> Jane Maxwell</p>	<p>Course-level learning goals developed in consultation with current and previous instructors of both CHEM 211 and 311</p> <p>Detailed learning objectives emphasizing core competencies required to achieve course-level goals</p>	<p>2014: Two-stage review activity probing students' background knowledge of key concepts from 1st year physics and CHEM 211 administered on first day of class</p> <p>Introduction of a two-stage midterm exam</p> <p>2015: Continued use of two-stage review and midterm exam</p> <p>Modified regular course assignments to include exam-type questions (marked for effort rather than correctness), based students' feedback.</p> <p>2016: Continued use of two-stage review and midterm exam. Continued use of revised course assignments.</p>	<p>2014: Increased use of in-class activities, including clicker questions and predictions related to demonstrations and simulations</p> <p>Group activities emphasizing the common decision-making and evaluation processes that link the different topic areas of the course</p> <p>2015: Continued and expanded use of in-class activities, clickers, demonstrations, and simulations</p> <p>Piloting a suite of tutorials focused on high-level problem-solving skills for the new course tutorials</p> <p>2016: Implemented tutorial activities</p>
<p>CHEM 315/325/335/345: Chemistry Integrated Laboratory (Spring 2013 start)</p> <p><u>Faculty:</u> J. Bates, G.</p>	<p>Course-level learning goals produced based on framework developed by previous CWSEI project in CHEM 123</p>	<p>April 2013: — Survey probing student perceptions of course (post-course) — Attitudes survey (C-LASS CHEM)</p>	<p>Learning goals incorporated into lab manual</p> <p>Analysis of course content for purpose of informing future</p>

<p>Bussiere, T. Kunz, V. Monga, J. Rodríguez Núñez, C. Rogers, R. Stoodley STLF: Elizabeth Gillis, Kerry Knox (2013-2014)</p> <p> Poster (Science Education Open House 2016): Developing the third-year integrated chemistry laboratory: Putting the pieces together</p> <p> Talk (Variety in Chemistry Education & Physics Higher Education Conference, August 2014): The use of cognitive task analysis to inform the development of a laboratory course in chemistry</p>		<p>September 2013: — Survey probing student perceptions of orientation to course and expectations (pre-course) — Attitudes survey (C-LASS CHEM)</p> <p>December 2013: Survey probing student perceptions of new online safety training module</p> <p>April and December 2014: Survey probing student perceptions of course (post-course)</p> <p>September 2014 and January 2015: Survey probing student perceptions of orientation to course and expectations (pre-course)</p> <p>Ongoing: Analysis of student lab reports with respect to progress towards achieving learning goals</p> <p>2015-2016: Lab report “wrappers” to assess student learning from oral and written laboratory reports.</p>	<p>development in terms of: — skills and techniques covered — cognitive tasks involved</p> <p>Dry lab workshop introduced focused on organic chemistry structures</p> <p>Pilot project in oral lab assessments for multiple experiments.</p>
<p>CHEM 341: Global Challenges: A Chemical Perspective</p>	<p>Course-level learning goals produced</p>	<p>April 2013: Survey probing student perceptions of course</p>	<p>Introduction of in-class interactive activities to provide enhanced</p>


<p>(Spring 2013 start)</p> <p>Faculty: Gregory Dake STLF: Elizabeth Gillis, Kerry Knox (2013-2014)</p> <p> Poster (Science Education Open House 2015): Using Course Committees as Student Feedback</p> <p> Poster (CWSEI EOY 2014): Research-based instructional strategies in a course on the role of chemistry in solving global challenges</p>		<p>and attitudes towards role of chemistry in society (post-course)</p> <p>January 2014 and January 2015: Survey probing student attitudes towards learning chemistry and role of chemistry in society (pre-course)</p> <p>2015: Exams replaced with two-stage exams (total of three exams)</p> <p>Student course committee created to provide continuous feedback on the course.</p>	<p>opportunities for discussion and peer-instruction, including:</p> <ul style="list-style-type: none"> — jigsaw activities — small-group discussion — whole-class discussion — concept mapping <p>Introduction of semester-long group investigative research and communication project involving several opportunities for revising work based on feedback, peer review, and structured practice in team-work</p> <p>Sample problems offered as additional resource</p>
<p>CHEM 113, 121, 415, 425, 449: Attitudes survey (C-LASS CHEM) administered Spring '09 (CHEM 113 & 121 also participated in the written Lab Skills Survey).</p> <p>CHEM 233: Detailed learning objectives, attitudes survey (C-LASS CHEM), “flipped classroom” approach.</p> <p>CHEM 425/448: Engaging students in cutting-edge chemical education research, report writing, and presentations.</p>			

Education Research


Comparison of Oral and Written Laboratory Reports

Compared to traditional written reports, oral assessment may provide a more accurate evaluation of conceptual understanding as well as provide enhanced opportunities for learning since feedback can be given in real time. We are studying the effect of mode of assessment on student learning and seeking to gain insight into how a student’s preparation and experience of assessment affects short- and long-term learning.

Two-Stage Review

Jane Maxwell, Lisa McDonnell (Biology), and Carl Wieman wrote the article  [An Improved Design for In-Class Review, Journal of College Science Teaching, Vol. 44\(5\), pp. 48-52 \(2015\).](#)

Analytical Chemistry Concept Inventory

Development of a diagnostic test to evaluate students' understanding of key concepts in 2nd year analytical chemistry is in progress.  [Talk \(CSC 97th Canadian Chemistry Conference, June 2014\): Development of a Concept Inventory for Measuring Learning Gains in Analytical Chemistry — Jane Maxwell](#)

Chemistry Concept Diagnostic Tests

Propose administration and validation of an existing chemistry concept test to first year chemistry students.

Organic Chemistry (CHEM 233) Learning Objectives Alignment Study

Investigating students' perceptions of the alignment between learning objectives and assessment, probing their ability to judge cognitive complexity of learning objectives, assessment items, and study tactics.

1st Year Practical Lab Skills


Compare students' achievement of practical lab skills as determined by written vs. hands-on assessment

CHEM 123 Lab Learning Goals

Developed multiple assessments of students' achievement of lab learning goals:  [Poster \(CWSEI EOY 2009\): Instruments for assessing practical skill development in a first-year chemistry laboratory course](#)

Attitudinal Survey

C-LASS CHEM given in multiple courses, statistical comparisons between UBC and CU-Boulder.

 [Poster \(April 2009\): General chemistry students' belief about chemistry and learning chemistry: An international comparison — Jennifer Duis, Carl Wieman, Laurel Schafer](#)

2014-2015: CLASS-Chem survey data from 2008-2010 re-analyzed to examine trends between attitudes, attitude shifts, and choice of major in science (with a focus on Chemistry and Biochemistry majors). We are also in the process of verifying the factor structure of CLASS-Chem survey responses among UBC students.

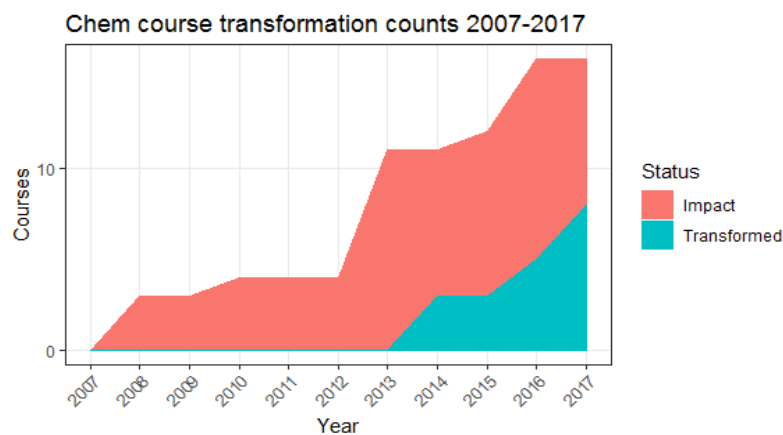
Presentations at national/international meetings

237th, 240th, & 249th American Chemical Society National Meeting, 21st & 22nd Biennial Conference on Chemical Education, 92nd, 93rd, 97th, & 98th Canadian Chemistry Conference, Improving University Teaching 34th International Meeting, 20th International Conference on Learning, Society for Teaching and Learning in Higher Education (2015).

Impact

Transformed Course Counts

As of Spring 2018, we had 16 courses with CWSEI and/or Skylight influence:







Impact in terms of seats/registrations


We can look at this in terms of the **55 undergraduate CHEM courses offered in 2017** with LEC, LAB or DST as primary activity and excluding distance ed. sections. In terms of **seats/registrations** (with LEC, LAB or DST as primary activity; excludes distance ed. sections):

EFFECT	Seats.2012	Seats.2013	Seats.2014	Seats.2015	Seats.2016	Seats.2017
Transformed	552	474	1911	2261	2349	2378
LabTransformed	3744	3585	3802	4010	4024	3897
Impact	441	410	349	364	397	398
Other/None	7490	7395	5687	5357	4950	4994

EFFECT	Prop.Seats.2012	Prop.Seats.2013	Prop.Seats.2014	Prop.Seats.2015	Prop.Seats.2016	Prop.Seats.2017
Transformed	4.5%	4.0%	16.3%	18.9%	20.0%	20.4%
LabTransformed	30.6%	30.2%	32.4%	33.4%	34.3%	33.4%
Impact	3.6%	3.5%	3.0%	3.0%	3.4%	3.4%
Other/None	61.3%	62.3%	48.4%	44.7%	42.2%	42.8%

Publications and Presentations

<p>Paper</p>	<p>A positive student experience of collaborative project work in upper-year undergraduate chemistry. Kerry Knox, Elizabeth Gillis, and Greg Dake (Chemistry, UBC)</p> <p>Chemistry Education Research and Practice, 20(2), 340–357 (2019), DOI: 10.1039/C8RP00251G</p>	<p>Link</p>
<p>Paper</p>	<p>Build Your Own Photometer: A Guided-Inquiry Experiment To Introduce Analytical Instrumentation Jessie Wang, José Rodríguez Núñez, Jane Maxwell, and Russ Algar (Chemistry, UBC)</p> <p>J. of Chemical Ed, Vol. 93(1), pp 166–171 (2016), DOI: 10.1021/acs.jchemed.5b00426</p>	<p>restricted access link</p>
<p>Paper</p>	<p>An Improved Design for In-Class Review E. Jane Maxwell (Chemistry, UBC), Lisa McDonnell (Zoology, UBC), & Carl Wieman</p> <p>Journal of College Science Teaching, Vol. 44(5), pp. 48-52 (2015)</p>	
<p>Paper</p>	<p>A Process for Developing Introductory Science Laboratory Learning Goals To Enhance Student Learning and Instructional Alignment Jennifer Duis, Laurel Schafer, Sophia Nussbaum, and Jaclyn Stewart (Chemistry, UBC)</p> <p>J. of Chemical Education, Vol. 90, No. 9, pp 1144–1150 (2013)</p>	
<p>Talk</p>	<p>The use of cognitive task analysis to inform the development of a laboratory course in chemistry Kerry Knox (Chemistry, UBC)</p> <p>Variety in Chemistry Education & Physics Higher Education Conference, University of Durham (August 2014)</p>	
<p>Talk</p>	<p>Development of a Concept Inventory for Measuring Learning Gains in Analytical Chemistry Jane Maxwell (Chemistry, UBC)</p> <p>CSC 97th Canadian Chemistry Conference, Vancouver, BC (June 2014)</p>	

<p>Poster</p>	<p>Students as key stakeholders: Exploring undergraduates' perceptions of teaching and learning in an introductory organic chemistry course Ashley Welsh (Curriculum & Pedagogy, UBC) & Jackie Stewart (Chemistry, UBC)</p> <p>Society for Teaching and Learning in Higher Education Conference, Kingston, ON (June 2014)</p>	
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Related Department Links

Chemistry Dept. home: <https://www.chem.ubc.ca/>

Chemistry Learning Blog: <http://learning.chem.ubc.ca/>