Contents

Chemistry Department

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).

CWSEI Dept. Director: Jackie Stewart (2010-present), Laurel Schafer (emeritus, 2007-2010)
STLFs: Elizabeth Gillis, Jane Maxwell, Kerry Knox (emeritus), Jennifer Duis (emeritus)
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

Course Transformation

Course	Learning Goals	New Assessments	Improved methods
CHEM 121: Structural Chemistry, with Application to Chemistry of the Elements (Lab component) (Oct '08 start) Faculty: Sophia Nussbaum STLF: Jennifer Duis Paper (JCE 2013): A Process for Developing Introductory Science Laboratory Learning Goals To Enhance Student Learning and Instructional Alignment	Course-level goals: Outline from CHEM 123, focus on transferable skill acquisition Experiment-level goals: process for development established Course-level outline and experiment-level development process appropriate for the entire lab program	Attitudes survey (C-LASS CHEM) given 3 Terms Development and implementation of end-of-term technique assessments o Year 1: TA visual assessment of technique with provided guide o Year 2: Visual assessment guide refined and technique questions added to the end-of-term quiz	Alterations made to increase alignment with 1st-year lab goals o Marks re-allocated to increase emphasis on maintaining a lab notebook o Directions on maintaining a lab notebook expanded in lab manual o Brief "taking observations" module developed and added during check-in o Peer marking of observations using supplied templates added to each experiment o Technique modules will be expanded to include choosing glassware for analytical vs. non-analytical purposes o A new experiment was piloted o "Pair-technique-ing" (ala comp. sci. pair-programming) was piloted with a small subset of students
CHEM 123: Physical and Organic Chemistry (Lab component) (July '08 start) Faculty: Sophia Nussbaum, Laurel Schafer, Jackie Stewart STLF: Jennifer Duis 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. Poster (CWSEI EOY 2009): Instruments for assessing practical skill development in a first-year chemistry laboratory course	Course-level goals: working version, inspired by Rice University's interdisciplinary science lab learning objectives, approved by Chemistry Lab Committee Experiment-level goals: (developed from existing course materials) 4 of 4 experiments complete and approved by Chemistry Lab Committee	Chemistry background and demographics survey developed and given 2 Terms Attitudes survey (C-LASS CHEM) given 2 Terms Pre-/Post-Lab skills survey (written) developed & given 4 Terms o "LG use" questions added Refined hands-on lab skills assessment implemented 2 terms Assessments of experiment specific learning goal achievement (surveys, observations, interviews) o 3rd round of refinement based on expert & student validation	Learning Goals incorporated into lab manual Alterations made to increase alignment with learning goals o Marks re-allocated to increase emphasis on maintaining a lab notebook o Directions on maintaining a lab notebook expanded in lab manual o Expanded quizzes will be introduced to test technical skills o Added manual dilutions to electrochem experiment to increase technical experience & conceptual understanding of the effect of dilution on voltage o 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

CHEM 211: Analytical Chemistry (Spring 2013 start) Faculty: Russ Algar, Anka Lekhi, José Rodríguez Nuñez STLF: Jane Maxwell Poster (Science Education Open House 2016): Pilot implementation of an online homework system for practice and feedback on decision-making skills Talk (CSC 97th Canadian Chemistry Conference, June 2014): Development of a Concept Inventory for Measuring Learning Gains in Analytical Chemistry	Course-level learning goals developed in consultation with current and previous instructors of both CHEM 211 and 311. 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.	Mid-term survey of student perceptions of instructional activities and tools. End-of-term surveys probing student perceptions of the course and the discipline of analytical chemistry Ongoing: Development of an analytical chemistry concept inventory	*Lecture:* Fall 2013: Introduction of concept questions and clickers, and increased use of team-based-learning (TBL) activities. Winter 2014: Introduction of i<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. Winter 2015: Continued use of i<clickers. Introduction of in-class worksheets for problem solving related to the equilibrium unit. *Lab:* Increased emphasis on lab skills via an early-term lab skills test (including a remedial intervention) and TA grading of lab skills based observation Fall 2013: Introduction and evaluation of new guided-inquiry experiment in which students design, build, and test a simple photometer Fall 2014: Introduction of a new guided-inquiry experiment based on comparing instrumental and classical methods of analysis.
CHEM 311: Instrumental Analytical Chemistry (Spring 2013 start) Faculty: Dan Bizzotto STLF: Jane Maxwell	Course-level learning goals developed in consultation with current and previous instructors of both CHEM 211 and 311. Detailed learning objectives emphasizing core competencies required to achieve course-level goals.	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. Two-stage midterm exam 2015: Continued use of two-stage review and midterm exam. Modified regular course assignments to include exam-type questions (marked for effort rather than correctness), based students' feedback. 2016: Continued use of two-stage review and midterm exam. Continued use of revised course assignments.	2014: Increased use of in-class activities, including clicker questions and predictions related to demonstrations and simulations. Group activities emphasizing the common decision-making and evaluation processes that link the different topic areas of the course. 2015: Continued and expanded use of in-class activities, clickers, demonstrations, and simulations. Piloting a suite of tutorials focused on high-level problem-solving skills for the new course tutorials. 2016: Implemented tutorial activities.
CHEM 315/325/335/345: Chemistry Integrated Laboratory (Spring 2013 start) Faculty: J. Bates, G. Bussiere, T. Kunz, V. Monga, J. Rodríguez Núñez, C. Rogers, R. Stoodley STLF: Elizabeth Gillis, Kerry Knox (2013-2014) Poster (Science Education Open House 2016): Developing the third-year integrated chemistry laboratory: Putting the pieces together 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	Course-level learning goals produced based on framework developed by previous CWSEI project in CHEM 123	April 2013: Survey probing student perceptions of course (post-course) Attitudes survey (C-LASS CHEM) September 2013: Survey probing student perceptions of orientation to course and expectations (pre-course) & C-LASS CHEM December 2013: Survey probing student perceptions of new online safety training module April and December 2014: Survey probing student perceptions of course (post-course) September 2014 and January 2015: Survey probing student perceptions of orientation to course and expectations (pre-course) Ongoing: Analysis of student lab reports with respect to progress towards achieving learning goals 2015-2016: Lab report "wrappers" to assess student learning from oral and written laboratory reports.	Learning goals incorporated into lab manual Analysis of course content for purpose of informing future development in terms of: • skills and techniques covered • cognitive tasks involved Dry lab workshop introduced focused on organic chemistry structures Pilot project in oral lab assessments for multiple experiments.

CHEM 341: Global Challenges: A Chemical Perspective (Jan 2013 start) Faculty: Gregory Dake STLF: Elizabeth Gillis, Kerry Knox (2013-2014) Poster (Science Education Open House 2015): Using Course Committees as Student Feedback Poster (CWSEI EOY 2014): Research-based instructional strategies in a course on the role of chemistry in solving global challenges	Course-level learning goals produced	April 2013: Survey probing student perceptions of course and attitudes towards role of chemistry in society (post-course) January 2014 and January 2015: Survey probing student attitudes towards learning chemistry and role of chemistry in society (pre-course) 2015: Exams replaced with two-stage exams (total of three exams) Student course committee created to provide continuous feedback on the course.	Introduction of in-class interactive activities to provide enhanced opportunities for discussion and peer-instruction, including: • jigsaw activities • small-group discussion • whole-class discussion • concept mapping 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 Sample problems offered as additional resource

CHEM 113, 121, 415, 425, 449: Attitudes survey (C-LASS CHEM) Spring '09 (CHEM 113 & 121 also participated in the written Lab Skills Survey)

CHEM 233: Detailed learning objectives, attitudes survey (C-LASS CHEM), "flipped classroom" approach.

CHEM 425/448: Engaging students in cutting-edge chemical education research, report writing, and presentations.

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.

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 (in development). 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: Assess students' achievement of lab learning goals.

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).

Computer Science Department

Computer Science received seed funding from CWSEI in 2007 and began the efforts listed below in the Fall. The department moved to full funding starting in mid-2008.

CWSEI Dept. Director: Ian Mitchell (starting Jan 2013), Paul Carter (emeritus)

STLFs: Jessica Dawson – involved in CPSC 100, 103, 110, 210, 320, 344, 444, 430
Hassan Khosravi – APSC 160, CPSC 259, 304
Allison Elliott Tew (emeritus) – involved in CPSC 110, 210, 211, 260, 310, and 317
Ryan Golbeck (emeritus) – involved in CPSC 110 and 210
Ben Yu (emeritus) – involved in CPSC 101, 111, 121, 211, 213, 221, 304, 310, 322, 404, and APSC 160
Ray Lister (emeritus) – involved in CPSC 111, CPSC 260, and APSC 160
Beth Simon (emeritus) – involved in the early work of CPSC 101, 111, 121, 211, 213, and 221
Part-time Faculty STLFs (roughly 20% appointments for two years, now completed):
Don Acton – involved in CPSC 213, 313, 317
Ed Knorr – involved in CPSC 259, 304, 404
Steve Wolfman – involved in developing a concept inventory for the "foundations of computing" stream (CPSC 121, 221, 320)

Faculty: D. Acton, M. Allen, P. Belleville, G. Carenini, P. Carter, C. Conati, A. Condon, M. Dulat, K. Eiselt, M. Feeley, M. Friedlander, W. Heidrich, H. Hoos, N. Hutchinson, G. Kiczales, E. Knorr, K. Leyton-Brown, J. Luk, K. Maclean, J. McGrenere, I. Mitchell, G. Murphy, R. Ng, R. Pottinger, D. Poole, G. Tsiknis, K. Voll, S. Wolfman

Post-docs: Frank Hutter, Gabriel Murray

Course Transformation

Course	Learning Goals	New Assessments	Improved methods
CPSC 100: Computational Thinking (Sept '16 start) Faculty: Rachel Pottinger, Will Evans STLF: Jessica Dawson	Course-level goals: complete Topic-level learning goals: drafted	Developing assessments to evaluate first offering of course. Includes pre- and post- surveys on student experience and attitudes (using CAS) to compare with other intro CS courses (103, 110, 301)	
CPSC 101: Connecting with Computer Science (Sept '07 start) Faculty: Meghan Allen, Anne Condon, Steve Wolfman, Holger Hoos STLF: Ben Yu, Allison Tew	Course-level goals: revision complete Topic-level goals: revision complete	Performed study of instructor & student perception and use of learning goals. Developing assessment to probe student understanding of JavaScript code. Piloted a new Computing Attitude Survey (CAS) in Fall of 2011 (part of the survey validation process). Pre- and post- surveys of student perceptions of computing science. Peer review of student-generated images through Mechanical TA. Analysis of exam questions to determine individual learning goals coverage and student performance	Developed and used a broad set of clicker questions. Adjusted delivery of course to use Just-in-Time teaching methods with pre-class readings and in-class learning activities. Based on the pre-readings, students submit "reading questions": questions about pre-reading material that was not clear, or questions that go beyond the pre-reading. TAs summarize common themes and pass them along to the instructor, who adapts the classroom session appropriately. Developed instructor course manual. Developed bank of previous exam questions keyed to individual learning goals. Conducted analysis of student retention (how many go on to take a second CPSC course).
CPSC 103: Introduction to Systematic Program Design (Sept '16 start) Faculty: Meghan Allen STLF: Jessica Dawson	Course-level goals: drafted	Developing assessments to evaluate first offering of course. Includes pre- and post- surveys on student experience and attitudes (using CAS) to compare with other intro CS courses (100, 110, 301)	
CPSC 110: Computation, Programs and Programming (Sept '09 start) Faculty: Gregor Kiczales, Paul Carter, Kurt Eiselt, Meghan Allen STLF: Jessica Dawson, Allison Tew, Ryan Golbeck	Course-level and topic-level goals: complete.	Have per-question analysis of midterm and final exam data. Developed weekly problem sets that provide students with timely feedback on their learning. Piloted a new Computing Attitude Survey (CAS) in Fall of 2011 (part of the survey validation process). 2015: Pre-surveys to compare student experience in 110 between general UBC students and Vantage cohort Winter 2015	Developed a series of relevant and engaging labs. A plug-in was developed for Dr. Racket IDE so that students can submit assignments electronically from the development environment. This reduces the number of tools that students have to master and allows the course to focus on concepts. Introduced peer-instruction questions at the beginning of each lab, and a peer-review exercise partway through the lab. Also updated lab problems to be more in-sync with lecture material.

		2016: Pre- and post-surveys to evaluate student experiences and attitudes (using CAS). Will continue to compare with other introductory courses (CPSC 301, plus 100, 103 for Winter 2016). Interviews with students who have failed or withdrawn from 110 on barriers to success in the course. Evaluated changes made to labs	
CPSC 111: Introduction to Computation (Sept '07 start) Faculty: Kurt Eiselt, Cristina Conati, Wolfgang Heidrich, J. Luk STLF: Ben Yu, Ray Lister This course is no longer offered. It has been replaced by CPSC 110.	Course-level goals: complete Topic-level goals: complete	Attitudinal survey revised and given at start and end of term in all sections of summer and fall terms. Cognitive pre-test developed and administered at start of course. The same test was administered to students in APSC 160. Questions targeting specific learning goals have been included on exams. A lab checklist has been developed to track the kinds of problems that students run in to during labs.	
CPSC 121: Models of Computation (Sept '07 start) Faculty: Steve Wolfman, Patrice Belleville, Kimberly Voll, Meghan Allen STLF: Ben Yu Poster (CWSEI EOY 2012): Effective Closed Labs in CPSC 121: Lessons from Eight Terms of Action Research Posters (CWSEI EOY 2010): Adaptation of JiTT in CPSC 121 and Changes in CPSC 121: Towards a coherent picture of computation	Learning goals have been further categorized to identify pre-class learning goals. Students are expected to achieve pre-class learning goals on their own in advance of the corresponding class.	Attitudinal surveys developed and administered in summer and fall terms. Student interviews conducted in summer and fall terms. Pre and post-tests developed and administered. MCQs developed for final exam that target specific learning goals. A scenario based think-aloud survey tool has been developed to study how students approach solving mathematical induction problems. The tool is being used to examine the effectiveness of a decomposition technique that teaches students to approach such problems by breaking them down into more manageable pieces.	Two-stage exam conducted in summer term. Results published in ICERI 2009 and further analysis appeared at SIGCSE 2010. Refined online quizzes used to assess pre-class learning goals on the basis of previous term's quiz results. Re-structured in-class problem solving activities to be based on progressive clicker questions with solo- and group-response format. Approximately 160 clicker questions developed and used in class. Continued work on labs to make them "open-ended" and driven by student exploration rather than closed-ended. Continued to re-design labs so that they are more closely aligned with core learning goals, avoiding extraneous detail. Established a protocol for preparing TAs to a consistent level and for developing a community of support among the teaching staff.
APSC 160: Introduction to Computation in Engineering Design (Sept '09 start) Faculty: Paul Carter, Ed Knorr STLF: Hassan Khosravi, Ray Lister, Ben Yu Poster (CWSEI EOY 2010): Student perceptions of online multimedia instruction with JiTT	Topic-level goals: complete	Attitudinal survey developed and administered at start and end of term. Analysis pending. Surveys assessing impact of Peer Instruction conducted in week 4 and week 8 of term. Increased number of midterms from 1 to 2 in an effort to provide students with more regular and more accurate feedback on their progress. Piloted a new Computing Attitudes Survey (CAS) in the Fall of 2011 as part of the survey validation process.	A series of approximately 30 screencasts have been developed that introduce students to basic concepts. Students are asked to study the screencasts before coming to class. Clicker questions have been developed to assess students' comprehension of the concepts presented in the screencasts. A series of in-class problem sets have been developed that allow students to further develop their understanding of the concepts learned in the screencasts. The new format was incorporated into all four sections of the course offered in 2009/2010. Over 800 students were enrolled. Feedback from students on surveys has been overwhelmingly positive. Analysis of learning gains is in progress. Peerwise online peer question system used in 2015W.

CPSC 210: Software Construction (Jan '10 start) Faculty: Gail Murphy, Meghan Allen STLF: Jessica Dawson, Allison Tew, Ryan Golbeck Poster (CWSEI EOY 2011): Measuring Student Confidence and Lab Material Balance in a Computer Science Course	Topic-level goals: solid draft in place	Parallel assessment in progress with CPSC 211 (the course that CPSC 210 will eventually replace). 2016: Post survey conducted on student experience and attitudes towards CS (using CAS).	Examining the use of cell phones in some labs to increase relevance and student engagement.
CPSC 211: Introduction to Software Development (Sept '07 start) Faculty: David Poole, Margaret Dulat STLF: Allison Tew, Ben Yu This course has been replaced by CPSC 210	Course-level goals: complete Topic-level goals: complete	Attitudinal survey developed and administered at start and end of both sections of fall term. Parallel assessment in progress with CPSC 210 (the course that will eventually replace CPSC 211)	Subversion repository has been developed that will facilitate distribution of code to students for labs and lectures. A subversion plug-in for the Eclipse IDE will be used to minimize the number of different tools that students have to master.
CPSC 213: Introduction to Computer Systems & CPSC 261: Basics of Computer Systems (Sept '07 start) Faculty: George Tsiknis, Don Acton STLF: Ben Yu	Course-level goals: complete, under review Topic-level goals: complete, under review	Pre and post-tests developed and administered during summer term. Two-stage exams (published ICERI 2009 & SIGCSE 2010).	All assignment and exam questions were tied to specific learning goals. A set of scripts was developed to provide students with individualized feedback web pages from which they can determine how they are doing not just on a given assignment, but also on individual learning goals.
CPSC 221: Basic Algorithms and Data Structures (Sept '07 start) Faculty: Kimberly Voll, Ed Knorr, Steve Wolfman STLF: Ben Yu Poster (CWSEI EOY 2013): "Dictionary Wars": An Inverted, Leaderboard-Driven Project for Learning Dictionary Data Structures	Course-level goals: complete Topic-level goals: complete	Post-test developed and administered at the end of summer term. Attitudinal survey revised and administered at the end of 2009 fall term.	Use JITT, in-class group problem solving and peer instruction, clickers or non-electronic clicker equivalents, and web-based quizzes to shift focus of courses to higher-level analysis and problem solving. Based on outcomes from the Foundations of Computing Concept Inventory, a "crash-course" on arrays has been added.
CPSC 259: Data Structures & Algorithms for Electrical Engineers (Fall 2012 start) Faculty: Ed Knorr STLF: Hassan Khosravi Poster (Science Ed. Open House 2016): Studying the Effects of Adding 'In-Lab' Programming Tests to a CS Service Course Poster (CWSEI EOY 2014): Extending and Improving the Role of Deliberate Practice in CPSC 259 Poster (CWSEI EOY 2013): Introducing Pair Programming in Intermediate C to Non-Specialists	Course and topic-level learning goals: complete	Apply pre-test as diagnostic of retention of learning from prerequisite course (APSC 160) Online quizzes for weekly pre-reading Bi-weekly individual programming quizzes alternate with regular pair-programming labs End-of-term survey of student confidence on learning goals Per-question final exam analysis	Pre-class readings Developed in-class materials that build on pre-class readings Revised labs Online simulation for hands-on practice with pointers, types, memory & addressing In-lab debugging exercise to enforce hands-on practice with the debugger. Peerwise online peer question system used in 2015W.

CPSC 260: Object-Oriented Program Design (Sept '09 start) Faculty: Don Acton STLF: Allison Tew, Ray Lister course has been replaced by CPSC 213/259/261	Topic-level learning goals: complete	Pre-test developed and administered in 2009/2010 that measure retention of learning from APSC 160.	A series of clicker questions has been developed.
CPSC 301: Computing in the Life Sciences (Sept '07 start, Jan '14 restart) Faculty: Ian Mitchell, George Tsiknis STLF: Ben Yu	Course & topic-level learning goals: complete	Weekly student surveys in first offering of the course to judge workload, relevance of topics Lab exam 2015: Slightly modified version of CAS administered 2016: Pre- and post- surveys on student experience and attitudes towards CS (using CAS).	Clicker questions & in-class group exercises Pair programming in labs 2014: Significant expansion of clicker questions and in-class group exercises accompanied by drastic reduction of traditional lecture slides 2015: Out of 24 classes, 15 include clicker questions and 17 include in-class exercises (for participation credit)
CPSC 304: Introduction to Relational Databases (Sept '09 start) Faculty: Ed Knorr, Rachel Pottinger, Raymond Ng STLF: Hassan Khosravi, Ben Yu Poster (CWSEI EOY 2010): CPSC 304: Course Transformation	Topic-level goals: complete	Attitudinal survey developed and administered at start & end of term. Pre and post-tests developed to assess change in learning. Student interviews conducted during fall term. Repository of clicker questions, including historical scoring data and Bloom's taxonomy classification. Per-question final exam analysis. Interaction graph between students in Peerwise collected for further analysis. Isomorphic clicker questions presented several lectures after initial use to measure retention in context of peer instruction.	Two-stage exams conducted in both midterms of fall 2009 term. A set of new tutorials has been developed and tested in spring 2010 in response to poor attendance in previous terms. The new tutorials are designed to incorporate active learning and have resulted in higher attendance. Tutorials were improved upon for summer 2010 offering of course to include reflection exercises such as the development of a concept map. Two new tutorials added in summer 2014, plus creation of a parallel version of the 2010 tutorials using alternative database software. Peerwise online peer question system used in 2016S.
CPSC 310: Introduction to Software Engineering (May '10 start) Faculty: Meghan Allen STLF: Allison Tew, Ben Yu	Course-level and topic-level learning goals: in progress	Diagnostic test developed to assess student preparation in learning.	New lecture material under development on topics that are more relevant (e.g., distributed version control systems).
CPSC 313: Computer Hardware & Operating Systems (Sept '12 start) Faculty: Don Acton	Course and topic level goals: draft	Two-stage exams. Student survey of unclear topics at the end of term.	Lecture by lecture timeline with commentary plus recordings of 2013W1 lectures. Adoption of a modern version control system for assignment distribution & collection (will maintain a record of student solutions for future analysis).
CPSC 314: Introduction to Software Engineering (Dec '14 start) Faculty: Dinesh Pai	Revised course-level learning goals: in progress	Survey to understand student motivation in preparation for upcoming course revisions.	
CPSC 317: Internet Computing (Sept '09 start) Faculty: Don Acton, Norm Hutchinson STLF: Allison Tew Poster (CWSEI EOY 2012): An Evidence-Based Transformation of a Computer Networking Course	Course-level goals: complete Topic-level goals: complete	Conducted initial survey to gather baseline data on student experience in course. Baseline data collected in the form of per-question analysis of exam data and attitudinal survey. Piloting Pearson's learning catalytics product as an alternative to clickers.	Developed group based, in-class learning activities and associated discussion questions focused on specific learning goals. These methods will be administered for the first time in Spring 2012.

CPSC 320: Intermediate Algorithms and Data Structures (Sept '09 start) Faculty: Kimberly Voll, Steve Wolfman STLF: Jessica Dawson		A test of expected prerequisite knowledge was developed and administered at the start of the term Regular, weekly COPUS observations to provide rapid feedback on use of in-class activities and worksheets (W2015)	Fully flipped version of the course developed and piloted by Steve Wolfman in Winter 2015. Pre-readings selected for each class with quiz at beginning of class. In-class worksheets developed and used as central content and activity for every lecture.
CPSC 322: Artificial Intelligence (Summer '08 start) Faculty: Giuseppe Carenini, Kevin Leyton-Brown Post-doc: Frank Hutter Graduate student: Byron Knoll STLF: Ben Yu	Course-level goals: complete Topic-level goals: complete	A large body of questions has been developed to be used as the core of future exams. Conducted survey on student use of practice problems and perceived usefulness for their learning.	A set of 19 practice problems complete with solutions have been developed and made available at www.aispace.org/exercises.shtml 12 of these 19 exercises are integrated with AI Space applets. Background reading for each exercise was also identified in the textbook. These exercises were also integrated into webCT and two quizzes for each problem were created. An additional set of 19 quizzes covering 7 of the practice problems were made available towards the end of the term. Two new AI Space applets have been developed.
CPSC 340: Machine Learning and Data Mining (Fall '14 start) Faculty: Raymond Ng Post-doc: Yashar Mehdad	Course and topic level learning goals complete.	Post-class student surveys Some repeated exam questions (Data analysis not completed because postdoc departed)	8 new problem-based laboratory modules to give students hands-on, TA supported practice with lecture concepts. The modules focused on applying different approaches to just two large datasets so that students could apply different techniques to the same data. 4 new assignments to complement the lab modules.
CPSC 344: Introduction to Human Computer Interaction Methods (Fall 2013 start) Faculty: Karon Maclean STLF/Faculty: Jessica Dawson Grad student: Oliver Schneider	Course level learning goals: complete Lecture-level and pre-reading-level learning goals: draft, used in 2014W1	Pre-readings and quizzes Replaced course project with a more gradual and scaffolded project. Increased frequency of feedback on project progress through regular weekly meetings with TA in tutorials. pre & post student surveys	Pre-reading allows time for interactive activities in the lecture. Developed in-lecture worksheet activities for 19 lectures (of 20 usual lecture slots). Documented activities with 'how-to' guides for future instructors. Reduction in the workload for expert TAs (so that more students can be supported without requiring more expert TAs). Development of TA roles for undergraduate TAs in addition to graduate TAs.
CPSC 402: Numerical Linear Algebra (Fall 2013 start) Faculty: Michael Friedlander Post-doc: Ting Kei Pong		Same as CPSC 406 below.	Same as CPSC 406 below.
CPSC 404: Advanced Database Systems (Sept '09 start) Faculty: Ed Knorr STLF: Ben Yu	Course and topic-level learning goals: complete	Attitudinal survey developed and administered at start & end of term Pre and post-tests developed to assess change in learning Clicker questions Per-question final exam analysis	Pre-reading Worked examples In-class exercises (using CC workbooks) for almost all lectures Students must submit solutions to pre- and in-class exercises
CPSC 406: Computational Optimization (Fall 2012 start) Faculty: Michael Friedlander Post-doc: N. Krislock	Course-level learning goals: complete	Conducted per-question analysis of relevant exam data before and after introduction of case studies to measure change in learning. Case study homework and write-up replace roughly half of traditional homework assignments. Survey of student opinion on the effectiveness of the case-study approach.	Developed four case studies for major modules in the course that give students practical, hands-on practice at solving a problem in the field. Each case study is accompanied by related in-class activities (two lecture hours) and a homework assignment.

CPSC 410: Advanced Software Engineering (Sept '11 start) Faculty: Eric Wohlstadter	Learning goals revised to provide a stronger connection between CPSC 410 and its major prerequisite CPSC 310.		
CPSC 422: Intelligent Systems (Sept '09 start) Faculty: Cristina Conati, Kevin Leyton-Brown, Giuseppe Carenini Post-doc: Frank Hutter	Topic / lecture level learning goals: draft.		All assignments have been revised with respect to learning goals and two new assignments have been developed. Exploration of IBM's recently released Watson tools to see whether they might be used to create new hands-on assignments; unfortunately, the tools turned out to be inappropriate.
CPSC 425: Computer Vision (Spring 2012 start) Faculty: Bob Woodham, Jim Little, David Lowe Graduate Student: Tristram Southey	Course-level learning goals: complete	Did per-question analysis of exam data before & after introducing revised materials to measure change in student learning Student survey on course content & pacing Added seven "practice quizzes" to provide more regular and timely self-assessment Modified homework assignments to better align with the types of questions asked on exams	Development of simulations for use in class. Development of framework that allows students to apply concepts learned in course to real-world computer-vision tasks. Switched language from Matlab to Python so that students can more easily access material outside of the lab
CPSC 430: Computers and Society (Spring 2012 start) Faculty: Kevin Leyton-Brown, Jessica Dawson STLF: Jessica Dawson Graduate Students: Chris Thornton & James Wright	Course-level learning goals: complete	Added 11 weekly essays with an automated calibrated peer review system Compared final exam results across multiple years Post-survey to assess student attitudes toward calibrated peer review system (Fall 2014, 2015)	Identified weekly pre-class reading assignments. Developed related mini-essays that students must complete prior to class. Essays are peer-reviewed. Class time can then focus on discussion, group exercises and analysis of arguments. Developed Mechanical TA, a software system to manage peer review of essays and reduce TA marking effort. Improved user interface developed and tested in fall 2014. Developed bank of calibration essays for students (and TAs) to practice on. Calibration essays are also silently & randomly included into the peer review process to spot-check quality of independent reviewers. 2015: Revised in-lecture activities and developed a set of worksheets for every lecture to facilitate peer-discussions on case studies during lectures.
CPSC 444: Advanced Methods for Human-Computer Interaction (Sept '10 start) Faculty: Joanna McGrenere, Jessica Dawson STLF: Jessica Dawson Graduate Student: Kailun Zhang	Course-level learning goals: complete	Post survey to assess course revisions (Winter 2016).	Added practical component to each tutorial in response to feedback from students. Reworked project and labs to streamline descriptions and milestones. Improved tutorial instructions for TAs Created a new lab to teach Android phone development skills. 2016: Transitioned to a more blended-learning approach: In-person tutorials were eliminated, and content was adapted a combination of online pre-class tutorials and in-lecture activities. Designed and deployed two online experiments that students use to collect experiment data at home (as opposed to in-lab). Developed step-by-step tutorials and Connect assignments to guide students in conducting the experiments and collecting data, performing data analysis, and interpreting their results. Revised and adapted tutorial activities and developed worksheets to be used in lecture. Pre-lecture quizzes and open-ended responses developed in Connect to guide students in completing pre-reading assignments & performing self-assessment of their understanding.

Poster (UBC Science Education Open House 2016): Retiring the Red Pen: Marking Exams Digitally

Poster (UBC Science Ed. Open House 2016): Using Learning Analytics for Providing Personalized Content and Feedback in Large Classes

Poster (UBC Science Education Open House 2016): Student Experience in Introductory CS Courses

Poster (UBC Science Education Open House 2015): Mechanical TA: Partially Automated High-Stakes Peer Grading

Poster (UBC Science Education Open House 2015): Student Attitudes Towards Partially-Automated Peer Grading

Poster (CWSEI EOY 2014): Misconceptions and Concept Inventory Questions for Binary Search Trees and Hash Tables

Poster (CWSEI EOY 2014): Using the CWSEI Approach to Updating Computer Science Systems Courses

Poster (CWSEI EOY 2013): A Plan for Transforming Systems and Database Courses in Computer Science

Learning Goals for Core Courses (CPSC 110, 111, 121, 210, 211, 213, 221, 310, 313, 320): A comprehensive set of learning goals (both course-level and topic-level) has been developed for most 1st and 2nd year core courses. Most of these courses use LGs regularly to some extent in class (e.g., many 111 instructors now show the LGs associated with each unit as they lecture on the unit). CPSC 313 also has rough draft LGs. Draft course-level learning goals for the new CPSC 110 and CPSC 210 have been completed.

CPSC 260: Object-Oriented Program Design: Don Acton and Ben Yu investigated the correlation of student performance with different components of this course.

Attitudinal Surveys: Survey instruments have been developed for CPSC 101, 111, 221, 317, 320, 404, and APSC 160. These instruments will facilitate the tracking of students' attitudes about the curriculum, their interest in Computer Science, and their expectations throughout their undergraduate years.

Peer Evaluation Primer for CS Instruction: Jessica Dawson prepared two documents on the use of peer evaluation in the context of computer science instruction, based on a literature review and discussions with instructors in the department who have used it. The first document *Introduction to Student Peer Review* is a brief five-page overview of what peer review is as well as the advantages and challenges of implementing peer review; it includes an annotated bibliography. The 2nd document *Resources and Guidance for Student Peer Review* contains a detailed checklist of issues that should be considered when thinking about implementing peer review, as well as an overview of peer review software systems available as of fall 2014.

Curriculum

Code communication in APSC 160, CPSC 111, and CPSC 260: Explored how students' ability to communicate about code changes during our core courses. A style of question that involves explaining the purpose of code is used across several exams to see how and whether students' progress in their ability to succinctly and abstractly describe the purpose of code fragments.

Research

PeerWise: Hassan Khosravi used the PeerWise system in APSC 160 and CPSC 259 and 304 in 2014–2016. PeerWise supports an online repository of multiple-choice questions that are created, answered, rated and discussed by students. This peer created and curated content was used for formative assessment by the students. The tool provides the instructor access to extensive analytics on student behaviours, and Hassan has downloaded this information for further analysis; for example, interaction graphs for students mediated by the questions. Hassan also developed a series of scripts which allow questions and answers to be extracted from the PeerWise system and used independently (for example, PeerWise could be used in a single offering and then an instructor curated subset of questions could be hosted locally in subsequent offerings); however, the benefits of this additional functionality was not sufficient to offset the disadvantages of losing access to the more comprehensive user interface provided by using the PeerWise tool directly, so its development has been suspended.

Computer Science Student Experience Project: Jessica Dawson began a research study to examine the outcomes and experiences of students in CS introductory courses, and in particular, to understand how these experiences may differ for difference students (for examples for CS majors and non-CS majors). In 2015 baseline data collection began via pre-post surveys in (CPSC 110 and CPSC 301) and student interviews and focus groups (CPSC 110). In collaboration with the course instructors, this data will be used to evaluate two new introductory CS courses (CPSC 100 and CPSC 103), each of which has a different target student audience than the existing introductory courses (CPSC 110, 301) the department offers. As part of this project, version 4 of the Computing Attitudes Survey (CAS) developed by Alison Tew is being used. The CAS has also been administered in CPSC 210 to evaluate changes in attitudes of CS-major students after their first and second programming course.
Poster (UBC Science Ed Open House 2016): Student Experience in Introductory CS Courses

Foundations of Computing Concept Inventory: Steve Wolfman has been developing a set of related concept inventories to assess student progress through our Foundations of Computing Stream (CPSC 121, 221, 320). The process began with the high level learning goals from the course, and then analyzed data from exams, project submissions and think-aloud interviews. Preliminary results were presented at SIGCSE 2014, and a special session on concept inventories in CS was run at SIGCSE 2015. A draft multiple choice CI covering the basic material has been piloted on students at the start of CPSC 121 and at the end of CPSC 121 and 221. New questions are still being developed, and further offerings of the CI will be undertaken.
Poster (CWSEI EOY 2014): Misconceptions and Concept Inventory Questions for Binary Search Trees and Hash Tables
Paper (SIGCSE 2014): *Misconceptions and concept inventory questions for binary search trees and hash tables*
Talk by Steve Wolfman, Nov 2013: *Developing a Concept Inventory for the Foundations of Computing Course Sequence*
Poster (CWSEI EOY 2013): Developing a Formative Assessment of Instruction for the Foundations of Computing Stream

Mechanical TA Software for Peer Review: CPSC 430 has traditionally used essay questions on the midterm and final exams to judge students' ability to express concepts discussed in this non-technical class; however, because of the high cost of grading essays it was not feasible to provide opportunities during the term for students to practice such essays. Kevin Leyton-Brown has developed a software system called Mechanical TA (MTA) which allows students to submit brief essays through an online portal and then shares the essays out for peer review. While many such systems are available, the novel feature of MTA is that it divides the students into two groups based on the quality of their peer reviews. The "supervised" pool of students submit their essays and peer reviews as normal, but TAs provide grades on both their essays and their peer reviews. Students whose peer reviews are consistently good graduate into the "unsupervised" pool, where their essays are assigned the median score among the peer reviews and their peer reviews are assumed to be good; TAs need grade only a subset of spot-checks and appealed reviews. Not only does this system reduce TA workload, but the students have incentive to produce high-quality peer reviews and (with the recent addition of a pool of example essays for calibration)

the means to improve their reviewing. A paper has appeared at the ACM Technical Symposium on Computer Science Education (SIGCSE) 2015: Wright, Thornton & Leyton-Brown, "Mechanical TA: Partially Automated High-Stakes Peer Grading", doi: 10.1145/2676723.2677278. A survey was run at the end of the fall 2014 offering to explore student opinions about MTA, and the data is currently being analyzed. There is also ongoing work on the user interface (both student-side and instructor-side).

The MTA software has been tested with three other courses (CPSC 101, 110 and 301) for other types of assignment (images and code). It is not currently being used in the other courses for several reasons: the instructor interface is still rather fragile, the department's tech staff have concerns about the stability and security of the software, and it appears that the approach is most effective when used for many assignments (such as the weekly essays in 430) but not worth the overhead when used for a small number of assignments. Avenues to overcome the first two issues have been identified, but it remains to be seen whether there are other instructors and courses which can overcome the latter issue.

Computing Attitudes Survey (CAS): Allison Tew is in the process of developing and validating the Computing Attitudes Survey (CAS), a new assessment instrument to gauge student attitudes and perceptions about learning computer science. The CAS is based on the Colorado Learning Attitudes about Science Survey (CLASS) and extends that work to include specific computing issues such as debugging and data representation. The CAS will be applicable to a broad range of students and was piloted in three introductory courses in Fall of 2011: CPSC 101, CPSC 110 and APSC 160. Various versions of the survey were run in various classes in 2012, 2013 and 2014. A paper has now appeared: B. Dorn and A. E. Tew. "Empirical Validation and Application of the Computing Attitudes Survey," in *Computer Science Education*, 25(1), 2015, doi: 10.1080/08993408.2015.1014142 and version 4 of the survey has been publicly released.

Longitudinal Study of Student Learning: Allison Elliott Tew is designing a research study into assessment of student learning across a sequence of software design courses running from 1st to 4th year. Implementation details are currently under development. Initial meetings have been held with faculty who teach the courses. The first step is to move from learning goals that focus on particular courses to learning goals that capture the progression from novice to expert over a sequence of courses.

Decomposition techniques in teaching proof by induction: Kim Voll applied a decomposition technique when teaching proof by induction in CPSC 121 in spring 2010. Ben Yu is currently interviewing students from both sections of the course taught last term using a think-aloud protocol developed in conjunction with Wendy Adams (UC). The results will be analyzed to determine if students taught with the decomposition technique demonstrate a stronger ability to perform proof by induction.

Just-in-time-teaching in APSC 160: Instructor has developed screencasts to introduce basic content to students. Students are expected to watch one or more screencasts before coming to class and are assessed on their grasp of this introductory material using clicker questions at the start of class. A collection of in-class problem sets has also been developed that will allow students to explore their understanding of more advanced content. We plan to conduct an assessment of retention of learning at the start of the follow-on course (CPSC 260) in the Fall and compare with results from last year where students had taken APSC 160 with more traditional instruction.

Just-in-time teaching in CPSC 121: Instructor has identified a subset of learning goals called `pre-class` learning goals. These are goals that students are expected to meet before coming to class. On-line tests have been developed to assess student learning for those goals. A set of in-class problems have been developed that address more advanced learning goals. Comparative survey work indicates dramatic increases in percentages of students that use the textbook and find it useful to their learning.

Just-in-time-teaching in CPSC 221: One instructor taught both sections in 2008/09 Winter term 2. Students in one section are seeing a JITT approach and the use of in-class activities involving peer instruction and discussion. Students in the other section are receiving more traditional instruction. Students in both sections are writing the same exams and completing the same homework assignments.

PeerWise: Conducted study of the use of PeerWise (an online collaborative multiple-choice question repository) by students in 2nd and 4th year courses in 2007/08. Surveyed students about how they use PeerWise and whether they feel submitting or answering questions helps them learn.

Self-theories: Conducted a study in 2007/08 of impact of students' self-theories relating to learning and ability on their success and persistence in beginning programming courses.

Learning Goals: Explicit use of learning goals in the classroom to aid student learning has been explored and is the subject of an article has been published in the Journal of College Science Teaching. Explicit use of learning goals has also spread to the Computer Science and Engineering department at UC San Diego, home institution of our first STLF.

Parson's puzzles: Conducted a study in 2007/08 of a new type of exam question for assessing similar skills to code writing questions. Results have been published in the proceedings of the Fourth International Computing Education Research Workshop.

Earth, Ocean and Atmospheric Sciences Department

Earth, Ocean and Atmospheric Sciences received full funding from CWSEI in 2007 and began the efforts listed below in Summer 2007. The overarching goal of the Department's science education initiative (EOAS-SEI) is to promote cultural change in our approach to teaching and learning and establish sustainable processes to continue and improve the work accomplished during the CWSEI project.

The EOAS-SEI program completed the first phase of CWSEI in 2014 with more than 40 courses either fully transformed or impacted by CWSEI. These courses are now using principles of research-based effective pedagogy in their design and implementation. Many instructors of these courses continue to iterate on improvements either on their own or with consulting help from STLFs. About 80% of EOAS faculty and over half of our sessional instructors have received direct support to adjust their courses and teaching from the SEI so far.

The second phase of the project – the Harris Project – is an extension of CWSEI that runs from 2014 to 2017. In addition to continuing course transformations and faculty support, this phase includes deliberate effort toward effective transfer of pedagogies to new instructors, experimenting with a paired-teaching model. This project is funded by John and Deb Harris, the UBC Faculty of Science, and the EOAS department.

Poster (Science Ed. Open House, 2016): Students' Perceptions of Teaching and Learning Experiences After 7 Years of CWSEI Support

Poster (CWSEI EOY 2013): Six Years of SEI in Earth, Ocean and Atmospheric Sciences

Poster (Geological Society of America 2013 Annual Meeting): Changing the Teaching Culture in a Large Research Oriented Department

Poster (Improving University Teaching, 2014): Comparing Student, Instructor and Observer Data to Assess a 7-Year Department-wide Education Initiative

CWSEI Dept. Director: Sara Harris
STLFs: Tara Holland, Sarah Sherman, Francis Jones (now STLF with the EOAS Teaching & Learning Enhancement Fund Project), Brett Gilley (emeritus), Erin Lane (emeritus), Joshua Caulkins (emeritus), Ben Kennedy (emeritus)
Faculty who have worked with STLFs on specific courses: S. Allen, R. Beckie, M. Bevier, M. Bostock, G. Dipple, E. Eberhardt, R. Francois, B. Gilley, E. Haber, S. Harris, F. Herrmann, K. Hickey, S. Hollingshead, T. Ivanochko, M. Jellinek, C. Johnson, F. Jones, L. Kennedy, M. Kopylova, M. Maldonado, U. Mayer, S. McDougall, J. Mortensen, D. Oldenburg, K. Orians, E. Pakhomov, R. Pawlowicz, V. Radic, K. Russell, C. Schoof, J. Scoates, M. Smit, P. Smith, D. Steyn, R. Stull, S. Sutherland, P. Tortell, M. Ver, S. Waterman, D. Weis
Additional Faculty/Instructors impacted by CWSEI: M. Allen, D. Athaide, P. Austin, A. Bain, E. Barns, T. Bissig, A. Caruthers, K. Chan, K. Grimm, L. Groat, P. Hammer, E. Hearn, O. Hungr, D. Jessop, M. Lipsen, L. Longridge, M. McKinnon, J. Monteux, L. Porritt, C. Suttle, B. VanStraaten, D. Winget, H. Zerriffi, D. Turner, T. Dzikowski
Students contributing to SEI project components: L. Bailey, L. Beranek, J-F. Blanchette-Guertin, G. Baldeon, A. Caruthers, D. Cassis, R. Cockett, J. Dohaney, R. Eso, G. Epstein, L. Greenlaw, M. Golding, L. Gurney, M. Halverson, L. Harrison, S. Henderson, T. Hirsche, K. Hodge, E. Holmes, A. Jolley, K. Ko, P. Lelievre, C. Leslie, C. Livingstone, K. Lucas, J. Mcalister, C. Miller, P. Olmstead, K. Rasmussen, J. Rhajiak, E. Schaeffer, J. Schiller, E. Scribner, I. Shinnick-Gordon, B. Smithyman, K. Smet, L. Stock, R. Taylor, D. Tomkins, D. Tommasi, C. Wong

CWSEI Extension: The Harris Project, 2014-2017

Paired-teaching for faculty professional development, transfer of effective pedagogy, and research:
EOSC 220: Fall '14. New instructor M. Smit paired with experienced instructors J. Scoates and M. Bevier. STLF: T. Holland
ENVR 200: Fall '14. New-to-course instructor H. Zerriffi and experienced instructor T. Ivanochko. STLF: T. Holland
ENVR 300: Spr '15. New-to-course instructor V. Christensen and experienced instructors T. Ivanochko and V. Radic. STLF: T. Holland
ATSC 303: Spr '15. Not-yet-CWSEI instructor R. Howard and experienced instructor R. Stull. STLF: T. Holland
EOSC 112: Fall '15. New instructor S. Waterman and experienced instructor S. Harris. STLF: T. Holland
EOSC 516: Fall '15. New instructor C. Kosman and experienced instructor T. Holland. STLF: S. Sherman
ENVR 200: Spr '16. New-to-course instructor T. Holland and experienced instructor S. Harris. STLF: S. Sherman
EOSC 210: Fall '16. New-to-course instructor S. McDougall and experienced instructors S. Hollingshead and E. Eberhardt. STLF: S. Sherman

STLF help with new course transformations:
EOSC 323: Start Jan '15. Faculty: L. Kennedy. STLF: S. Sherman
EOSC 478: Start Jan '16. Faculty: E. Pakhomov and W. Cheung. STLF: T. Holland

STLF help revisiting earlier course transformations:
EOSC 210: Start Apr '15. Faculty: S. Hollingshead and E. Eberhardt. STLF: S. Sherman
EOSC 221: Start Spr '16. Faculty: M. Kopylova. STLF: S. Sherman
EOSC 270: Start Fall '16. Faculty: M. Maldonado, STLF: S. Sherman

STLF help with new course development:
EOSC 240: Start Nov '14. Faculty: S. Hollingshead and several other occasional geological engineering faculty. STLF: T. Holland
EOSC 113: Start May '15. Faculty: R. Stull. STLF: S. Sherman
EOSC 471: Start Fall '16. Faculty S. Allen. STLF: T. Holland
EOSC 448 (temporary course code): Start Fall '16. Faculty C. Johnson. STLF: S. Sherman

Other:
EOSC 472: Nov '14-May '15. Faculty: K. Orians. TA: J. McAlister. Student-generated and peer-reviewed textbook.

The Harris Project is funded by John and Deb Harris, the UBC Faculty of Science, and the Earth, Ocean and Atmospheric Sciences Department.

Completed Course Transformations			
Course	**Learning Goals**	**New Assessments**	**Improved methods**
EOSC 111: Laboratory Exploration of Planet Earth (Sept '07 – May '11) Faculty: Sara Harris STLF: Brett Gilley Ongoing updates to pre-post assessment, lab activities, and quizzes. Course transferred to new instructor (R. Mindel) Poster (GSA, 2011 & CWSEI EOY 2012): Invention Activities in an Introductory Lab: Minerals, Rocks, Biodiversity, & Earthquakes	Course-level goals: complete Lab-level goals: complete	Two-stage (individual & group) quizzes 3rd draft of Pre/Post assessment complete for all topics Post-lab surveys for each lab End-of-term survey	Invention activities (Introduction, Minerals, Rocks, Biodiversity) Student-derived methods (Earthquakes, Groundwater, Dinosaurs, Waves, Estuaries)
EOSC 112: The Fluid Earth: Atmosphere and Ocean (Jan '08 – May '14) Faculty: Roger Francois, Sara Harris, William Hsieh STLF: Erin Lane Course transferred to various new instructors (V. Radic, E. Pakhomov, D. Steyn, S. Waterman) Poster (CWSEI EOY 2009): Climate Science/Oceanography Misconceptions	Course-level goals: complete Lecture-level goals: complete	Midterm & end-of-term surveys Online quizzes Validated pre-post survey Student engagement observations Student workloads questions Greenhouse effect assessment	Widespread use of thought-provoking clicker questions Relevance slide added to each lecture, relevance added throughout class Concept sketches and in-class worksheets Two-stage exams Study skills interventions
EOSC 114: The Catastrophic Earth: Natural Disasters (Sept '07 start) Faculty: Roland Stull, Erik Eberhardt, Mary Lou Bevier, Stuart Sutherland, Joel Finnis, Graham Andrews STLF: Francis Jones (~1000 students per yr) **New in 2010:** Introduction of group exams, overseen by Brett Gilley and Roland Stull. Course transferred to various new instructors. Poster (CWSEI EOY 2013): Does collaborative testing increase students' retention of concepts?	Course-level goals: complete Lecture-level goals for all lectures: complete	Midterm & end-of-term surveys Pre-course diagnostic on basic skills Online homework based on text readings introduced Fall 2008 Attitudes survey Videos about use of worksheets and 2-stage exams to support professional development of instructors (http://blogs.ubc.ca/wpvc/)	Course Management System and a custom website used extensively for content delivery, quizzing, surveying, logistics. Use of thought-provoking clicker questions in all lectures Pre-post question "wrappers" around video clips to focus and assess student learning Custom text introduced Off-schedule pre-exam review/question sessions Fall '09: Preliminary experiment with PeerWise in one section. Not continued beyond Fall '09. Multiple sequential instructors with one lead instructor and administrative support. Database of questions with answering analytics prepared based on several years' exams
EOSC 210: Earth Science for Engineers (Jan '08 start) Faculty: Erik Eberhardt, Ulrich Mayer, Stuart Sutherland STLF: Brett Gilley Course transferred to various new instructors (S. Hollingshead, S. McDougall) Poster (CWSEI EOY 2010): EOSC 210: Introduction to Earth Science for Engineers	Course-level goals: complete Lecture-level goals: complete Goals for all labs: complete	End-of-term survey Mineral exam Peerwise	Widespread use of clicker questions (4-8 in each 1.5-hour lecture), focus attention, test understanding, and drive discussion Small group or pair discussions in most classes Many case studies relevant to lectures Labs redesigned with new activities linked to learning goals; labs streamlined and reworked over Summer/Fall 2012

EOSC 211: Computer Methods in Earth, Ocean & Atmosph. Sci. (Jan '09 start) Faculty: Rich Pawlowicz, Catherine Johnson STLF: Joshua Caulkins Poster (CWSEI EOY 2010): EOSC 211: Transformations and results	Course-level goals: complete Lecture-level goals: complete Learning goals for Labs/Assignments: draft	Pre-post assessment: Administered in Teach 1 and edited for Teach 2, can be used "as is" for all future terms Midterm and end-of-term surveys New types of exam questions based on computer science concepts	In-class worksheets for every lecture Pair-programming used in all labs and assignments. Name-sticks used to call on students during lectures and in-class discussions Post-lecture Interviews Lab interviews
EOSC 212: Topics in the Earth & Planetary Sciences (Jan '08 start) Faculty: Mark Jellinek, Michael Bostock STLF: Francis Jones (~30 students per yr) Further refinements of generic science thinking activities and assessments were carried out in Fall '10, primarily by the instructor (M. Jellinek), with minor input and support from F. Jones. Poster (CWSEI EOY 2011): Promoting and Measuring General Scientific Reasoning Expertise of 2nd Year Students	Course-level goals: complete Focus is on science thinking skills rather than content	End-of-term survey for project evaluation Quizzes on readings for both individual and teams, using Team Based Learning strategies Two projects (presentation and poster), including feedback at multiple stages of delivery Pre-post test related to model-based reasoning Peer assessment of some homework and both projects Regular graded abstract writing and question-posing assignments Student participation in rubric design for reading, writing and questioning	Course management system used extensively for content delivery, quizzing, surveying, logistics Team Based Learning elements: permanent teams, individual/team quiz protocols & in-class team activities Content from Scientific American and other articles and lectures Three modules chosen to highlight departmental research strengths Guest speakers for each module Instruction and practice at developing science article reading, questioning & discussing skills Project topics are student-determined Question posing, abstract writing and model based reasoning rubrics are used; in Fall 2010, question posing aspect was more closely guided so students know whether to ask content or discussion oriented questions. Capstone week introduced to revisit core skills and learning goals Two instructors with roughly half the classes attended by both
EOSC 220: Introductory Mineralogy (Jan '08 start) Faculty: Stuart Mills, Mary Lou Bevier, James Scoates STLF: Ben Kennedy, Joshua Caulkins, Erin Lane, Brett Gilley Additional work by R. Mindel, J. Dohaney; course transferred to various instructors. Poster (CWSEI EOY 2011): Tracking Student Progress with a Mineralogy/Petrology Concept Inventory	Course-level goals: complete Lecture-level goals: complete	Midterm and end-of-term surveys Lab quizzes	In-class activities and discussions are part of each lecture. 3x5 cards used for student responses and feedback. Labs reworked and provided more structure to students and TAs Students create their own reference "mineral book" that can be used later for studying. 2011-2013: Explicit frameworks and framework activities, and active, group based classroom strategies introduced in a big way. Also strategies for required memorizing introduced. Students now like this course.
EOSC 221: Introductory Petrology (Sept '07 start) Faculty: Maya Kopylova STLF: Brett Gilley Course transferred early on to M. Kopylova	Course-level goals: complete Lecture-level goals: complete Lab goals: complete	Pre/post assessment	Labs rewritten - more structure activities linked to goals Small group lecture activities in each lecture 3x5 cards for ongoing assessment of students and the course Many smaller quizzes after each module Improved course framework (spaced lectures that do more to highlight differences rather than massed lectures, covering all of one rock type).

EOSC 222: Geological Time (Sept '11 start) Faculty: Paul Smith STLF: Francis Jones (~50 students per yr)	Course-level goals: completed Module and lab-level goals completed	Weekly lab exercises End of term lab exam In-class activities (next column) serve as formative assessment opportunities.	Roughly half the content was re-worked by P. Smith and R. Mindel. Four of ten labs were re worked with the assistance from an experienced teaching assistant. Complete lecture observations (student engagement plus in-class observations) were conducted during Spring 2011. Roughly 10 in-class group activities for use during class were developed during Spring 2012 teaching term.
EOSC 223: Field Techniques (May '09 start) Faculty: Mary Lou Bevier STLF: Josh Caulkins Poster (CWSEI EOY 2010): EOSC 223: Development and Implementation of an in-field assessment protocol for an introductory geologic field course	Course-level goals: completed	Pre-post assessments and in-field assessments	Increased instructor-student interaction in the field.
EOSC 252: Introduction to Experimental Geophysics (Sept '09 start) Faculty: Felix Herrmann STLF: Francis Jones (~15 students per yr) Transformation project adjourned prior to January 2011 teaching term because the class is no longer offered.	Course-level goals: agreed upon Lecture-level goals: first versions	Weekly lab or homework exercises supported by TAs In-class demonstrations assessed for "participation". The beginnings of regular on-line self-test quizzing based on assigned readings. More to come the time the course is taught. Extensive end of term survey about initiatives and preferences.	Enhanced context for all material by: - Reworked four Lab exercises - Re-compiled all lab exercises into consistent format, which recognizes progression of learning from one exercise to the next. - Dropped two labs in favor of a new "capstone exercise" (a context rich exercise using new forms of data (borehole well logs) and lab results from earlier work). - Projects involving student-chosen topics, and 3-stage deliverables with TA & peer feedback. - Guided demonstrations introduced to four class lectures, including pre-demonstration "prediction" worksheets.
EOSC 321: Introduction to Igneous Petrology (Jan '10 start) Faculty: Maya Kopylova STLF: Brett Gilley	Course-level goals: complete Lecture-level goals: complete	End-of-term survey '09 & '10 Student focus groups Mineral quizzes, exams, group project	Development of several new labs "Wake up" activities in each lecture Distributed mineral quizzes (as opposed to one quiz in week 1) Improved exam creation and marking/grading scheme Exams questions tied to learning goals Tectonic setting group project with group contract; in presentations of project, students required to incorporate data presented by other students and come to their own conclusions.
EOSC 322: Metamorphic Petrology (Sept '08 start) Faculty: Greg Dipple STLF: Erin Lane	Course-level goals: complete Topic-level goals: complete	Midterm survey Pre-reading quizzes	Rock sample and relevance in lectures Just-in-Time-Teaching (pre-readings and online quizzes given prior to module)

EOSC 326: Earth and Life Through Time (Jan '10 start) Faculty: Stuart Sutherland STLF: Francis Jones (~160 students per yr) Dec 2012: A video record of one lab and its follow up Friday activity has been developed to support PD of instructors Poster (AGU 2012): Fossils, Facies and Geologic Time; active learning yields more expert-like thinking in a large class for senior science students	Course-level goals: complete Module-level goals: complete (14 modules) with minor revisions in progress	Pre-requisite self-test, plus corresponding catch up material Weekly online exercises based on assigned readings from text and elsewhere. Regular use of clickers in class Weekly "active Friday" worksheets (see "Improved Methods") Midterm and final exams plus a comprehensive end-of-term survey	New text to help remove low level content from class. Clicker questions are improving as experience is gained. Weekly homework based on assigned readings helps keep students on task. Students do these once for grades, then they are re-opened for practice before exams. Weekly "Active Fridays" allows 1/3 of all classes to be 100% peer instruction, active learning. Work is guided, and instructor plus 2 teaching assistants circulate during work. Two hands-on lab exercises substitute for 2 weeks of lectures. Deliverables are completed during class in groups.
EOSC 328: Field Geology (May '10 start) Faculty: Ken Hickey, James Scoates STLF: Josh Caulkins Posters: (CWSEI EOY 2011): Measuring Novices' Field Mapping Abilities Using an In-Class Exercise Based on Expert Task Analysis (GSA 2010): Geologic Expertise and Field Mapping: Lessons from a 3rd Year Undergraduate Field School Talk: (GSA 2014): Mapping For Mastery: Evolution of the University of British Columbia Oliver Field School	Course-level goals: complete	GPS tracking of students, in-field assessments Pre-Post assessments Attitudes assessment	Designed and implemented 2-day "Bootcamp" prior to traveling to field school New mapping exercises Peer-to-peer learning Paced scaffolding (replaced "sink or swim" approach)
EOSC 329: Groundwater Hydrology (Jan '10 start) Faculty: Roger Beckie STLF: Francis Jones, Joshua Caulkins (~160 students per yr)	Course-level goals: complete Module-level goals: draft – need distributing among modules. Learning goals for Labs: complete	Pre-post assessment Clicker questions introduced into nearly all lectures –Weekly labs are taught & marked by TAs. Some lab materials were moved to course management system to improve efficiency and feedback. Weekly TA meetings with the instructor help ensure consistency in all four lab sections. Midterm and final exams plus a comprehensive end-of-term survey during the transformation process.	Classroom observations and post-lecture interviews were carried out early in the transformation process Lab exercises were substantially refined and aligned with learning goals, and expectations have been made more explicit. TAs have well developed guidance for instructing and running labs. Introduced three case studies to correspond with lab work. Some small group work during lectures. Clickers added to all lectures to help leverage Socratic teaching to advantage all students.
EOSC 331: Introduction to Mineral Deposits (Jan '10 start) Faculty: James Scoates, Ken Hickey STLF: Brett Gilley Poster (CWSEI EOY 2012): 3 years of Improving Student Impressions of EOSC 331 Poster (GSA 2014): Transforming An Upper-Year Mineral Deposits Class Through Interactive Engagement	Course-level goals: complete Lecture level goals: complete Lab-level goals: complete	End-of-term survey Sketches in first and last labs Smaller quizzes replace midterms	New course frameworks developed Reduced length of midterms, inserted framework activity after each quiz Activities in many lectures Rewrote all labs; labs now have "checkpoints" and are handed in at the end of lab How does a geologist sketch activity Poster session activity –successful model; developed poster rubric Summative "deposits in space & time" activity Improved final exam format Work has continued past "official" transformation. Many more activities

EOSC 332: Tectonic Evolution of North America (Sept '08 start) Faculty: James Mortensen STLF: Brett Gilley Course Transferred to E. Barnes for one semester	Course-level goals: draft Module-level goals: draft	Pre/Post Assessment rewritten for Jan 2010 (validated with former students) Midterm survey Peer Review Essay assignment End-of-term survey	Activities and discussions planned for some lectures Just-in-Time-Teaching (pre-readings and online quizzes given prior to each module)
EOSC 355: The Planets (Sept '08 start) Faculty: Catherine Johnson STLF: Francis Jones New course, taught 1st time in Spring 2009. (~70 students/yr) **Fall 2010**: second instructor supported and observed by STLF as a "transfer" and sustainability experiment. Poster (CWSEI EOY 2010): Continuing development of in-class activities in an upper level science elective	Course-level goals: complete Module-level goals: finalized for Spring 2010 term.	Pre-course skills diagnostic and "attitudes toward planetary sciences" Midterm survey for improving course delivery and focus Frequent in-class quizzes Clickers, major capstone homework exercises for each of 3 modules, in-class team-based worksheets used to set up or practices lecture content & skills. Major project, including 3-stage deliverables, & peer assessment No final exam	Course management system used for content delivery, quizzing, surveying, logistics Use of permanent teams for quizzes and in-class worksheet-based activities Clickers used for pre-lecture prediction and mid-lecture discussions Online and in-class quizzes, especially to ensure accountability and assess comprehension of basic content, thus permitting higher level in-class activities & lectures. Major poster presentation projects are a primary source of grades. Logistical strategies were adjusted to better meet student needs and improve logistical efficiency in 2013.
EOSC 372: Introductory Oceanography: Circulation and Plankton (Jan '09 start) Faculty: Susan Allen, Kristin Orians, Maria Maldonado, Erin Lane STLF: Erin Lane	Course-level goals: complete Lecture-level goals: complete Assignment learning goals: complete	Mid-term & end-of-term surveys Daily online quizzes Pre-requisite knowledge diagnostic quiz Draft post test Student workloads questions	Widespread use of thought-provoking clicker questions Daily assignments with online quizzes In class demonstrations and analogies developed
EOSC 373: Introductory Oceanography: Climate and Ecosystems (Sept '09 start) Faculty: Maria Maldonado, Susan Allen, Roger Francois, Erin Lane STLF: Erin Lane	Course-level goals: complete Lecture-level goals: complete	Mid-term survey Draft diagnostic test Daily online quizzes	Widespread use of thought-provoking clicker questions Daily assignments with online quizzes
EOSC 472: Introduction to Marine Chemistry and Geochemistry (Sep '09 start) Faculty: Kristin Orians STLF: Joshua Caulkins	Course-level goals: complete, editing for new content Lecture-level goals: draft, editing for new content	Midterm and end-of-term surveys Reading quizzes introduced. Reworked homework sets. Term papers enhanced to be a "critical review paper" which includes greater depth of comprehension	Weekly worksheet activities Anonymous peer-reviewed writing assignment with instructor feedback Post-lecture student interviews Investigating new textbook options, perhaps introducing a packet of articles Name sticks used during lectures

The following courses have undergone improvement with minor STLF support

ATSC 201: Just-in-Time Teaching and clickers - Faculty: R. Stull

ENVR 200: Team projects, studying metacognition - Faculty: K. Chan, S. Harris, T. Ivanochko, M. Johnson, D. Steyn

ENVR 300: Team projects - Faculty: K. Chan, T. Ivanochko, V. Radic, D. Steyn

EOSC 110: In-class worksheets and clickers. Used the Geoscience Concept Inventory to measure student learning - Faculty: M. Bevier, L. Porritt

EOSC 116: In-class worksheets and clickers. Pre-post testing. Faculty: S. Sutherland, M. Golding, J. Mortensen, S. Sherman. STLF: F. Jones

EOSC 118: Activities in the online setting (offered only as Distance Education). Faculty: D. Turner, T. Dzikowski, STLF: B. Gilley

EOSC 250: Active classes and Socratic lectures – Faculty: C Schoof, STLF: B. Gilley

EOSC 270: Two homework exercises that use UBC's Beaty Museum of biodiversity for synthesis of principle concepts, early and late in the course. M. Maldonado, E. Pakhomov, F. Jones and a grad student. Results assessed, minor adjustments made, and exercises are now permanent part of course.

EOSC 315: Clickers (one year only) - Faculty: M. Lipsen

EOSC 324: No longer offered - Faculty M. Bevier

EOSC 333: Learning goals, in class activities, field trips, labs summative activities STLF: B. Gilley

EOSC 340: Just-in-Time Teaching, clickers, worksheets, two-stage exams - Faculty: S. Harris, P. Austin, T. Ivanochko. (Talk at GSA 2014: University Students' Ideas About Climate Concepts Lack Systems Dynamics Thinking)

EOSC 350: Team Based Learning - Faculty: D. Oldenburg, STLF: F. Jones

EOSC 352: Active classes and Socratic lectures – Faculty: C Schoof, STLF: B. Gilley

EOSC 420: Developing lab activities and student conference on projects. Faculty: K Russell, L. Porritt. STLF B. Gilley

EOSC 421: Lab projects, lecture activities, and field trip Faculty: A. Caruthers STLF B. Gilley

EOSC 424: Learning goals, activities, labs, and projects Faculty: J. Scoates and K. Hickey STLF B. Gilley

EOSC 433: Scaffolding exercises for design and reporting on design projects, and a peer assessment of intermediate work. E. Eberhardt, F. Jones, and a grad student. (Presentation, U. Calgary, 2014: Improving and Assessing Research, Design and Reporting Skills of STEM Students)

EOSC 442: Lab projects. Faculty: T. Ivanochko. STLFs: F. Jones & B. Gilley

EOSC 445: Active class; project management. Faculty: S. Hollingshead. STLF: F. Jones

EOSC 450: Student projects. Faculty: C. Johnson. STLF: F. Jones

EOSC 474: Group e-posters. Faculty: E. Pakhomov. STLF: B. Gilley

EOSC 478: Eposter project and online poster session. Faculty: E. Pakhomov STLF B. Gilley

Curriculum

Service Courses Curriculum Committee evaluated precedents, conducted surveys, and analyzed student data to articulate a list of learning goals for all service courses under the subheadings "Knowledge and Major Concepts", "Skills", and "Habits and Attitudes". The list was revised based on faculty input, was presented at the department's retreat in April 2009, and adopted by the department. Goals are posted on the departmental website.

Atmospheric Science Curriculum Committee defined program goals. (S. Allen, chair)

Environmental Science Curriculum Committee conducted student focus groups and extensive data analysis on student enrollment data and developed a set of recommendations and a revised curriculum (D. Steyn, chair)

Geophysics Curriculum Committee reinstated the Geophysics Majors program (E. Hearn, chair)

Geology Curriculum Committee reinstated the Geology Majors program. A matrix correlating courses and program objectives is under development (J. Scoates and S. Sutherland).

Oceanography Curriculum Committee is actively working to define program goals & build links among courses. They have also created two new combined majors in Oceanography programs (with biology and with physics), and a new oceanography minor. (S. Allen, chair)

Geological Engineering Curriculum has started a course/objectives matrix in anticipation of an upcoming program review.

Exit Survey: An online survey has been developed for graduating 4th year EOAS students from all streams. Data will provide us with student perspectives on the EOAS academic programs, career goals and curriculum recommendations. This information will help us improve our program structure, content, and courses. The survey was initiated in April 2009 and administered annually since then. Results 2009–2014 have been processed and summarized.

TA Development

Established a **TA training course** for graduate students (EOSC 516: Teaching and Learning in Earth & Ocean Sciences)
Course is run primarily by graduate students who have facilitator training. Enrolment is about 15/year. Poster (CWSEI EOY 2010): Teaching and Learning in the Earth and Ocean Sciences: Adding Geoscience Education to the Graduate Student Curriculum at UBC

Learning goals: Course level goals, learning goals for each session
Assessments: Using Physics' Teaching Attitudes Survey as Pre/Post, Formative Evaluation after each session, Summative Evaluation, Beliefs about Reformed Science Teaching and Learning Survey (BARSTL)
Methods and materials: Mini-lesson practice, Group discussions, Lab redesign project

Research

See http://eos.ubc.ca/research/cwsei/research.html for a list of previous and continuing projects.

See http://www.eos.ubc.ca/research/cwsei/resources/research/eossei-ResearchList.pdf for a complete list of research results from EOAS-SEI 2007-2014, including peer-reviewed publications, undergraduate honors theses, and conference presentations.

Other

Videos of exemplary STEM teaching strategies: Seven short clips produced to help faculty and students new to research-based instructional practices visualize what it's like to teach and learn in transformed courses. See http://blogs.ubc.ca/wpvc/.

EOAS-SEI Times: An (approximately) monthly newsletter containing results from courses, tips and information for instructors (58 editions so far)

Teaching and Learning Workshops: One-two per year are facilitated by STLFs for participants within and outside EOAS.

Visitors: Cathy Manduca, director of the Science Education Resource Center at Carleton College; Eric Riggs, co-director of the Center for Research and Engagement in Science and Mathematics Education, Purdue University; Leslie Reid, Tamaratt Teaching Professor, University of Calgary; Frank Granshaw, Portland Community College; Anne Marie Ryan, Dalhousie University; Jane Schoonmaker, University of Hawaii-Manoa; Steve Taylor, Kauai Community College; Julie Libarkin, Michigan State University; Barbara Bruno, University of Hawaii-Manoa.

Workloads and enthusiasm study: Relative and absolute workloads in 25 courses were collected between 2009 and 2014, with densest data in 2009-2011. Results are being summarized and analyzed with the intent to publish. Relative workloads and relative enthusiasm data in nearly all undergraduate courses were collected for the 2013-2014 academic year.

Student Perceptions of Learning study: During the 2013-2014 academic year, students in 78% of the 74 undergraduate courses taught in EOAS were surveyed with an instrument designed to ascertain how they perceive specific teaching and learning strategies. Results have been processed and a publication is being prepared.

Impact assessment: After 7 years of CWSEI support, we are now measuring effectiveness and efficiency of learning and teaching strategies by gathering data from three complementary perspectives: (i) measures of learning, (ii) student & instructor perceptions, and (iii) course observations. Each perspective is being examined in terms of both current practices and changes in practices since 2007.

Case Study of Transformative Educational Change: Carried out September 2014 by Huber and Hutchings: *Huber, Mary Taylor, and Hutchings, Pat. 2014. The Carl Wieman Science Education Initiative in Earth, Ocean, and Atmospheric Sciences, University of British Columbia: Benchmark Report. A Bay View Alliance Case Study. (Unpublished manuscript, Fall 2014)*.

Enhancing Distance and Face-to-face Education: A two year post-CWSEI project funded by UBC's Flexible Learning Initiative (2014-2016). This project builds directly upon gains made during the EOAS-SEI to improve courses offered in both distance education and face to face modes.

Teaching, Learning, and Assessing Scientific Reasoning Abilities in large Face-to-face and Online Courses: A two-year post-CWSEI project funded by UBC's Teaching and Learning Enhancement Fund (2016-2018). This project builds on work from EOAS-SEI and the previous Flexible Learning project.

Life Sciences Program

The Life Sciences Program (Depts. of Zoology, Botany, and Microbiology & Immunology) received its first funding from CWSEI in 2007. The funding was renewed and extended in 2011 with four new STLFs starting in late 2011 and early 2012. The new funding allows STLFs to work with all second year core courses in the newly designed and implemented Biology Program at UBC. Two additional STLFs were hired in 2013, in conjunction with the Flexible Learning Initiative project for two first-year core courses, and one more was hired in January 2015. We are currently implementing interactive activities and peer discussion in core courses in the Biology program from first to third year. The types of activities we are implementing include clicker questions with peer discussion, worksheets, case studies, learning activities, and invention activities. We have also assisted with the implementation of learning goals and pre-reading assignments in most of these core courses. In addition, conceptual inventories in information transfer and community and population ecology have been developed and are used to evaluate the effectiveness of various class activities. On a larger scale, we are currently carrying out a department-wide characterization of the impact of various classroom practices (COPUS observations) on student learning (concept inventory data).

CWSEI Dept. Director: P. Schulte

STLFs: T. Rodela, N. Schimpf, M. Barker (emeritus), L. McDonnell (emeritus), M. Mullally (emeritus), M. Hansen (emeritus), L. Weir (emeritus), M. Banet (emeritus), B. Clarkston (emeritus), T. Kelly (emeritus), J. Taylor (emeritus), H. Yurk (emeritus)

Faculty (instructors teaching targeted courses): K. Smith, G. Spiegelman, G. Bradfield, W. Goodey, R. Turkington, M. O'Connor, E. Hammill, P. Kalas, S. Chowrira, P. Schulte, J. Klenz, G. Haughn, D. Altshuler, D. Moerman, C. Berezowsky, A. O'Neill, W. Tetzlaff, S. Ellis, S. Graham, M. Berbee, G. Bole, J. Whitton, D. Srivastava, P. Tortell. M. Hawkes, C. Douglas, E. Hinze, M. Graves, J. Brodie, R. Young

Faculty (others involved in working groups, committees, or ad-hoc support): G. Bole, C. Pollack, A. O'Neal, K. Nomme, B. Couch

Skylight Affiliate: G. Birol; **Students and Post-Doctoral Fellows:** T. Deane, E. Jeffrey, R. Oh, M. Tseng, N. Wang, P. van Stolk

Course Transformation

Course	Learning Goals	New Assessments	Improved methods
BIOL 111: Cell and Organismal Biology (Sept '07 - Sept '08) Faculty: Kathy Nomme, Jennifer Klenz Skylight Liaison: Gülnur Birol	Course-level goals: complete Topic-level goals: complete	Midterm student evaluations Focus groups Biology attitudinal survey Clicker questions	Case studies, clicker questions, group activities; online reading quizzes Peer tutor support Intentional alignment of topics with student work and assessment
BIOL 112: Cell Biology (Sept '07 start) Faculty: K. Smith, S. Chowrira, C. Douglas, E. Hinze, M. Graves; previous: E. Gaynor, T. Kion, G. Spiegelman STLF: Jared Taylor ('07-'11); Megan Barker ('13-'14) Poster (CWSEI EOY 2010): Invention Activities in First Year Biology	Course-level goals: complete Topic-level goals: complete	End-of-term surveys Student interviews to assess problem solving abilities End-of-term assessment of learning and invention groups to assess transfer abilities Biology attitudinal survey Concept inventory Student perspectives and faculty perspectives on the value of active learning course components Course management: TA workload Classroom practices captured (COPUS data)	Developed and refined a series of invention/investigation activities for in class once per week. As of 2014, two of these have been maintained in the course. Just-in-Time Teaching incorporated with pre-class readings. In-class writing assignments Clicker questions with peer discussion End of week problems PeerWise used in all sections; PeerWise workshops implemented to give students guidance in writing multiple choice questions. Targeted pre-reading assignments; weekly pre-reading quizzes
BIOL 121: Ecology, Genetics and Evolution (Sept '07 start) Faculty: C. Pollock, G. Bole, P. Kalas, B. Couch, A. O'Neill Skylight Liaison: G. Birol STLF: Martha Mullally ('13), Lisa McDonnell ('15)	Course-level goals: complete Topic-level goals: complete (revised and extended for the ecology unit in '11)	Mapping of multi-section course outcomes onto assessments Biology attitudinal survey Meiosis concept inventory (in preparation)	Peer tutors; Learning centre Clickers implemented in most sections; PeerWise used in some sections. Concept inventory in community and population ecology used to evaluate effectiveness of in-class activities (Kalas '11). Two-stage review activity used in multiple sections.
BIOL 140: Laboratory Investigations in Life Sciences (Sept 2014 start) Faculty: K. Nomme, C. Sun, M. Moussavi, L. Norman, B. Germano, P. Kalas STLF: Natalie Schimpf	Overall course goals to be re-examined, existing objectives revised	Documentation of TA hours TA focus group interviews Observations of lab classes Collecting student reports of time spent on activities outside of class Past student survey conducted	Refocused assessments and tasks to support prioritized skills/knowledge Standardised outside of lab format Clarified requirements and introduced grading rubrics for assignments, incorporated into class activities

Talk (UBC Science Ed Open House 2016): Biology 140 Renewal; Responding to Student Feedback		Course-specific evaluation administered to students Student experience focus groups Concept Inventories: BEDCI, SRBCI, 'SCENDI' ('Scenario Diagnostic Inventory' - in-house developed set of pre-post questions InterCLASS data collected	Increasing research authenticity – explicit links to authentic and local research (feature videos, scenario and Beaty Biodiversity Museum activities) Guidance and scaffolding of writing process (repeated practice of scientific explanation) and experimental design TLEF: Development of digital instructional resources - 'Draw-my-life' narrated animation - Researcher profile videos - Interactive tutorials (branching decision tree) Additional resources – posters and QR code links to background organism and factor information.
BIOL 200: Fundamentals of Cell Biology (2013 start) Faculty: R. Young, N. Abraham, N. Pante, L. Kunst, L. Chen, M. Graves STLF: Megan Barker	Course-level goals: complete Topic-level goals: complete Writing-specific goals: complete	Concept inventory developed and deployed across the course Student writing project (press release) developed Targeted modification of writing assessments on midterm and final exam Classroom practices data (COPUS observations) Tutorial observations: protocol developed & feedback given to TAs TA tracking timesheets were setup and deployed	Writing assignments scaffolded through semester (2013) Clicker questions with peer discussion (section-dependent) Pre-reading assignments and pre-quizzes developed and deployed Two-stage review activities built and used Worksheets developed and piloted
BIOL 201: Cell Biology II: Introduction to Biochemistry (Jan '08 – Sept '08; 2013-) Faculty: Sunita Chowrira, Jeffrey Richards, Reinhard Jetter; previous: Wade Bingle STLF: Jared Taylor ('08) Megan Barker (2013-)	Lecture -level goals: complete	Chemistry concept pre-test Focus group interviews Focus group follow-up survey (entire class) Biology attitudinal survey Tutorial observations (using COPUS protocol) and feedback	Recommendations provided to faculty in 2008 by Jared. More recent: Pre-reading assignments and quizzes developed by course coordinator (deployed 2015) Worksheets and clicker question development/support (section-dependent) Two-stage review (section-dependent)
BIOL 204: Vertebrate Structure and Function (Jan '08- start) Faculty: Bill Milsom, Angie O'Neill, Wolfram Tetzlaff STLF: Laura Weir	Course-level goals: complete Topic-level goals: complete	Clicker questions Post test: Vista Reading/Content quizzes In-class exam-style questions with posted rubrics and feedback	New study questions Midterm teaching evaluations Improvement of group activities and discussions in class Revised course content and lecture materials incorporating real life examples. Enhanced problem solving approach including comparisons. Introduced exam-style question practice into lecture time Collected data regarding approaches to teaching phylogenetics Piloting Calibrated Peer Review for short essay questions
BIOL 205: Comparative Invertebrate Zoology (Jan '13 start) Faculty: Angie O'Neill STLF: Laura Weir	Course-level goals: In process Topic level goals: In process	Clicker questions Pre-reading assignments for lecture and laboratory	Clicker questions with peer discussion Pre-reading assignments that cover both lecture and laboratory material Midterm teaching evaluations Collecting data regarding approaches to teaching phylogenetics

BIOL 209: Non-vascular Plants (Sept '12 start) Faculty: Mary Berbee, Michael Hawkes STLF: Laura Weir	Course-level goals: completed Topic level goals: completed	Clicker questions Independent research projects	Clicker questions with peer discussion Alignment of exam questions and learning objectives Collecting data regarding approaches to teaching phylogenetics Use of worksheets in class
BIOL 210: Vascular Plants (Jan '13 start) Faculty: Shona Ellis, Sean Graham STLF: Laura Weir	Course-level goals: completed Topic level goals: completed	Clicker questions In-class worksheets	Clicker questions with peer discussion Alignment of exam questions and learning objectives Collecting data regarding approaches to teaching phylogenetics
BIOL 230: Fundamentals of Ecology (formerly BIOL 304) (Sept '09 start) Faculty: D. Srivastava, R. Turkington, W. Goodey, E. Hammill, J. Brodie STLF: Malin Hansen Poster (CWSEI EOY 2011): Measuring Learning Gain in a Transformed Introductory Ecology Course Poster (CWSEI EOY 2012): Evaluating Interactive Activities by Measuring Student Learning Gain	Topic-level/ class specific goals: completed and provided to students Learning goals have been linked to exam question, iclicker questions and pre-reading questions.	The CLASS pre and post biology attitude surveys have been used in all sections each term (2009-2013) A pre/post conceptual survey for community and population ecology has been developed and is used Student interviews have been conducted to assess class activities and methods and to validate conceptual survey Midterm survey has been developed and is used to assess class activities and methods	Clicker questions with peer discussion Pre-reading assignments with multiple choice and open ended question (with feedback) are issued each week Small group in-class discussions 23 on-line article-based practice problems/case studies developed; some have been implemented as in-class activities 3 mandatory field labs implemented Two tutorials have been designed and implemented (for summer courses only) The conceptual inventory in community and population ecology has been used to evaluate the effectiveness of in-class activities (Instructor: Roy Turkington and Wayne Goodey '11) Conceptual questions on population dynamics are used to compare the effectiveness of in-person tutorials and on-line tutorials ('12-'13). The effectiveness of using analogies when teaching ecology was evaluated using optional tutorials ('11). Two-stage group exams were used for two midterms (J. Brodie & M. Hansen '13)
BIOL 234: Fundamentals of Genetics (Jan '12 start) Faculty: J. Klenz, P. Kalas, D. Moerman, G. Haughn, C. Berezowsky STLF: Lisa McDonnell Poster (CWSEI EOY 2013): Comparing post-course retention of conceptual and procedural knowledge in genetics Poster (SABER 2014): Exploring ways to overcome misconceptions about genetic linkage and molecular markers (Klenz and McDonnell) Article (CourseSource 2015): Teaching Genetic Linkage and Recombination through Mapping with Molecular Markers (McDonnell and Klenz)	Topic level learning goals – complete, used to structure lectures, tutorials, assessments, and provided to students.	Genetics Concept Inventory Test Student think-aloud interviews to assess problem solving in genetics Interviews conducted to assess course satisfaction Problem solving and conceptual understanding assessed with some handed-in homeworks Mid-term and end-of-term satisfaction surveys deployed to assess class activities and student attitudes Regularly collecting feedback from TAs about their experience and the challenges they observe students experiencing Classroom observations (COPUS) for instructor feedback	Clicker questions with peer discussion and in-class worksheets used (by most instructors) Targeted pre-reading assignments with quiz are used weekly. Tutorials with an emphasis on group work and facilitation by TAs deployed weekly Improved support for TAs to provide students with a consistent experience across multiple tutorial sections Peer-discussion used in-class regularly Improved approach to teaching problem solving Two-stage review activity used

BIOL 234: Fundamentals of Genetics – online section (Sept – Dec '14) Faculty: Rosie Redfield STLF: Lisa McDonnell	Topic level learning goals – complete, used to structure lectures, tutorials, assessments, and provided to students	Genetics Concept Inventory Test Mid-term and end-of-term satisfaction surveys deployed to assess class activities and student attitudes Common exam questions with non-online section Observations of tutorials to capture student difficulties	Tutorials with an emphasis on group work and facilitation by TAs deployed weekly Two-stage review activity used
BIOL 260: Fundamentals of Physiology (Jan '12 start) Faculty: Patricia Schulte, Philippe Tortell STLF: Mandy Banet ('12-'13), Laura Weir ('14), Tammy Rodela ('15-continuing)	Course level learning goals: complete Lecture-level learning goals: complete Goals have been linked to exams, online activities, and clicker questions	Mid-term teaching survey deployed for student feedback on in-class and out-of-class activities Mid-course and end-course surveys conducted to get specific detail on active learning aspects of the course Pre and post conceptual survey for physiology developed and implemented New three-stage homework model with student reflection stage designed and deployed to provide students with timely feedback Classroom observations (COPUS) done to provide feedback to instructors Creation of a course package for transfer of course materials	Clicker questions with peer discussion Pre-reading assignments with an online quiz (including one open-ended JITT questions) are issued each week. Practice exam questions are provided as online and in-class activities to give students practice and feedback on what is expected from them when answering a short essay question. Worksheets and problem sets in class with real-time instructor feedback. Rearranged course schedule to include overview lectures introducing main physiology concepts for each in-course module Accompanying concept-based clicker questions and worksheets were designed and deployed to complement the overview lectures for each module
BIOL 306: Advanced Ecology (2010-2013) Faculty: Gary Bradfield, Wayne Goodey, Mary O'Connor STLF: Malin Hansen	Topic-level/class specific goals: completed and provided to students	The CLASS pre and post biology attitude surveys have been used in all sections each term ('10, '11 and '12). A pre/post conceptual survey for advanced ecology has been developed and is used. A pre/post conceptual survey on competition models have been developed. Student interviews have been conducted to assess class activities and methods and to validate conceptual survey. Mid-term survey has been developed and is used to assess class activities and methods.	Clicker questions with peer discussion Pre-reading assignments with multiple choice and open ended questions (with feedback) are issued each week. Small group in-class discussions have been incorporated. Twenty-three on-line article based practice problems have been developed. Some of them were implemented as in-class learning activities in '11 and '12 (approximately one learning activity per week). The conceptual inventory on competition models is being used to evaluate an in-class learning activity. Three mandatory field labs have been implemented. Two tutorials have been designed and implemented (for summer courses only).

BIOL 310: Introduction to Animal Behaviour (2011-2012) Faculty: Wayne Goodey STLF: Malin Hansen	Topic-level/class specific goals: completed and provided to students Learning goals have been linked to exam question, iclicker questions and pre-reading questions	The CLASS pre and post biology attitude surveys have been used in all sections each term ('11-'12). A pre/post conceptual/attitudinal survey has been developed by the instructor and is used. Mid-term survey will be developed and used.	Clicker questions with peer discussion Pre-reading assignments with multiple choice questions (with feedback) are issued each week. Small group in-class discussions have been incorporated. An entire 50 min lecture per week is devoted to an in-class group discussion activity. Mandatory field labs have been part of the course for some years. Student project and associated poster presentation have been part of the course for some years.
BIOL 325: Introduction to Biomechanics (2014 start) Faculty: Phil Matthews STLF: Natalie Schimpf	Finalising course learning goals	Pre and post diagnostic in first iteration (as part of department-wide COPUS)	Intention (for next iteration) to incorporate pre-class readings and quizzes, clicker questions, in-class activities and worksheets. Class participation to be included in final grade
MICB 325: Microbial Genetics (Jan '11–'12) Faculty: Tom Beatty STLF: Jared Taylor Poster (CWSEI EOY 2012): Restructuring Microbiology 325: Microbial Genetics	Learning Goals: complete	A newly developed Bacterial Gene Regulation Concept Inventory is being used in a trial run.	Currently tutorial/homework questions are being converted into clicker questions that will be used during a weekly 50-minute tutorial lecture. Currently undergoing transformation to use a full active learning with JiTT format.
BIOL 331: Developmental Biology (Sept 2016 start) Faculty: Vanessa Auld STLF: Tammy Rodela	Course-level: in progress Topic-level: in progress	Intention to observe lecture (COPUS) and labs to provide feedback to instructors, release mid-course and end-course student attitudinal surveys	Course revision to include: Pre-readings and quizzes Clicker questions Weekly homework question (three-stage including student reflection) Peer discussion Activities focusing on primary literature in developmental biology
BIOL 335: Molecular Genetics (Dec '14-'15) Faculty: Craig Berezowsky, Yuelin Zhang, Don Moerman STLF: Lisa McDonnell	Iterative process to revise goals underway	Using concept inventory (pre- and post) to measure learning gains Observing tutorials to capture baseline information to inform change Observing lecture (COPUS) to provide instructor feedback Mid-course survey deployed	To be incorporated as part of course revision: - Peer instruction - Clickers - Group work to solve complex problems
BIOL 336: Fundamentals of Evolution (Jan. '12 start) Faculty: Jeannette Whitton, Greg Bole STLF: Bridgette Clarkston ('12) Laura Weir ('13-'14)	Course-level: in progress Topic-level: complete	Mid-course and end-course student attitudinal surveys Clicker questions Speciation Concept Inventory (in validation stage)	Weekly targeted textbook pre-reading assignments and quizzes Assessment questions drawn from learning goals. Tutorials more connected to lecture section and converted from informal discussion to more structured group work with worksheets and discussion. Clicker questions with peer discussion; broader use of clicker questions (e.g., assess prior knowledge, make predictions, probe misconceptions) In-class practice exam questions and worksheets are used. Two-stage review activity implemented

BIOL 361: Introduction to Physiology (Sep '12 start) Faculty: Doug Altshuler, Tammy Rodela, Agnes Lacombe STLF: Mandy Banet, Tammy Rodela	Lecture-level learning goals: Goals were provided to students. Goals have been linked to exams, iclicker questions, practice problems, and homework.	Pre-term assessment on topics covered in the course was given first day of class. End-of-term survey conducted to get specific detail on active learning aspects of course. Focus groups used to provide feedback on class activities & methods.	Clicker questions with peer discussion Pre-reading assignments with an online quiz (including one open-ended JITT questions) are issued each week. Practice exam questions are provided as in-class activities to give students practice and feedback on what is expected from them when answering a short essay question. Developed and piloted worksheets and case studies Two-stage group exams were used
BIOL 362: Cellular Physiology (Jan 2015 start) Faculty: Robin Young STLF: Megan Barker	Learning goals already in place	Concept inventory Ongoing peer feedback as part of term project	Two-stage review Support with case studies, student writing and peer group feedback
BIOL 456: Comparative and Molecular Endocrinology (Jan 2015 start) Faculty: Tammy Rodela	Course-level and topic-level learning goals completed	Two-stage exam style exams Developing a course pack for transfer of course-related materials	In-class worksheets and case studies designed and deployed Practice exam questions provided as online and during in-class activities Student writing project (science journalism paper) developed Developed weekly pre-reading and assignments focusing on the scientific (primary) literature

CWSEI-LS consulting on courses and changes undertaken by individual faculty members:

BIOC 203 and BIOC 302: Fundamentals of Biochemistry & General Biochemistry (Faculty: Robert Maurus) – 2015: Megan Barker is consulting with the instructors of these courses, conducting tutorial observations & giving TA feedback using qualitative observations & COPUS data.
Microbiology 300: Microbial Ecology (Faculty: William Mohn) – Course-level and topic-level learning goals completed, survey, in-class group problems, poster made by learning group, in-class and out-of-class student learning group problems, clickers.
Microbiology 302: Immunology (Faculty Pauline Johnson) – worked with Jared Taylor to create learning goals.
Microbiology 409: Advanced Microbial Genetics (Faculty: Steven Hallam) – Course-level and topic-level learning goals completed, student survey, in-class workshops using groups of students, clickers.
BIOL 441: Fall 2014: Megan Barker consulted with Geoff Wasteneys about the structure of the fourth-year course, and provided some support on the curriculum request documents
BIOL 463: Gene Regulation in Development (Faculty: Pam Kalas) – Used two-stage review activity on the first day of class, deployed concept inventory

Curriculum

Organizational Planning:

- Biology Program curriculum working group proposed extensive changes to the program. G. Birol is on the committee with faculty from Botany and Zoology.
- Established a methodology for developing learning objectives (e.g. Angie O'Neill's work within the scope of BIOL 204 resulted in development of 3rd year physiology courses' learning outcomes with Trish Schulte and Agnes Lacombe)
- Developed a comprehensive project plan for the new upper level ecology courses led by Diana Srivastava with the help of Harald Yurk 2007/2008.
- **Curriculum Mapping Project:** Life Sciences STLFs B. Clarkson, M. Banet, L. Weir, and L. McDonnell have undertaken curriculum mapping project of the biology program. Information about nearly all biology courses have been collected and the information is being used to map the overlap (and gaps) in the coverage of course-level and program-level learning goals and skills.

Evidence Based Approach to Curriculum Design:

- **Concept Inventories:** Jared Taylor and Liz Imrie with help from George Spiegelman developed gene regulation concept inventory in BIOL 112 which has been validated and deployed in some large classroom settings. A smaller version of the inventory has been used in Biology 112 as a pre-test, and the full inventory as a post-test. Additionally, the inventory was deployed in MICB 325 as both a pre and post-test. Malin Hansen developed a concept inventory in population and community ecology which has been validated and is used to evaluate the effectiveness of in-class activities in both BIOL 121 and BIOL 230/304. Ad hoc concept inventories have been developed and implemented in BIOL 260.
- **4th year Biology Satisfaction Survey:** Evaluation of Student Satisfaction and Skills by Harald Yurk and Gülnur Birol provided evidence about student satisfaction and areas for improvement in the program.
- **Attitudinal Survey:** The CLASS pre and post biology attitude surveys have been used in several first, second, third and fourth year courses between 2009-2013. This is part of a longitudinal study where we investigate shifts in students' attitudes towards biology from first to fourth year.
- **Ecological Attitude Surveys:** Harald Yurk conducted surveys on ecological attitudes of students before and after ecology instruction and at different program levels 1st, 3rd, and 4th year, and grad students. The survey use was based on the learning goal that ecology education should build an informed citizenry which can be measured as an attitude change towards environmental issues.

- **Chemistry Concepts:** Jared Taylor conducted a review of UBC biology courses to determine the required chemistry knowledge. As a starting point, the required courses for the Cell Biology and Genetics program were analyzed to determine the relevant chemistry content. This was followed by a general survey of other UBC biology courses. The report provided important insight into decisions regarding the chemistry content.
- **Conceptual Understanding of Natural Selection:** Harald Yurk assessed conceptual understanding of natural selection in 1st and 3rd year students before and after instruction, using a multiple choice survey (Conceptual Inventory of Natural Selection, CINS, developed at San Diego State University). The CINS measures the presence and absence of the seven key principles of natural selection plus three other concepts that are related to natural selection but are not considered key concepts, such as speciation. Harald also used another short answer instrument in BIOL 336 to test for common misconceptions about natural selection.
- **Focus Group Interviews:** e.g. BIOL 111, BIOL 121, BIOL 201, 4th year students 2007-2009
- **Learning Objectives:** At present 16 out of 51 biology courses (200 level and up) have topic level learning objectives, some of which were developed by faculty members only and some with the help of STLFs. In addition, all first year biology lecture courses have topic level learning objectives. These objectives are helpful to guide the work of discipline specific committees in identifying the depth and breadth of concepts.
- **UBC PAIR data**

Research

CWSEI funded:

- **Use of Scientific literature across the Biology Program:** Life Sciences STLFs N. Schimpf, T. Rodela have undertaken a program-level project examining how scientific literature is used in Biology courses. Surveys are being developed to collect perspectives from both a faculty and students.
- **Characterizing Active Classrooms and Student Learning:** Laura Weir, Lisa McDonnell, Megan Barker, Natalie Schimpf, and Tammy Rodela are conducting a department-wide study examining whether a relationship exists between levels of active learning in classrooms (characterized through COPUS observations) and student learning (pre-post test CI scores). Data collection and analysis is completed and a manuscript is in preparation. Poster: UBC Science Ed Open House 2016.
- **Three stage online homework model: providing timely feedback to students in large enrollment courses:** Tammy Rodela is measuring how a required homework assignment with a reflection stage helps students interact with course materials. Data collection is complete and analysis is underway.
- **Effects of jargon on conceptual understanding**: Megan Barker and Lisa McDonnell conducted a pilot project to assess the effects of jargon on learning new concepts in first year biology. Paper: McDonnell, L., Barker, M. K. and Wieman, C. (2016), Concepts first, jargon second improves student articulation of understanding. Biochem. Mol. Biol. Educ., 44: 12–19. doi:10.1002/bmb.20922.
- **Study skills workshops to improve student performance:** Laura Weir, in collaboration with Ashley Welsh, Sara Harris, Costanza Piccolo, Sandra Merchant, and Jackie Stewart, has been running workshops in BIOL 121 to help students understand how the course learning objectives can be linked to exam questions. Next steps toward improving the effectiveness of these workshops are underway.
- **Problem Solving in Genetics:** Lisa McDonnell conducted a study to investigate how students solve problems in genetics, and how to modify course activities to improve student ability at problem solving in genetics. Student interviews and tests continue to be collected to assess the effectiveness of changes to the way we teach problem solving. Posters (CWSEI EOY 2014; SABER 2014: Beyond the content: Improving student problem-solving in genetics). Manuscript prepared for submission.
- **Retention of conceptual and procedural knowledge in genetics:** Lisa McDonnell is measuring the degree of retention of conceptual understanding and procedural knowledge (how to solve problems) in genetics. Students from summer, fall, and spring terms are recruited approximately 2.5 months after course completion to write a previously-written conceptual inventory and exam questions. Data collection and analysis is complete and a manuscript is in preparation
- **Pre-reading Study:** Mandy Banet collaborated with Cynthia Heiner (former STLF in Physics) to study the implementation of directed pre-readings in across disciplines. Paper (2014): Preparing students for class: How to get 80% of students reading the textbook before class
- **Two-stage Collaborative Test Study**: Bridgette Clarkston collaborated with Brett Gilley (STLF in EOAS) to study the effects of testing students in groups vs. individually on student learning. Their paper "Collaborative Testing: Evidence of Learning in a Controlled In-Class Study of Undergraduate Students" was published in the Journal of College Science Teaching (Vol. 43, No. 3, 2014).
- **Constructing logical arguments:** Laura Weir is examining the effectiveness of repeated practice with feedback on the construction of logical arguments on open-ended essay type examinations.
- **Biology Attitudinal Survey:** Gulnur Birol and Malin Hansen have completed a study that compares student attitudes in first and fourth year courses. The CLASS pre and post biology attitude surveys have been used in several first and fourth year courses between 2009-2013. This is part of a longitudinal study where we investigate shifts in students' attitudes towards biology from first to fourth year. Paper (CBE-LSE 2014): Longitudinal Study of Student Attitudes in a Biology Program.
- **Evidence-Based approach to teach genetic linkage and recombination:** Lesson and tutorial activities developed by Lisa McDonnell and Jennifer Klenz. Activities used and tested (via clicker questions and post-test) in 200 level genetics class. Poster (SABER 2014): Exploring ways to overcome misconceptions about genetic linkage and molecular markers, article accepted for publication (CourseSource, http://coursesource.org/).
- **Learning Activities/Case Studies:** Malin Hansen studied the effectiveness of in-class activities in BIOL 121 and BIOL 230 using a concept inventory in population and community ecology.
- **Tutorial vs. in-class activities:** Malin Hansen compared student learning from using separate tutorials in addition to traditional lectures vs. in-class activities using a concept inventory in population ecology.
- **Use of analogies to teach ecology:** Malin Hansen studied the effectiveness of using analogies when teaching ecology using optional tutorials in BIOL 230/304 in the fall of 2011.
- **Invention Activities: Invention Activities:** Jared Taylor, George Spiegelman and Karen Smith conducted a study of the effectiveness of invention activities in developing students' reasoning/problem solving skills and ability to transfer knowledge to novel situations.
  Paper (Winter 2010): Using Invention to Change How Students Tackle Problems — Jared L. Taylor, Karen M. Smith, Adrian P. van Stolk, and George Spiegelman (CBE—Life Sciences Education)
  An Instructor's Guide and accompanying materials for Invention Activities in Cell Biology (11 MB zip file) - prepared by Jared L. Taylor and George B. Spiegelman in Life Sciences.
- **Learning Objectives:** Jared Taylor in collaboration with Beth Simon, STLF in Computer Science, conducted a study of student and faculty perceptions of the usefulness of learning goals. Their paper on this work is published in the Journal of College Science Teaching (Nov/Dec 2009). What is the Value of Course-Specific Learning Goals?

- **Student Satisfaction Survey:** Harald Yurk and Gülnur Birol investigated student satisfaction within the biology program. In April 09, 2009, student responses were collected in fourteen forth year biology courses.
- **Writing Assignment Study:** Rosie Redfield and Tamara Kelly conducted a study on the effect of different types of assignments on student's writing and clarity of thought January – April 2008.
- **Characterising Active Classrooms and Student Learning:** Laura Weir, Lisa McDonnell, Megan Barker and Natalie Schimpf are conducting a department-wide study examining whether a relationship exists between levels of active learning in classrooms (characterized through COPUS observations) and student learning (pre-post test CI scores).
- **Visual communication of classroom practices data: a design study for instructors, researchers, and institutions.** In conjunction with Jessica Dawson (STLF from Computer Science). An investigation of the potential uses for COPUS data among the diversity of end-users, and design of appropriate visuals to aid interpretation and impact.

Spin-off projects with funding from other resources (e.g. TLEF, Skylight, Faculty/Graduate Student Teaching Certificate Program) in addition to CWSEI funding:

- **Course Curriculum Mapping in a Multi Section Course:** Angie O'Neill, Gülnur Birol and Carol Pollock have submitted a paper on the teaching and assessment of learning outcomes in a multi-section first year biology course.
- **Non-majors Biology Course Development:** Kathy Nomme and Gülnur Birol are conducting a study on student attitudes and beliefs towards biological sciences in a non-majors first year biology course using focus group interviews, midterm evaluations and attitudinal survey data.
- **Study Habits of Students in a 2nd year Biology Course:** Gülnur Birol, Lacey Samuels, Ellen Rosenberg and Joanne Nakonechny are conducting a study on students' study habits in BIOL 200 using both quantitative and qualitative data collected over a period of three years.
- **Questions for Biology:** Funded by Two Skylight grants, developing concept questions for first year Biology courses using material collected in BIOL 112 and BIOL 121. People involved are Jared Taylor, Gulnur Birol, Leah MacFadyen, George Spiegelman. Karen Smith, Tracy Kion, Carol Pollock, Angie O'Neill, Pam Kalas, Carol Pollock and Jennifer Klenz. Poster (CWSEI EOY 2012): Developing Concept Inventories for Biology and EOY 2011: The Operon Concept Inventory: Measuring Targeted Learning Gains in Microbiology
- **Understanding the impact of jargon within first- and second-year biology to improve student learning:** Skylight Development Grant, with matching funds from Biology Dept. People involved are Lisa McDonnell, Megan Barker, Marcia Graves (with additional support from James Cooke and Pam Kalas).

Other

- **BIOL 310: September - December 2008** Leticia Aviles and Harald Yurk conducted a study on the usefulness of group discussions in class through in-class observations and focus groups.
- **MICB 202: January – April 2008:** Yiannis Himaras did a MICB 448 project under the supervision of Tracy Kion and Gülnur Birol to conduct an exploratory project to investigate student learning in MICB 202.
- **BIOL 352: January – April 2013:** Mandy Banet collaborated with Santokh Singh to measure the impact of short oral presentations on student's comfort and ability to communicate about scientific research.
- **BIOL 340: Sept-Dec 2012**: Lisa McDonnell consulted with a 448 student to conduct a study about the effectiveness of a predict-and-reflect exercise on student learning in experimental cell biology.
- **Fall 2014 and Winter 2015:** Outreach within department, including a clicker choreography workshop, a case studies workshop, and beginning the LS-STLF blog online.

Mathematics Department

Starting in 2008, the UBC Mathematics Department is participating in the Carl Wieman Science Education Initiative (CWSEI) to improve undergraduate science education. In 2010 the Math-CWSEI program underwent a major expansion thanks to the generous donation by Prof. David Cheriton, UBC alumnus, now Professor of Computer Science at Stanford University.

An important first step in all the courses involved in the project is to create a set of learning goals. Learning goals make explicit what the students are expected to be able to do at each stage of the course. They are useful to instructors in preparing tests, and assessing the success of a course. In lower level courses, where the students and instructors may start out thinking about the material in radically different ways, learning goals help focus the instruction at the appropriate level. They provide a communication channel for successive instructors in a given course, so that effort in improving pedagogy is transmitted. Made available to students, they help students assess their understanding and prepare for exams. An important last step for all the projects in the Math CWSEI is the archiving of materials in the SEI Course Materials Archive. This archive contains material developed by departments participating in the CWSEI at UBC, and is intended to be an open resource for educators.

In 2008-2009 our projects were concentrated in two areas: (1) computing and computer labs in Math 152, Math 256 (Mech 221), Math 257/316, Math 253 (Mech 222), and Math 307. These courses had all recently introduced computing as an intrinsic part of the syllabus. The Math CWSEI helped in the creation of tutorials and lab materials, assisted in integrating the computational component into the course material and developing testing methods, and assessed the effectiveness of the computational component; (2) support for the Math 180/184 workshops and the Basic Skills Test. The introduction of problem-solving workshops in all sections of Math 180 and Math 184 in 2008 brought new challenges in the course management and coordination. The SEI helped to assess the effectiveness of the program in such large, multi-section courses, and contributed to the development of effective program management strategies. The SEI also contributed to the revision of the Basic Skills Test, providing support for a statistical analysis of the test and developing a computer-based version of the test. Poster (CWSEI EOY 2011): Basic Skills in Mathematics

In 2009-2010 our focus was mainly in-depth assessment of student activities and engagement, improvements to course materials based on data collected in the previous year, and better coordination of workshops and labs with course lectures. The Math CWSEI also provided support for the development of a new computing module in Math 318.

In 2010, the Math CWSEI expanded to incorporate new, longer term projects, mostly involving tracking and improving key skills throughout the curriculum. Projects are now underway to assess and track proof skills, basic algebra skills, and student attitudes and perceptions of mathematics. The Math CWSEI also continues to support the implementation of effective teaching methods and use of classroom technologies (clickers, online homework, etc.).

CWSEI Dept. Director: Costanza Piccolo (2010-present), Stephanie van Willigenburg (2009-10), Richard Froese (2008-09)
STLF: Alain Prat (Dec '15-), Sandra Merchant (emeritus, March '10-Feb '16), Kseniya Garaschuk (emeritus, Sep '14-July'16), Wes Maciejewski (emeritus, Sep '13-Dec '14), Joseph Lo (emeritus, Jun '10-Dec '13), Warren Code (emeritus, Jan '10-Dec '12), Katya Yurasovskaya (emeritus, July '11-Aug '12), Paul Ottaway (emeritus, Sept-Dec '09)
Faculty: Currently involved: E. Cytrynbaum, L. Keshet, Y-H Kim, M. MacLean, B. Marcus, G. Martin, C. Piccolo, A. Rechnitzer. Involved in past projects: R. Anstee, J. Bryan, A. Chau, M. Doebeli, R. Froese, J. Gordon, R. Gupta, S. Gustafson, B. Homsy, F-S, Leung, P. Loewen, A. Peirce, S. Ramdorai, Z. Reichstein, D. Schoetzau, G. Slade, S. van Willigenburg, M. Ward, B. Wetton, O. Yilmaz
TA's and Postdocs: Involved in the past: P. Bell, M. Berube, J. Gou, A. Herrera, R. Hiller, V. Kapoor, I. Karimfazli, D. Karslidis, C. Lee, R. Liang, A. Lindsay, T. Milnor, A. Nguyen, M. Raggi, L. Robson, S. Rose, R. Schwarz, A. Raghoonundun (with Skylight support), G. de Oliveira, W. Thompson, M. Willoughby, A. Zaman

Course Transformation

Course	Learning Goals	New Assessments	Improved methods
MATH 101: Integral Calculus with Applications to Physical Science and Engineering (Spring 2012) Faculty: Rajiv Gupta STLF: Costanza Piccolo, Alain Prat Poster (CWSEI EOY 2013): WeBWorK: An effective online tool for assessment in mathematics	No revision	In-class short diagnostic Test on basic differential calculus skills Weekly common homework assignments Study skills survey	Online homework using WeBWorK
MATH 102: Differential Calculus w/ applications to Life Sciences (2012-2015) Faculty: Eric Cytrynbaum, Leah Keshet STLF: Kseniya Garaschuk, Wes Maciejewski, Sandra Merchant, Costanza Piccolo Poster (UBC Science Ed Open House 2016): Feasibility and effectiveness of group exams in mathematics courses	Course-level and topic-level goals are complete	Online basics math skills diagnostic Pre-lecture assignments Weekly common homework Midterm & end-of-term survey Classroom observations Survey on spreadsheet labs and associated WeBWorK problems Surveys on group quizzes	Online homework using WeBWorK Spreadsheet labs converted to Excel and WeBWorK Pre-lecture videos, pencasts and assignments, and interactive teaching methods in class using clickers Group quizzes

MATH 104/184: Differential Calculus with applications to Social Sciences and Commerce (Jan '10 – Dec '14) Faculty: Mark MacLean ('10-'11), Sujatha Ramdorai ('12), C. Lee (postdoc) STLF: Warren Code ('10-'12), Wes Maciejewski ('14) TA: M. Raggi ('10), L. Robson ('11) Poster (CWSEI EOY 2013): MAPS: Math Attitude and Perceptions Survey (developed by STLFs Warren Code, Joseph Lo, Sandra Merchant) Poster (CWSEI EOY 2013): Teaching Methods Comparison in a Large Introductory Calculus Class Paper: Teaching Methods Comparison in a Large Calculus Class (Code et al., 2014)	Course-level goals: second draft complete Topic-level goals: second draft complete and incorporated into weekly "learning guides" for instructors with specific textbook examples for each goal.	*All sections*: - Attitude survey with short diagnostic test - Instructor interviews - Class observations *MacLean's sections*: - Midterm and end-of-term surveys - Clicker session data - In-class activity audio + written *Methods Comparison ('11):* - Math 104 Calculus Diagnostic to measure student calculus background from high school. - Topic quizzes for Related Rates and Linear Approximation. *Ramdorai's section ('12):* - Student work from in-class worksheets - Clicker and diagnostic data (as previous years)	*All sections*: - Developed weekly "learning guides" for instructors to enhance coordination; guides incorporate learning goals, practice problems and pedagogical approaches and issues. - Developed common online and paper homework assignments. - Facilitated weekly instructor meetings *MacLean's sections*: - Developed in-class activities and clicker questions. *Methods Comparison ('11):* - Structured class notes, lesson plans, clicker questions and pre-reading assignments for the Related Rates and Linear Approximation weeks, with evidence of better conceptual learning over more traditional instruction. *Ramdorai's section ('12):* - Worksheets for almost all current course topics, some clicker questions to support, used in final 20 minutes of each 80-minute class period. *Lee's sections ('14):* - Assignments and quizzes to promote learning multiple differentiation approaches and flexibility in applying them
MATH 180/184: Differential Calculus (Workshop component) (Sept '08 – Fall '11) Faculty: Rajiv Gupta, Albert Chau, Richard Anstee STLF: Costanza Piccolo ('08-'10), Warren Code ('11) TA: V. Kapoor, R. Schwarz, A. Zaman Poster (CWSEI EOY 2010): First Year Calculus Workshops	Course-level goals: complete Workshop goals: complete	Midterm and end-of-term surveys on workshop activities and student attitudes. Weekly quizzes Class observations	Workshops 1-12 complete: added workshop-level learning goals and list of required basic skills; created new problems with course-specific applications; created activities to promote metacognition, developed problem solving strategies. Program Structure and Management: Expanded the administrative structure and TA training; developed problem database (with Skylight support) to ease weekly production of workshop material.
MATH 110: Differential Calculus (2010-2015) Faculty: Fok-Shuen Leung, Costanza Piccolo STLF: Joseph Lo ('10-'12), Warren Code ('12-'13), K. Garaschuk ('14) Poster (CWSEI EOY 2012): Precalculus Skills Poster (CWSEI EOY 2012): What might affect student performance in a Math Course? Poster (UBC Science Ed Open House 2015): Using prompted self-explanations in first-year calculus	Course-level goals: complete Workshop goals: complete	Diagnostic Test on Basic Skills Attitude and study habit survey Midterm class and workshop surveys Class observations of workshops and lectures Focus groups and surveys on use of textbooks ('12 and '13) Survey of student perceptions of learning gains ('14) Student interviews after lectures to monitor difficulties and effectiveness of class activities ('14)	New workshop format developed to address low student engagement in workshop activities. Online homework assignments used in all sections. Archiving of course material for future use Weekly remedial work on basic skills. Use of existing free online text, with collection of supporting web materials ('12-'13) Clicker questions and self-explanation group worksheets ('14)
MATH 121: Honours Integral Calculus (Jan '15 start) Faculty: Young-Heon Kim STLF: Kseniya Garaschuk	No revision		Expanded and improved weekly homework on WeBWorK

MATH 152: Linear Systems (Computer Labs component) (Sept '08 – 2010) Faculty: Brian Wetton STLF: Warren Code ('09-'10), Costanza Piccolo ('08-'09) TA: A. Lindsay Poster (CWSEI EOY 2011): Redesign of Computer Labs for Engineering Students in a Linear Algebra Course	Course-level goals: complete Topic-level goals: complete	End-of-term lab surveys Pre/post-tests on Matlab syntax and basic programming structures. Pre/post-tests on translation of word problems into linear systems. Lab observations and TA interviews to determine student difficulties and completion rates.	Labs rewritten to tie in more closely with the course material, and revised after a full term of use. Paper-based homework, midterm exam and final exam questions developed to test/practice Matlab syntax and basic programming structures. Lecture notes revised to include Matlab material.
MATH 200: Calculus III (Sept '12 – Dec '13) Faculty: Julia Gordon STLF: Joseph Lo	No revision	Diagnostic test on first-year calculus materials Midterm and end-of-term surveys on online homework, in-class activities and supplementary materials	In-class activities were developed. 3D graphics were produced for use in class and interactive supplementary materials on UBC Blog
MATH 210: Introduction to Mathematical Computing (Sept '11 – Dec '13) Faculty: Dominik Schoetzau STLF: Joseph Lo	Topic-level goals: complete and revised	Diagnostic test on series and first year calculus Computer-based exams Student survey Class and lab observations	Course curriculum has been substantially changed. All standard course materials (course outline, lecture notes, assignments and exams) have been redeveloped. In-class computer-based activities developed.
MATH 215/255: Elementary Differential Equations I (Sept – Dec '13) Faculty: Stephen Gustafson STLF: Joseph Lo	No revision	Weekly common online homework assignments	Online homework using WeBWorK
MATH 220: Mathematical Proof (March '10 – Aug '14) Faculty: Andrew Rechnitzer STLF: Katya Yurasovskaya (July '11- Aug '12), Sandra Merchant ('10-'14) Poster (CWSEI EOY 2011): Assessing Basic Skills for Mathematical Proof Poster (CWSEI EOY 2012): Workshops and the First Course in Mathematical Proof Poster (CWSEI EOY 2013): Development and Analysis of a Basic Proof Skills Test	Course level and topic level goals are complete	Basic proof skills diagnostic pre/post test Midterm and end-of-term surveys Student interviews after lectures to monitor difficulties and effectiveness of class activities. Student problem-solving interviews to assess learning and retention of proof skills Short in-class individual and group quizzes	Small group problem-solving sessions ("workshops") were created and comprise approximately 25% of lecture time. Course syllabus and textbook have been standardized from term-to-term. Pre-lecture quizzes, daily group worksheets, and clicker questions
MATH 221: Matrix Algebra (Sept '12 – Dec '13, Sep '15 – Dec '15) Faculty: Zinovy Reichstein, Daniel Coombs STLF: Joseph Lo, Kseniya Garaschuk Poster (UBC Science Ed Open House 2016): Feasibility and effectiveness of group exams in mathematics courses	No revision	Weekly common online homework assignments and practice tests Midterm and end-of-term surveys on online homework Surveys on group exams	Online homework using WeBWorK Group exams

Math 230/335: Mathematics for Elementary Teachers (June '11 – April '12) Faculty: Stephanie van Willigenburg, John MacDonald STLF: Katya Yurasovskaya Poster (CWSEI EOY 2012): Math course for future elementary teachers at UBC	Course-level goals – complete Topic-level goals- complete Comments by instructor added as a teaching aid for future instructors.	Diagnostic pre/post test, which also includes survey-type questions on student career plans and attitudes/beliefs regarding mathematics.	A list of study tips for students specific to the course and the audience. A set of study skills and tips relevant to future teachers of elementary educations students. A website with resources and useful links has been put together for future departmental use.
Math 253 (Mech 222): Multivariable Calculus (Computer Labs component) (Sept '08 – April '12) Faculty: Philip Loewen STLF: Warren Code TA: M. Willoughby, W. Thompson Poster (CWSEI EOY 2011): How do novices spend time programming in MATLAB?	Goals incorporated into weekly learning guides and lab documents. Substantial detail added in the second year.	Weekly surveys of student completion rates and attitudes. Lab observations and TA interviews to determine most significant student difficulties. Automated student session logging to measure time spent on various tasks and frequency of common syntax errors (improved from trial run in Math 256). Pre-lab quiz late in the term to track basic skills and measure interpretation of MATLAB code.	Labs have been updated to tie in more closely with the course material, and have been further revised based on data from the first implementation with evidence of more collaboration, higher completion rates and more positive student attitudes due to the revisions. MATLAB resource web page developed for student reference, especially for those with weaker backgrounds.
Math 253: Multivariable calculus (Fall 2012) Faculty: Jim Bryan SLTF: Costanza Piccolo	No revision	Weekly common homework assignments	Online homework using WeBWorK
Math 256: Differential Equations (Jan '15 start) Faculty: Eric Cytrynbaum STLF: Sandra Merchant	No revision	Pre-lecture assignments Weekly surveys in WeBWorK for student feedback on pre-lecture resources	Pre-lecture videos, readings and associated assignments, coupled with clickers and active learning activities in lectures.
Math 256 (Mech 221): Differential Equations (Computer Labs component) (Sept '08 – 2010) Faculty: Brian Wetton STLF: Warren Code ('10-'12), Paul Ottaway (Sept-Dec '09), Costanza Piccolo ('08-'09) TA: W. Thompson Poster (CWSEI EOY 2011): How do novices spend time programming in MATLAB?	Learning goals: complete	Lab observations and TA interviews to determine most significant student difficulties. End of term student attitude surveys. Trial run of automated student session logging to measure time spent on various tasks and frequency of common syntax errors.	New labs have been developed and revised based on feedback from the first two offerings. Matlab demonstrations have been used in lectures. Targeted questions have been designed for the final exams and used to assess learning in the lab sessions. MATLAB resource web page developed for student reference, especially for those with weaker backgrounds.
Math 257/316: Partial Differential Equations (Computer Labs component) (Sept '08–Fall '11, Spring '15) Faculty: Anthony Peirce STLF: Costanza Piccolo, Kseniya Garaschuk TA: G. de Oliveira	Topic-level goals: complete	Student survey about attitudes towards the use of spreadsheets and the learning of numerical methods in the course. Diagnostic test on infinite series	Course-specific, online Excel tutorials are completed; sets of homework assignments, in-class demos using spreadsheets, and a PowerPoint presentation on numerical methods have been developed.
MATH 264: Vector Calculus for Electrical Engineering (Spring 2012) Faculty: Ozgur Yilmaz STLF: Costanza Piccolo	No revision	Classroom observation Midterm student survey	This is a new course; all materials were developed from scratch.

Math 305: Applied Complex Analysis (Sept '10 – April '12) Faculty: Michael Ward STLF: Joseph Lo TA: P. Bell	Topic-level goals: complete	Diagnostic assignment on series End-of-term survey Analysis of grades and comparison between students in Math 300 and 305 based on their enrollment programs	This is a newly-developed course. All standard course material (course outline, lecture notes, assignments, and exams) has been developed from scratch.
Math 307: Applied Linear Algebra (Computer Labs component) (2008 – 2011) Faculty: Richard Froese STLF: Costanza Piccolo TA: A. Raghoonundun	Course-level goals: revision is completed Topic-level goals: revision is completed	Student surveys Pre-reading/diagnostic quizzes Special homework assignments with extensive use of Matlab	Lecture Notes have been updated extensively. Matlab/Octave resource page developed. Basic Matlab/Octave tutorials have been developed, including a set of practice problems on basic syntax and programming.
MATH 318: Probability with Physical Applications (Computer-based component) (2010 – 2011) Faculty: Gordon Slade Postdoc: Richard Liang	Course-level goals: complete Topic-level goals: complete	Tracked scores on computer-based homework exercises and exam questions. Mid-semester and end-of-semester attitude surveys	Octave/Matlab-based questions drafted for each of the homework assignments and for each of the two midterms and the final exam. Octave resource webpage constructed (based on the Math 307 page) to assist the students in getting started with using Octave.
MATH 342: Algebra, Coding Theory and Cryptography (Jan '14 start) Faculty: Brian Marcus STLF: Sandra Merchant	No revision	Proof concept test (second draft) on specific proof skills	Proof skills review exercise (run as a 2-stage individual/group test) at start of course
MATH 358: Engineering Analysis (Jan '12 – Dec '12) Faculty: Bud Homsy STLF: Warren Code TA: I. Karimfazli	New course; topics only finalized during term.	Computer lab observations Pair of student surveys: after second and after final computer lab	Matlab activities for biweekly labs (5 total for the term) which build on paper-based assignments, all produced for this new course. Labs revised based on student feedback.
MATH 360: Mathematical Modeling in Science (Jan '10 – April '12) Faculty: Michael Doebeli STLF: Costanza Piccolo ('11-12), Sandra Merchant ('10-11)	Course-level goals: complete	Computer-based exams Midterm student survey Class observations Student focus group	Matlab-based in-class activities were developed for weekly labs.

Additional Undergraduate Program Activities

The Basic Skills Test: The Math CWSEI contributed to the revision of the Basic Skills Test, providing support for a statistical analysis of the test and developing a computer-based version of the test. Poster (April 2011): Basic Skills in Mathematics

Pre-Calculus Diagnostic: (2014-2016) Kseniya Garaschuk, working with Prof. Mark Maclean, developed a pre-calculus diagnostic assignment for all first-year students.

Guide for Instructor-in-charge: (2015-) Kseniya Garaschuk, working with Instructor Costanza Piccolo, developed a guide for the Instructor-in-charge of large courses with tips and recommendations on how to manage a multi-section course.

Research

Math Attitude and Perceptions Survey (MAPS): A survey developed by the UBC Mathematics STLFs to characterize students' attitudes and perceptions about learning mathematics. Paper: W. Code, S. Merchant, W. Maciejewski, M. Thomas, & J. Lo (2016), The Mathematics Attitudes and Perceptions Survey: an instrument to assess expert-like views and dispositions among undergraduate mathematics students. *International Journal of Mathematical Education in Science and Technology (IJMEST)*, http://dx.doi.org/10.1080/0020739X.2015.1133854, (preprint available here).

Two-Stage quizzes: Kseniya Garaschuk studied the implementation and outcomes of two-stage (individual + group) quizzes in two different math courses. Poster (UBC Science Ed Open House 2016): Feasibility and effectiveness of group exams in mathematics courses

Prompted self-explanations in first year calculus: Costanza Piccolo and Kseniya Garaschuk implemented prompted self-explanations in a first year calculus course and measured outcomes and student perceptions. Poster (UBC Science Ed Open House 2015): Using prompted self-explanations in first-year calculus

Teaching methods comparison in a large calculus class Warren Code, Costanza Piccolo, David Kohler, and Mark MacLean conducted a study to compare the learning in an active-learning class vs. a more traditionally taught class. Paper: Teaching methods comparison in a large calculus class, ZDM, Vol. 46(4), pp. 589–601 (2014), http://dx.doi.org/10.1007/s11858-014-0582-2, (preprint available here)

Basic Proof Skills Test and Proof Concept Test: Sandi Merchant developed a Basic Proof Skills Test for use at the second year level and a Proof Concept Test to assess proof skills appropriate for 3rd and 4th year math majors. Poster (2013): Development & Analysis of a Basic Proof Skills Test

Physics and Astronomy Department

Physics & Astronomy received seed funding in 2007 and began the efforts listed below in the Fall of that year. The department moved to full funding starting in 2008. A new phase began in 2014 – the Harris Project – an extension of CWSEI that runs from 2014 to 2017. In addition to continuing course transformations and faculty support, this phase includes deliberate effort toward effective transfer of pedagogies to new instructors using a co-teaching (paired teaching) model. This project is funded by John and Deb Harris, the UBC Faculty of Science, and the Physics & Astronomy Dept.

CWSEI Dept. Director: Doug Bonn, Georg Rieger (emeritus), Mona Berciu (emeritus)

STLFs: Linda Strubbe, Jared Stang, James Day, Emeritus: Jim Carolan, Louis Deslauriers, Ido Roll, Peter Newbury, Cynthia Heiner

Faculty: D. Bonn, J. Folk, B. Gladman, J. Iqbal, D. Jones, J. Ives, A. Kotlicki, K. Madison, J. Matthews, M. Pavan, H. Richer, I. Stairs, M. Van Raamsdonk, S. Reinsberg, G. Rieger, L. Van Waerbeke, C. Waltham, C. Wieman, J. Zibin, S. Burke, D. Witt, V. Sossi, J. Roettler, J. Charbonneau, S. Bates, J. Young, D. Bryman, I. Affleck, V. Hinkov

Students: J. Bale, D. Fujimoto, F. Moosvi

Involved in the past: E. Altiere, S. Berkman, N. Holmes, S. Martinuk, D. Mazur, B. Ramshaw, E. Schelew, M. Sitwell, J. Stang (now an STLF), S. Vafaei, C. Veenstra, T. Vernstrom, M. Warren, R. Wong

Course Transformation

Course	Learning Goals	New Assessments	Improved methods
ASTR 310: Exploring the Universe I: The Solar System (Summer '08 – 2012) Faculty: Brett Gladman, Harvey Richer STLF: Peter Newbury Grad Students: M. Milkeraitis, S. Lawler, M. Gendre, S. Vafaei Poster (CWSEI EOY 2011): Shifting to a Copernican Model of the Solar System by Shifting Away from a Copernican Model of Teaching	Course-level goals: complete Topic-level goals: complete	Improved midterm and final exam questions based on assessing learning goals	Created 6 activities for tutorials including guidelines for TAs for facilitating the activities. Using MasteringAstronomy for Just-in-time teaching (Gladman) Aligning lecture material with learning goals Peer instruction using clickers (Richer) Using Lecture-Tutorial workbooks (Richer)
ASTR 311: Exploring the Universe II: Stars and Galaxies (Summer '09 – 2012) Faculty: Ingrid Stairs, Jeremy Heyl, Ludovic Van Waerbeke, Jim Zibin STLF: Peter Newbury Grad Student: M. Gendre, T. Vernstrom Poster (CWSEI EOY 2010): Transforming Introductory Astronomy: from Learning Goals to Instruction and Assessment	Course-level goals: complete Topic-level goals: complete	Developed pre/post concept test for tutorial activities Improved final exam based on learning goals. Light and Spectroscopy Concept Inventory (LSCI) pre- and post-test (Stairs) Pre-, Post-testing with the Test of Astronomy Standards (TOAST)	Developed 7 50-minute activities for tutorial sessions including guidelines for TAs for facilitating the activities Intense focus on learner-centered instruction: peer-instruction with clickers, lecture-tutorial workbook, in-class worksheets (Stairs)
PHYS 100: Introductory Physics (Sept '07 – ongoing) Faculty: Georg Rieger, Andrzej Kotlicki, Stefan Reinsberg STLFs: Ido Roll, Jim Carolan Grad Student: F. Moosvi, M. Sitwell, S. Berkman Video: http://blogs.ubc.ca/wpvc/intro-physics-active-class/ Paper (Physics in Canada, 2014): A "flipped" approach to large-scale first-year labs Poster (CWSEI EOY 2013): Interactions between teaching assistants and students boost engagement in physics labs	Course-level goals: complete Topic-level goals: complete Lab goals revised towards skills development: complete	Conducted study on impact of learning goals on student self-assessment of understanding Lab diagnostic developed & interviews conducted Improved the lab skills assessment - given to students on the first and last weeks of the term Conducted study comparing different forms of invention activities and support for group work Used two-stage midterm exams Evaluated all labs using surveys and interviews Use of a frequent-testing approach	Clicker questions improved and more student engagement during lectures. Revised the labs – they now include a homework component; students do the actual experiments prior to coming to the lab for data analysis. The labs & homework build on each other so that each component is required for the subsequent task; they create a sequence in which students use new tools to analyze old data, or collect more data to improve conclusions from data collected earlier, etc. Added clicker questions to the lab – a couple of clicker questions at the beginning of class are used to recap previous labs. Several questions at the end of the lab are used to summarize the lab and frame the discussion about what was done during that specific lab. Description of the reformed lab and lab worksheets are now available at http://www.phas.ubc.ca/teaching-support

Poster (CWSEI EOY 2012): Transforming and Evaluating the Physics 100 Labs			Use of Learning Catalytics and bi-weekly quizzes (2014) Development of an online lab section with experiments at home and online support Developed a blended resource for use in face-to-face and online sections based on an edX platform. Integrated open-stax textbook and labs at home.
PHYS 101: Energy and Waves (2007–2015 for transformation; paired teaching ongoing) Faculty: Fran Bates, Georg Rieger, Cynthia Heiner, Javed Iqbal, Alex Mackay STLF: Jared Stang (2015-) Cynthia Heiner, Peter Newbury Poster (CWSEI EOY 2013): Productive Engagement with PhET Simulations	Course-level goals: compete Topic-level goals: complete	Conducted survey targeting students approach to and learning from pre-readings, clickers, and in-class worksheets Used 2-stage exams (summer) Conducted survey targeting attitudes towards 2-stage exams Joss Ives is currently developing a diagnostic test specifically for PHYS 101 content.	Developed new lab experiments on measurement/uncertainty and interference Complete set of in-class activities and worksheets developed Complete set of pre-reading assignments developed Use of PeerWise in spring and summer. A similar tool that expands the capability of PeerWise to different learning objects is currently under development for Blackboard/Connect, with the goal of supporting pre-class reading. Paired teaching in one section: pairing of a research scientist with a PER specialist Using two-stage exams consistently in midterms and finals from Fall 2014 onwards Learning object assessments deployed in W2 sections (2013 and 2014). Initially through Connect, now entirely within UBC Blogs (including assessment). Paired teaching (Spring 2016): pairing two STLFs (Stang & Strubbe)
PHYS 102 (now PHYS 118): Electricity, Light and Radiation (2009–2015) Faculty: Georg Rieger, Fran Bates, Vesna Sossi, Joerg Roettler, James Charbonneau STLF: Jared Stang (2015-) Peter Newbury, Louis Deslaurier	Course-level goals: complete Topic-level goals: complete	Creating pre-lab exercises using PhET simulations Used two-stage exams (summer) Used the BEMA diagnostic	Fully interactive environment Complete set of reading assignments, clicker questions, and worksheets Revising lab experiments Use of the Washington Tutorials Paired teaching in one section: pairing of a research scientist with a PER specialist
PHYS 107 & 109: Enriched Physics 1 lab and Intro to Experimental Physics (Sept '07 – ongoing) Faculty: Doug Bonn STLF: J. Day, I. Roll, L. Strubbe Grad Student: N. Holmes Poster (PERC 2013): Doing science or doing a lab? Engaging students with scientific reasoning during physics lab experiments Poster (CWSEI EOY 2011): On Guided Invention Activities that Support Scientific Reasoning and Domain Learning Posters (CWSEI EOY 2010): Preparing students for learning through invention activities and Using Invention Tasks to Help Students Become Better Scientists	Course-level goals: complete Topic-level goals: complete	Developed & validated physics lab pre-post diagnostic. Conducted study on the impact of invention activities completed preceding versus following a lesson. End-of-term survey Conducted studies on the impact of structure in invention activities on learning and on scientific reasoning skills Several additional surveys being used to measure student attitudes and motivation across the year including the E-CLASS (C-LASS for Experimental Physics) and Achievement Goal Questionnaire Conducting study on gender biases of mix-gender groups during experiments Conducting study on students' use of evaluation and reflection during experiments and their understanding of measurement and uncertainties	Developed 15 invention activities on data interpretation and analysis Developed marking rubrics for all labs and improved them to reward for quality of measurements and experimental and reflection procedures Introduced Learning Catalytics to support peer instruction during lab discussions and instruction Introduced scientific reasoning scaffolding in early experiments to encourage reflection and evaluation in order to improve the quality of measurements Introduced (weekly) reflection questions for students, to help them recognize their development as scientists and connect their in-class learning to other science courses and everyday life

PHYS 107: Enriched Physics I (Sept '10 – Fall '14) Faculty: Ian Affleck STLF: Jim Carolan	Course-level goals: complete Topic-level goals: under development	Pre and post concept surveys completed ('10 and '11) Lecture observations Student post course interviews completed for '10 and '11 Pre and post problem solving skills surveys completed '11. Used the Mechanics Baseline Test and the CLASS survey.	Clicker use – developed Online pre reading quizzes – developed In-class activities – worksheets developed
PHYS 117: Dynamics and Waves & **PHYS 118: Electricity, Light and Radiation** (Sept '14 – ongoing) Faculty: Joss Ives and Georg Rieger	Course-level goals and topic –level goals: complete	Used the FCI in English and Chinese Use of bi-weekly tests Use of two-stage tests and exams Conducted BEMA survey	Development of two sections for an international cohort of students ("Vantage College") Fully interactive environment (fully developed 'flipped' approach) Complete set of reading assignments, clicker questions, and worksheets Paired teaching in one section: pairing of a research scientist with a PER specialist
PHYS 119: Experimental Physics Lab (Jan '16 – ongoing) Faculty: D. Bonn, J. Ives, R. Kiefl STLF: L. Strubbe Poster (Science Education Open House 2016): Developing Student Attitudes in the First-Year Physics Lab at UBC AAPT/PERC presentations forthcoming (summer 2016)	New course (mostly) using first half of curriculum from PHYS 107 / PHYS 109	Conducted CDPA at beginning of course Conducted ECLASS at beginning and end of course	Revised first three labs to introduce confidence intervals and probability distributions more clearly As above in Phys 107, introduced (weekly) reflection questions for students, to help them recognize their development as scientists and connect their in-class learning to other science courses and everyday life
PHYS 157 & 158: Introductory Physics for Engineers I & II [formerly PHYS 153] (Sept '10 – ongoing) Faculty: Sarah Burke, Don Witt, Andrzej Kotlicki, Kristin Schleich, Michael Hasinoff STLF: Cynthia Heiner, Louis Deslauriers Poster (CWSEI EOY 2012): Transforming traditional large lectures into active learning environments	Course-level goals: complete Topic-level goals: complete	Compared student performance on exams in transformed course vs. earlier traditional version. Conducted BEMA survey Conducted student survey rating course elements	Bank of clicker questions In-class activities for entire term Peer instruction Learning goals were referred to throughout the course for aligning material and for creating exams Paired teaching in one section: pairing of a research scientist with a PER specialist Use of PhET simulations in conjunction with pre-reading assignments
PHYS 159: Introductory Physics Laboratory for Engineers [formerly part of PHYS 153] (Nov' 11 – ongoing) Faculty: Doug Bonn, Jeff Young, Michael Hasinoff, Bill McCutcheon, Don Witt, Evert Koster STLF: James Day	Course-level learning goals: complete	Two final lab exams created, closely aligned with course-level learning goals. Peer assessment between TAs, to promote and support deliberate practice	Three "tutorial weeks" modified (based on last year's TA and student feedback) to provide students with basic skills needed for the rest of course (i.e. use of basic stats, uncertainty analysis, and experimental design) Rubrics created for individual labs. Brief pre-lab readings created. 2-day TA & instructor training sessions added
PHYS 200: Relativity and Quanta (Sept '08 – 2015) Faculty: Mark Van Raamsdonk, Joanna Karczmarek STLF: Louis Deslauriers	Course-level goals: complete Topic-level goals: complete	Lecture & HW session observations Analyzed Mid-term Midterm & end-of-term survey	Weekly interactive tutorials developed Improved clicker questions Use of pencasts (J. Karczmarek)

PHYS 250: Introduction to Modern Physics (2009 – 2015) Faculty: Carl Wieman, Louis Deslauriers STLF: Louis Deslauriers	Course-level goals: complete Topic-level goals: complete	Development of an extended Quantum Mechanical Conceptual Survey Lecture & HW session observations Two-stage exams Analyzed Mid-term Midterm & end-of-term surveys Measured long term retention of quantum concepts	Weekly tutorials developed Bank of clicker questions In-class activities for entire term Measurement of long term retention for the quantum part of course Demonstrated a successful intervention with lower performing students
PHYS 301: Electricity and Magnetism (2009, 2014) Faculty: Doug Bryman		Administered the CUE (Colorado Upper Division Electrostatics Assessment, 2009 & 2014)	Clicker questions incorporated into lecture (2014)
PHYS 304: Introduction to Quantum Mechanics (2010–2014) Faculty: Kirk Madison, Ariel Zhitnitsky STLF: Louis Deslauriers	Course and topic-level goals: 80% complete	Lecture & HW session observations Measured effect of BONUS clicker questions on student engagement during voting period. Compared student performance to previous terms – transformed course scores are consistently higher Measured student engagement in general. Compared it to other course the eng phys cohorts were taking at the same time.	Creating a bank of clicker questions Designing in- class activities for every lecture Improved engagement during clicker questions by adding BONUS questions Clicker questions and weekly quizzes (2014)
PHYS 315: Physics of Materials (Sept '11 – 2014) Faculty: Vladimir Hinkov STLF: James Day Poster (CWSEI EOY 2012): The transformation of Physics 315	Course-level goals: complete Topic-level goals: complete	Homework assignments closely aligned to learning goals	New clicker questions drafted & older clicker questions improved Training on delivery of clicker questions and subsequent results In-class group activities Implementation of pre-reading lecture video recorded to help instructor associate feedback on style with actual footage Formative midterm and year-end feedback form created
PHYS 333: Energy and Climate (online) (2014 – ongoing) Faculty: James Charbonneau	Detailed set of learning goals created	Piloted the "Adaptive comparative judgment" online peer review system (students compare assignments based on a supplied rubric) Created rubrics for all assessments	Problem sets linked to learning objectives Targeted quiz questions in online materials Authentic take-home experiments with PowerPoint-based lab reports
PHYS 401: Electromagnetic Theory (Sept '11 – 2012) Faculty: Doug Bryman STLF: Peter Newbury	Course-level goals: draft Topic-level goals: complete set		Creating in-class worksheets and clicker questions aligned with learning goals Focus on moving from instructor-centred to student-centred instruction Development of pre-reading assignments
PHYS 403: Statistical Mechanics (2014) Faculty: Mayra Tovar			Use of clicker questions (coloured cards) and worksheet activities (2014)
PHYS 408: Optics (Sept '09 – 2013) Faculty: David Jones STLF: Louis Deslauriers Course successfully transferred to Kirk Madison	Course-level goals: complete Topic-level goals: complete	Developed Optics Conceptual Survey Lecture & HW session observations Analyzed Mid-term Transformed course scores are consistently higher than previous terms Measured student engagement and compared it to other course the students were taking at the same time	Created a bank of clicker questions In-class activities for entire term Developed a remedial tutorial for students lacking pre-requisite in signal processing (Fourier Transforms) Development of active learning materials for two new topics: Quantum optics and non-linear optics

PHYS 450: Quantum Mechanics (Jan '09 – 2013) Faculty: Joshua Folk STLF: Louis Deslauriers	Course and topic -level learning goals: 95% complete	Lecture & HW session observations Analyzed Mid-term Conducted study on impact of student peer discussions vs. classic instruction on students' knowledge retention	Created a bank of clicker questions (including isomorphic questions to test longer-term retention)

PHYS 170 & 270 – Mechanics diagnostic surveys are being administered annually to monitor conceptual learning gains and aid future course development. Clicker usage is being encouraged in the large multi-section engineering course, PHYS 170, with lecture observation and advice from STLF Jim Carolan. Paired teaching in one section of PHYS 170.

PHYS 101 & 108 - clicker usage was developed & improved in these large freshman courses with extensive observation and advice from Jim Carolan

Curriculum

Extensive diagnostic testing by Jim Carolan and Louis Deslauriers uncovered information that will inform curriculum decisions. Extensive testing of first and upper year students using an electricity and magnetism concept survey (BEMA) is providing information on learning gains and retention. The results from the survey are being used in decisions about merging the Eng. Phys and Honours Phys. streams of E&M. These results also feed into decisions about the freshman treatment of E&M concepts. There are also efforts to optimize the way E&M topics are covered in various courses, at all levels, to formulate a set of coherent learning goals for these courses and to ensure that faculty will strive to achieve these learning goals in the future. Poster (CWSEI EOY 2011): Tracking Students' Knowledge of Electricity and Magnetism from 1st to 3rd Year

The large first-year physics courses (PHYS 101 & PHYS 102) include 6 3-hour lab experiments. Because it is so difficult to sync the concepts presented in multiple lecture sections with the experiments, we are trying to convert the lab experiments to self-contained "learning units." These would include pre-lab exercises and lab activities that contain all the necessary information. Wherever they are in the sequence of lectures, instructors could use these experiments to preview what's coming next, to reinforce what they're currently covering, or to wrap up already-covered topics. The development and testing of several activities and pre-lab exercises started in the Summer 2010 PHYS 102 section.

TA Development

[2015-2016] Linda Strubbe, Dhaneesh Kumar, Derek Fujimoto and Doug Bonn have been developing a TA training program for TAs who are teaching in the first-year physics labs (PHYS 107, 109, 119). We hold a weekly meeting for TAs with the instructor or head TA to discuss pedagogy, practice and discuss facilitating (e.g., invention activities), discuss likely student issues and how to address, and give TAs practice with the experiment. This is being evaluated using a TA confidence survey and weekly reflection surveys, along with observations (protocol being developed by Damien Quentin).

A coordinating team of graduate students in the department developed and regularly run a very successful, one-day interactive workshop, which started in the beginning of the 2007 fall term by former graduate students Mya Warren, Joss Ives, and Sandy Martinuk. The workshop is required for incoming graduate students and available to veterans as well. A system of mentor TAs provides a structure in which senior graduate TAs oversee other graduate students in the first year undergraduate courses and help to develop their teaching skills through a peer-mentorship framework. 'Head TAs' are also deployed in each of the large multi-section courses to develop and deliver course-specific training as follow-up throughout the term.

This program is enhanced by a graduate course in pedagogy in Physics & Astronomy: PHYS 520, Teaching Techniques in Physics and Astronomy. This course exposes students to current Physics education research literature and allows them to apply the research to their own teaching by developing sample clicker questions or invention activities. In addition, many students complement this course with a directed studies project that allows them to get involved in physics education research in the department.

Many excellent resources from the training program can be found at http://www.phas.ubc.ca/~phas_ta/, including a TA Handbook developed by current and past TA training coordinators. Poster (CWSEI EOY 2015): Physics & Astronomy TA Professional Development Program, Paper (The Physics Teacher, 2013): Teaching Assistant Professional Development by and for TAs

Research

Jared Stang and Linda Strubbe are conducting a study investigating the effectiveness of paired teaching as a method of faculty development in teaching. Poster (UBC 2015 Science Ed Open House): Two models of paired teaching in first year physics lectures, and Poster (UBC 2016 Science Ed Open House): Paired teaching for faculty professional development. A paper with preliminary results has been accepted to the Proceedings of the Western Conference on Science Education. Collection of conference presentations for this project.

Joss Ives is studying two-stage exams with two major projects. With Simmer Mand, he is modelling student success on related clicker questions a few days after the two-stage exam (undergraduate honours thesis). With Nutifafa Kwaku Sumah, he is analyzing video of students partaking in the group stage of the exam to understand how students participate (undergraduate honours thesis). Analysis is ongoing with Jared Stang, Nutifafa Kwaku Sumah, and Matias de Jong van Lier. UBC 2016 Science Ed Open House posters

Jared Stang, Megan Barker, Sarah Perez, Joss Ives, and Ido Roll are conducting a study in PHYS 157 on using PhET sims (online interactive physics simulations) to enhance pre-reading assignments. UBC 2016 Science Ed Open House poster

Linda Strubbe is conducting a study (with Doug Bonn and Joss Ives) in PHYS 119 on student attitudes about experimental science during the first-year physics lab. She has developed pre-lab questions where students reflect on their learning and development as a scientist, and is analyzing results from pre- and post-semester ECLASS surveys. UBC 2016 Science Ed Open House poster

Linda Strubbe is working with Anabele Pardi (graduate student at the Max Planck Institute for Astrophysics in Germany) to study student attitudes during a summer school on astronomy held in Nigeria in July 2015.

Natasha Holmes and Doug Bonn have conducted groundbreaking research focused on improving students' scientific reasoning and critical thinking in an introductory physics laboratory course. They developed a simple learning framework that employs cycles of decisions about making and acting on quantitative comparisons between datasets or data and models. This led to significant and sustained improvement in students' critical thinking behaviors. The work has been published in the Proceedings of the National Academy: N. Holmes, C. Wieman, and D. Bonn (2015) Teaching critical thinking, *Proceedings of the National Academy of Sciences*, 112(36), pp. 11199–11204. Also see Doug Bonn's talk slides from the UBC 2016 Science Ed Open House: Making Comparisons: A Strategy for Teaching Scientific Reasoning.

We graduated our second PhD student in physics education research. Natasha Holmes' thesis work about the intervention in the Phys 107/109 labs can be found online at: http://circle.ubc.ca/handle/2429/51363

Natasha Holmes, Ido Roll, and Doug Bonn have published a paper on issues of gender during experiments. Holmes, N.G., Roll, I., & Bonn, D.A. (2014) Participating in the physics lab: does gender matter? *Physics in Canada,* 70(2). James Day, Jared Stang, Natasha Holmes, Dhaneesh Kumar, and Doug Bonn have a follow-up paper on the gender gap on the CDPA and behavior differences in the lab that could contribute to such a gap which is accepted the Physical Review Physics Education Research.

Jared Stang and Ido Roll published a paper on TA interactions and student engagement in the first-year physics lab: Interactions between teaching assistants and students boost engagement in physics labs, Phys. Rev. ST Phys. Educ. Res. **10**, 020117 (2014).

Natasha Holmes, James Day, Idol Roll & Doug Bonn, with further assistance from students Hiroko Nakahara, and Brad Ramshaw, have been studying the effectiveness of invention activities to improve students' data interpretation and analysis skills and understanding. This has included classroom observation, pre/post testing with a lab diagnostic (Day & Bonn, Physical Review ST-PER 2011, Development of the Concise Data Processing Assessment), and data-mining of student work on an online system used to deliver invention activities. The latter is being used to understand how invention activities can help students develop high level scientific reasoning skills. Several papers on invention activities have been published about productive failure activities (Day, Holmes, Roll, & Bonn, 2013 PER Conference Proceedings; Holmes, Day, Park, Bonn, & Roll, Instructional Science 2013; Roll, Holmes, Day, & Bonn, Instructional Science 2012). Poster (CWSEI EOY 2012): The Invention Support Environment: Where Do We Go From Here?

Cynthia Heiner, Georg Rieger, and Carl Wieman have published two papers on two-stage exams: *Physics Exams that Promote Collaborative Learning*, The Physics Teacher (2014) and *Examinations That Support Collaborative Learning: The Students' Perspective,* J. College Science Teaching (2014).

Georg Rieger, Michael Sitwell, Jim Carolan, and Ido Roll have published a paper on the reformed Phys 100 labs. G.W. Rieger et al., A "flipped" approach to large-scale first-year labs, Physics in Canada, 70(2), (2014).

Cynthia Heiner and Mandy Banet (Biology) have published a paper on pre-reading assignments. American J. Physics 2014: *Preparing students for class: How to get 80% of students reading the textbook before class*

Peter Newbury has completed pre- and post-testing of ASTR 310 and ASTR 311 tutorial exercises, such as the Human Orrery (The Physics Teacher, **48**, 9, 573-577 (2010)). The results were presented at AAS 216, May 23-27, 2010 in Miami, FLA. In Stair's ASTR 311 (Fall 2010) students wrote the Light and Spectroscopy Concept Inventory pre- and post-test. The results are used to compare the impact of interactive, learner-centered instruction to similar introductory astronomy courses across the U.S.

Louis Deslauriers, Georg Rieger, and Bing Dai studied the impact of pre-reading on the sophistication of student questions during lectures. The study took place in Physics 101, 102 and 250. Results consistently show that pre-reading along with proper incentive leads to an increase in the sophistication of student questions.

Louis Deslauriers, Joshua Folk, and Georg Rieger studied the impact of learning goals on student self-assessment of their understanding in Physics 100 and Physics 101; Louis Deslauriers and Joshua Folk conducted a study in PHYS 450 aimed at comparing the effect of peer discussions and classic instruction on students' knowledge retention.

Other

Widespread deployment of conceptual inventories to assess student understanding of mechanics and electricity & magnetism concepts. These include an extensive vertical survey from first to fourth year using the new lab diagnostic, a similar vertical survey using the BEMA diagnostic, and use of the FCI in freshman classes and sophomore mechanics.

Widespread deployment of CLASS student attitudes about science surveys in all first year courses, with testing done in Sept., at the end of the first term, and again at the end of the second term.

Jim Carolan looked at 2008-2014 survey data with a special focus on gender differences. He also looked at FCI, MBT, CLASS, and BEMA results in several courses as a function of time.

Louis Deslauriers has developed a math diagnostic to assess upper-level physics students' grasp of the math skills needed to succeed in the senior courses. This tool will be used to make judgments about curriculum and will feed discussions with the math department about their curriculum. This complements the math department's own efforts on entrance-level testing of math skills. A math diagnostic for first-year math has also been automated. The two diagnostics are available online at:
First Year Diagnostic: http://cwsei-diagnostics.sites.olt.ubc.ca/first-year-math-diagnostic/
Upper Year Diagnostic: http://cwsei-diagnostics.sites.olt.ubc.ca/upper-level-math-diagnostic-exam/

2010-2012, we published a newsletter focusing on various teaching activities taking place in conjunction with the CWSEI STLFs. Instructors involved in a transformation, or TAs involved with or students taking such transformed courses express their views about what works and what doesn't, and how things can be further improved. These 1-to-2 page newsletters were distributed to the entire faculty in order to keep them informed about these various efforts and give them a contact person to talk to if they become interested in any particular aspect.

A very fruitful exchange of ideas and information has taken place with professor Marjan Zadnik from Perth, Australia, who has visited our department for 6 weeks during his sabbatical leave. We hope this will lead to strong ties for research and exchanges with his university in the future.

Peter Newbury and Cynthia Heiner have developed and successfully ran workshops on peer instruction and creating clicker questions; Cynthia Heiner developed a workshop on pre-reading assignments.

Tony Signal from Massey University, New Zealand, visited our department in 2012 for the entire fall term. Tony contributed to the improvements of labs in Phys 100 and is very interested in transforming the introductory quantum mechanics at Massey. He had long and fruitful discussions with Jim Carolan, Louis Deslauriers, Georg Rieger, and Ido Roll.

We introduced a monthly physics education seminar series that has included both formal research and more informal implementation presentations by instructors, graduate students, and visiting researchers.

Statistics Department

The Statistics CWSEI program started in 2007 and initially concentrated on the transformation of STAT 200, Elementary Statistics for Applications, an introductory course presently taken by around one thousand undergraduate students per year. In recent years our focus has expanded to enhance the teaching and assessment on STAT 241/251, Elementary Statistics (a calculus-based introduction for Applied Science and Computer Science students), STAT 300, Intermediate Statistics for Applications (a second course accessible to any student with a generic first course in Statistics), STAT 302, Introduction to Probability, STAT 305, Introduction to Statistical Inference, and STAT 443, Time Series and Forecasting. Our aim is to enhance the teaching and learning experience within our undergraduate courses through methods of proven effectiveness. There are eight faculty members and one STLF recently involved in the Statistics department's CWSEI project.

Poster (CWSEI EOY 2014): Recent Developments in the Transformation of Statistics Courses With Highlights on Study Skills Workshops and Lab TA Surveys

Poster (CWSEI EOY 2013): An Overview of Transformations of Statistics Courses via CWSEI, with highlights on interactive engagement in STAT 300, STAT 302 and STAT 305

CWSEI Dept. Director: Bruce Dunham
STLF: Gaitri Yapa
Faculty: A. Bouchard-Cote, B. Dunham, P. Gustafson, Y. Lim, N. Nolde, J. Petkau, W. Welch, L. Wu, E. Yu

Course Transformation

Course	Learning Goals	New Assessments	Improved methods
STAT 200: Elementary Statistics for Applications (2007 start) Faculty: Eugenia Yu, Yew-Wei Lim STLF: Gaitri Yapa	Course-level goals: complete Topic-level goals: complete	Compared the effectiveness of two different lab activities in helping students understand sampling distributions. Comparison of student performances on exam and midterm questions following targeted interventions. On-line mid-course survey, for small amount of credit, elicits sizeable response and useful data. Survey given during study skills workshop to gather data on student study habits. Following up on student test performances to evaluate the effectiveness of the study skills session.	Developed and trialed worksheets/in-class activities for use in each class. Clicker questions used in every class. Lab activities improved to focus on key concepts that learners typically find difficult. Students work together in pre-assigned groups within each lab. Pre-reading quizzes trialed to begin each lab session. TAs completed a feedback survey on their opinions about each lab session. Weekly on-line assignments in WeBWorK, eleven in total. Two-stage midterm and final examination trialed, in which students collaborated in their lab groups for part of the tests. Adopted more efficient method for grading written assignments to reduce turnaround time. Study skills sessions offered to help students study for the course more effectively and make links between the assessment tools and the learning goals.
STAT 203: Statistical Methods (2015-2016) Faculty: Bruce Dunham	Course-level goals: complete Topic-level goals: complete		All lecture and lab sessions use in-class activities on which students work in preselected groups. Class activities are supported by clicker questions. On-line homework assignments in WeBWorK, with eleven sets of questions created. Two-stage midterm test and final exam adopted, in which students collaborate in their lab groups for part of each test.

STAT 241/251: Elementary Statistics (Sept '11 start) Faculty: Yew-Wei Lim STLF: Gaitri Yapa Poster (CWSEI EOY 2012): Recent Developments in the Transformation of Statistics Courses with Highlights on Revisions to STAT 241/251 Labs	Course-level goals: complete Topic-level goals: complete	Intervention used to address misconception identified on midterm exam question. On-line mid-course survey, for small amount of credit, elicits sizeable response & useful data, including data on study habits. Post-course interviews, also used to validate a new concept inventory, explore student retention. Following up on student test performances to evaluate the effectiveness of the study skills session.	Context rich problems included in assignments, midterm tests and examination. On-line homework assignments in WeBWorK, ten sets of questions in total. New material incorporated to expand the number of labs. Students work together in pre-assigned groups within each lab. TAs completed a feedback survey on their opinions about each lab session. Study skills sessions offered to help students study for the course more effectively and make links between the assessment tools and the learning goals.
STAT 300: Intermediate Statistics for Applications (Sept '12 start) Faculty: Bruce Dunham, Paul Gustafson, Lang Wu STLF: Gaitri Yapa	Course-level goals: complete Topic-level goals: complete	On-line mid-course survey, for small amount of credit, elicits sizeable response and useful data. Planning to investigate how students taking this course perform on STAT 305 and STAT 306 compared to peers who did not take STAT 300. Comparison of performances on a final examination question suggests learning gain due to WeBWorK homework.	All lecture and lab sessions use in-class activities on which students work in preselected groups. Class activities are supported by clickers questions. Detailed course notes created, available via course website. New labs in Earth Science Building provide better environment for group-based activities. TAs completed an on-line feedback survey on their opinions about each lab session. Two-stage midterm test and final exam trialed, in which students collaborated in their lab groups for part of each test. On-line homework assignments in WeBWorK, with ten sets of questions created. Twenty-four short "pencast" mini-lectures made available on-line. Course successfully transferred to another instructor from the original instructor via a co-teaching project.
STAT 302: Introduction to Probability (Sept '11 start) Faculty: Alexandre Bouchard-Cote, Eugenia Yu STLF: Gaitri Yapa	Course-level goals: complete Topic-level goals: complete	Post-course knowledge retention interviews conducted, with eight student participants so far. On-line mid-course survey, for small amount of credit, elicits sizeable response & useful data. Effectiveness of an intervention – teaching on topic via in-class activity compared to traditional lecture – compared via student performance on final examination question over two terms.	Clicker questions developed and used for each lecture. Created and trialed ten in-class activities to target concepts where student misconceptions have been observed. Students work on activities in pre-selected groups each class. Weekly WeBWorK on-line homework assignments created, twelve sets in total.
STAT 305: Introduction to Statistical Inference (Sept '12 start) Faculty: John Petkau, William Welch STLF: Gaitri Yapa	Course-level goals: complete Topic-level goals: complete	Post-course knowledge retention interviews on-going. On-line mid-course survey, for small amount of credit, elicits sizeable response and useful data.	All lecture and lab sessions use in-class activities on which students work in preselected groups. Class activities are supported by clicker questions. New labs in Earth Science Building provide better environment for group-based activities. On-line homework assignments in WeBWorK, with nine sets of questions developed. TAs completed an on-line feedback survey on their opinions about each lab session.

STAT 443: Time Series and Forecasting (Sept '09 start) Faculty: Bruce Dunham, Natalia Nolde STLF: Gaitri Yapa	Course-level goals: complete Topic-level goals: complete STAT 443 Learning Outcomes (learning goals)	On-line mid-course survey planned, for small amount of credit.	All lecture and lab sessions use in-class activities on which students work in preselected groups. Class activities are supported by clicker questions. Regular lab sessions recently introduced. TAs complete an on-line feedback survey on their opinions about each lab session. On-line homework assignments in WeBWorK, with six sets of questions developed. Two-stage midterm test and final exam adopted, in which students collaborate in their lab groups for part of each test.

STAT 100 – Statistical Thinking: A rather novel introductory course in the discipline, STAT 100 involves six "modules", each on a different theme in statistical science accessible to learners who have not had previous exposure to the discipline. The course was offered for the second time in 2009, and after the first run it was decided by the teaching team (of five instructors) that clickers would be used in future to help improve student engagement. This idea was implemented, and in-house training and support was offered by Eugenia Yu. Nearly all of the faculty in the department have used clickers in their teaching.

STAT 335 – Statistics in Quality Assurance: This course was revived in 2008, having not been offered for some years. The new incarnation of the course was enhanced using CWSEI methodology. In particular:

(a) Learning outcomes were devised.

(b) Detailed books of notes covering the material were created and posted online.

(c) In-class activities were used in the lectures, during which the students would work in groups on an activity, aided by the support of the instructor.

(d) Laboratory activities involving group work were used to illustrate concepts using computer applications.

Assessment Tools

Student Attitude Surveys: We have developed a Learning Attitudes Survey for Statistics. Near the start and end of STAT 200, students are expected to complete this on-line attitude survey. The survey attempts to gauge how students perceive the relevance of the discipline, their enthusiasm for studying it and how they go about learning in Statistics. A robust method of analyzing the resulting data has been devised and encoded in R (a freely available package for statistical computing), and a user guide has been created. Anyone wishing to implement our method on their own data should contact Dr. Bruce Dunham at b.dunham@stat.ubc.ca. A description of the method, and our findings from the analysis of our data, are being written up for future publication.

Concept Inventory for STAT 241/251: Work is on-going with the validation of a proposed concept inventory for STAT 241/251. This course is a calculus-based introduction to probability and statistics, and although such courses are widely offered there is no other existing concept inventory. Any instructor wishing to trial this concept inventory should contact Dr. Bruce Dunham at b.dunham@stat.ubc.ca.

WeBWorK Online Homework Tool: We are developing and implementing online homework problems for the large enrolment courses. The on-line homework application WeBWorK has been enhanced to integrate the statistical software R, and questions are being devised that make use of R's capacity to generate data, perform analyses, and create graphics. Presently WeBWorK homeworks are being used in STAT 200, 203, 241/251, 300, 302, 305, 404, and 443.

Assessing the Difficulty Level of Examinations: When a course is transformed, it appears inevitable that changes are reflected in assessment tools. Typically, for example, examination questions become more concept-oriented following a transformation of the methods of teaching and learning. This can make it difficult to evaluate the effectiveness of the changes in pedagogy. One promising approach to this issue involves attempting to calibrate the difficulty of an examination by equating the questions on the test to levels of Bloom's taxonomy. In this way an examination may be scored for difficulty, and compared with other examinations on the same course. Since student performances on assessments are readily accessible, we are developing a way of "Blooming" our examinations to help investigate how students perform in relation to objective measures of the difficulty level of the examinations. It is hoped this may be used to validate the effectiveness of course transformations in Statistics.