## Chemistry Department

The Chemistry CWSEI program started in 2008 and has hired a Science Teaching and Learning Fellow, Jennifer Duis. The Chemistry CWSEI program is presently concentrating on evaluation and redesign of the CHEM 123 lab – Physical and Organic Chemistry. The First Year Assessment sub-committee of the Chemistry Lab Committee is overseeing this project. The sub-committee members are: Laurel Schafer (chair), Guillaume Bussiere, Brian Cliff, Sophia Nussbaum, John Sherman, Jackie Stewart, Robin Stoodley, and Mark Thachuk. In conjunction with these efforts, undergraduate laboratory revitalization for years 2 - 4 is ongoing in the department.

Skylight Affiliate Jackie Stewart has been involved with the CWSEI since the start of the overall initiative in 2007 and has been doing substantial redesign of CHEM 233 Organic Chemistry for the Biological Sciences and working with the teaching teams in CHEM 121 and 202 to improve learning in those courses (independently funded by the department and TLEF).

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

**SEI Director:** Laurel Schafer
**STLF:** Jennifer Duis
**Faculty:** B. Cliff, G. Dake, N. Dryden, S. Nussbaum, L. Schafer, J. Sherman, R. Stoodley, and M. Thachuck
**Skylight Affiliate:** Jackie Stewart
**Visiting Scholar:** Pam Wolff
**Consultant:** Dave Pushkin
**Students:** Aalia Sachedina, James Zhou, Y. C. (Ainge) Chang

### Course Transformation

| Course | Learning Goals | Assessments | Improved methods |
|---|---|---|---|
| **CHEM 121: Structural Chemistry, with Application to Chemistry of the Elements (Lab component)**(Oct '08 start)<br>Faculty: S. Nussbaum<br>STLF: Jennifer Duis | Course-level goals: Outline from CHEM 123, focus on transferable skill acquisition<br><br>Experiment-level goals: process for development established<br><br>Course-level outline and experiment-level development process appropriate for the entire lab program | Attitudes survey (C-LASS CHEM) given 2 Terms<br><br>Development and implementation of end-of-term technique assessments<br>o Year 1: TA visual assessment of technique with provided guide<br>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<br>o Marks re-allocated to increase emphasis on maintaining a lab notebook<br>o Directions on maintaining a lab notebook to be expanded in lab manual<br>o Brief "taking observations" module to be developed and added during check-in<br>o Technique modules will be expanded to include choosing glassware for analytical vs. non-analytical purposes<br>o A new experiment is being piloted |
| **CHEM 123: Physical and Organic Chemistry (Lab component)** (July '08 start)<br>Faculty: S. Nussbaum, L. Schafer<br>STLF: Jennifer Duis<br>Skylight: Jackie Stewart | Course-level goals: working version, inspired by Rice University's interdisciplinary science lab learning objectives, approved by Chemistry Lab Committee<br><br>Experiment-level goals: (developed from existing course materials) 4 of 4 experiments complete and approved by Chemistry Lab Committee<br>o Further refinement of LGs underway | Chemistry background and demographics survey developed and given 2 Terms<br><br>Attitudes survey (C-LASS CHEM) given 2 Terms<br><br>Pre-/Post-Lab skills survey (written) developed & given 4 Terms<br>o "LG use" questions added<br><br>Refined hands-on lab skills assessment implemented 2 terms<br><br>Assessments of experiment specific learning goal achievement (surveys, observations, interviews)<br>o 2nd round of refinement, conversion to m.c./T-F, validation, and implementation completed | Learning Goals incorporated into lab manual (under refinement)<br><br>Alterations made to increase alignment with learning goals<br>o Marks re-allocated to increase emphasis on maintaining a lab notebook<br>o Directions on maintaining a lab notebook to be expanded in lab manual<br>o Expanded quizzes will be introduced to test technical skills<br>o Addition of manual dilutions to electrochemistry experiment to increase technical experience and conceptual understanding of the effect of dilution on voltage<br>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 113, 121, 415, 425, 449:** Attitudes survey (C-LASS CHEM) administered Spring '09 (CHEM 113 & 121 also participated in the written Lab Skills Survey).
- **CHEM 425/448:** Engaging students in cutting edge chemical education research, report writing, and presentations.

## Curriculum

- As CHEM 121/123 is in many ways a service course, identify interdisciplinary science lab skills that other science streams consider to be important and/or are expecting students to get from 1st year chemistry to improve "service".
- Survey Co-op employers to aid in determining impact on upper level laboratory revitalization.
- Modification of course curriculum for CHEM 415/425 approved by Chemistry Department to expand research opportunities to chemistry majors.

## TA Development

The second round of modified TA training was implemented by Anka Lekhi and Sophia Nussbaum, with support from the TA Training Program through the Provost and Vice-President Academic Office and the Chemistry Department.

## Research

**Attitudinal Survey:** C-LASS CHEM given in multiple courses, statistical comparisons between UBC and CU-Boulder.
**CHEM 123 Lab Learning Goals:** Assess students' achievement of lab learning goals.
**1st Year Practical Lab Skills:** Compare students' achievement of practical lab skills as determined by written vs. hands-on assessment
**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.
**Chemistry Concept Diagnostic Tests:** Propose administration and validation of an existing chemistry concept test to first year chemistry students.

## Other

Presentations at national/international meetings: 237th American Chemical Society National Meeting, 92nd & 93rd Canadian Chemistry Conference, Improving University Teaching 34th International Meeting.

## 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. We currently have one full-time STLF. Another STLF has been hired and will be joining us in the Fall. We plan to hire at least one more STLF for the Fall.

**SEI Director:** Paul Carter

**STLFs:** Ben Yu

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

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

**Post-doc:** Frank Hutter, Gabriel Murray

### Course Transformation

| Course | Learning Goals | Assessments | Improved methods |
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| **CPSC 101: Connecting with Computer Science** (Sept '07 start)<br>Faculty: M. Allen, A. Condon, S. Wolfman, H. Hoos<br>STLF: Ben Yu | Course-level goals: complete<br>Topic-level goals: complete | Performed study of instructor & student perception and use of learning goals.<br>Developing assessment to probe student understanding of JavaScript code. | Used clicker questions in class.<br>Developed broad set of clicker questions. |
| **CPSC 110: Computation, Programs and Programming** (Sept '09 start)<br>Faculty: G. Kiczales, P. Carter, K. Eiselt | Course-level and topic-level goals: in progress | | Developing a series of relevant and engaging labs.<br>Examining the possibility of incorporating online screencasts as a mode of pre-instruction thereby allowing for more active learning during class periods. |
| **CPSC 111: Introduction to Computation** (Sept '07 start)<br>Faculty: K. Eiselt, C. Conati, W. Heidrich, J. Luk<br>STLF: Ben Yu, Ray Lister | Course-level goals: complete<br>Topic-level goals: complete | Attitudinal survey revised and administered at start and end of term in all sections of summer and fall terms.<br>Cognitive pre-test developed and administered at start of course. The same test was administered to students in APSC 160.<br>Questions targeting specific learning goals have been included on exams.<br>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)<br>Faculty: S. Wolfman, P. Belleville, K. Voll, M. Allen<br>STLF: Ben Yu | 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.<br>Student interviews conducted in summer and fall terms.<br>Pre and post-tests developed and administered in fall term.<br>MCQs developed for final exam that target specific learning goals.<br>A scenario based think-aloud survey tool has been developed to study how students approach solving mathematical induction | Two-stage exam conducted in summer term. Results published in ICERI 2009 and further analysis appeared at SIGCSE 2010.<br>Refined online quizzes used to assess pre-class learning goals on the basis of previous term's quiz results.<br>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. |

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| | | 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. | Continued work on labs to make them "open-ended" and driven by student exploration rather than closed-ended. |
| **CPSC 210: Software Construction** (Jan '10 start)<br>Faculty: G. Murphy, M. Allen | Course-level and topic -level goals: in progress | | Examining the use of cell phones in some labs to increase relevance and student engagement. |
| **CPSC 211: Introduction to Software Development** (Sept '07 start)<br>Faculty: D. Poole, M. Dulat<br>STLF: Ben Yu | Course-level goals: complete<br>Topic-level goals: complete | Attitudinal survey developed and administered at start and end of both sections of fall term. | |
| **CPSC 213: Introduction to Computer Systems** (Sept '07 start)<br>Faculty: G. Tsiknis<br>STLF: Ben Yu | Course-level goals: complete<br>Topic-level goals: complete | Pre and post-tests developed and administered during summer term. | Two-stage exam conducted in summer term. Results published in ICERI 2009 and further analysis appeared at SIGCSE 2010. |
| **CPSC 221: Basic Algorithms and Data Structures** (Sept '07 start)<br>Faculty: K. Voll, E. Knorr<br>STLF: Ben Yu | Course-level goals: complete<br>Topic-level goals: complete | Post-test developed and administered at end of summer term.<br>Attitudinal survey revised and administered at 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. |
| **CPSC 260: Object-Oriented Program Design** (Sept '09 start)<br>Faculty: D. Acton<br>STLF: Ray Lister | 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 304: Introduction to Relational Databases** (Sept '09 start)<br>Faculty: E. Knorr, R. Pottinger, R. Ng<br>STLF: Ben Yu | Topic-level goals: draft | Attitudinal survey developed and administered at start and end of term.<br>Pre and post-tests developed to assess change in learning.<br>Student interviews conducted during fall term. | Clicker questions developed and used in fall offering of course.<br>Two-stage exams conducted in both midterms of fall 2009 term.<br>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.<br>Tutorials are being improved upon for summer 2010 offering of course to include reflection exercises such as the development of a concept map. |
| **CPSC 310: Introduction to Software Engineering** (May '10 start)<br>Faculty: M. Allen<br>STLF: Ben Yu | Course-level and topic-level learning goals: in progress | Diagnostic test developed to assess student preparation in learning. | |
| **CPSC 320: Intermediate Algorithms and Data Structures** (Sept '09 start)<br>Faculty: K. Voll | | A test of expected prerequisite knowledge was developed and administered at the start of the term. | |

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| **CPSC 322: Artificial Intelligence** (Summer '08 start)<br>Faculty: G. Carenini, K. Leyton-Brown<br>Post-doc: Frank Hutter<br>STLF: Ben Yu | Course-level goals: complete<br>Topic-level goals: complete | A large body of questions have been developed to be used as the core of future exams | A set of practice problems complete with solutions have been developed.<br>Two new AI Space applets have been developed. |
| **CPSC 404: Advanced Database Systems** (Sept '09 start)<br>Faculty: E. Knorr<br>STLF: Ben Yu | Topic-level learning goals: draft | Attitudinal survey developed and administered at start and end of term.<br>Pre and post-tests developed to assess change in learning. | |
| **CPSC 422: Intelligent Systems** (Sept '09 start)<br>Faculty: C. Conati, K. Leyton-Brown<br>Post-doc: Frank Hutter | Learning goals under development. | | All assignments have been revised with respect to learning goals and two new assignments have been developed. |
| **APSC 160: Introduction to Computation in Engineering Design** (Sept '09 start)<br>Faculty: P. Carter<br>STLF: Ray Lister, Ben Yu | Topic-level goals: complete | Attitudinal survey developed and administered at start and end of term. Analysis pending.<br>Surveys assessing impact of Peer Instruction conducted in week 4 and week 8 of term. | 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.<br>Clicker questions have been developed to assess students' comprehension of the concepts presented in the screencasts.<br>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.<br>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. |

**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 are investigating 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.

## Curriculum

**Code communication in APSC 160, CPSC 111, and CPSC 260:** Exploring 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:** 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 accepted

for publication 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.

- **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.
- **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.
- **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.

## Earth and Ocean Sciences Department

Earth & Ocean Sciences received full funding from CWSEI in 2007 and began the efforts listed below in Summer 2007. The EOS-SEI program is making excellent progress with 19 courses currently at various stages of transformation and 11 more courses "unofficially" being improved using the principles of research-based effective pedagogy. Over 60% of EOS faculty are involved in the SEI in some capacity (committees, working groups and/or making changes to their courses). The overarching goal of the EOS-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.

**SEI Director:** Sara Harris

**STLFs:** Francis Jones, Brett Gilley, Erin Lane, Joshua Caulkins, Ben Kennedy (emeritus)

**Faculty (instructors teaching targeted courses):** S. Allen, G. Andrews, R. Beckie, M.L. Bevier, M. Bostock, G. Dipple, E. Eberhardt, J. Finnis, R. Francois, M. Grey, S. Harris, F. Herrmann, K. Hickey, W. Hsieh, M. Jellinek, C. Johnson, M. Kopylova, M. Maldonado, U. Mayer, S. Mills, J. Mortensen, K. Orians, R. Pawlowicz, J. Scoates, R. Stull, S. Sutherland

**Faculty (others involved in working groups, committees, or ad-hoc support):** P. Austin, M. Bustin, K. Grimm, L. Groat, P. Hammer, E. Hearn, O. Hungr, T. Ivanochko, M. Lipsen, J. Monteux, D. Oldenburg, K. Russell, P. Smith, D. Steyn, C. Suttle, P. Tortell, L. Ver, D. Weis, D. Winget

**Students:** L. Bailey, L. Beranek, J-F. Blanchette-Guertin, A. Caruthers, D. Cassis, J. Dohaney, R. Eso, L. Gurney, M. Halverson, S. Henderson, T. Hirsche, K. Hodge, A. Jolley, K. Ko, P. Lelievre, C. Leslie, C. Livingstone, K. Lucas, J. Mcalister, K. Rasmussen, J. Rhajiak, E. Schaeffer, B. Smithyman, K. Smet, R. Taylor, D. Tomkins, D. Tommasi, C. Wong

### Course Transformation

| Course | Learning Goals | Assessments | Improved methods |
|---|---|---|---|
| **EOSC 111: Laboratory Exploration of Planet Earth** (Sept '07 start)<br>Faculty: S. Harris<br>STLF: Brett Gilley<br><br>Transformation completed in Fall '08 w/ ongoing updates to pre-post assessment, lab activities, and quizzes | Course-level goals: complete<br><br>Lab-level goals: complete | Individual and group quizzes<br><br>3rd draft of Pre/Post assessment complete for all topics<br><br>Post-lab surveys for each lab<br><br>End-of-term survey | Invention activities (Introduction, Plankton & Marine Ecosystems)<br><br>Student-derived methods (Earthquakes, Groundwater, Dinosaurs, Waves, Estuaries)<br><br>Contrasting cases (Sediments & Sedimentary Rocks) |
| **EOSC 112: The Fluid Earth: Atmosphere and Ocean** (Jan '08 start)<br>Faculty: R. Francois, S. Harris, W. Hsieh<br>STLF: Erin Lane | Course-level goals: complete<br><br>Lecture-level goals: complete | Midterm & end-of-term surveys<br><br>Draft pre-post test on student misconceptions in oceanography & climate change<br><br>Student engagement observations<br><br>Student workloads questions | Widespread use of thought-provoking clicker questions<br><br>Peer instruction<br><br>Relevance slide added to each lecture, relevance added throughout class. |
| **EOSC 114: The Catastrophic Earth: Natural Disasters** (Sept '07 start)<br>Faculty: R. Stull, E. Eberhardt, M.L. Bevier, S. Sutherland, J. Finnis, G. Andrews<br>STLF: Francis Jones<br><br>Transformation completed in Spring '10. | Course-level goals: complete<br><br>Lecture-level goals for all lectures: complete | Midterm & end-of-term surveys<br><br>Pre-course diagnostic on basic skills<br><br>Online homework based on text readings introduced Fall 2008<br><br>Attitudes survey | Vista Course Management System and a custom website used extensively for content delivery, quizzing, surveying, logistics.<br><br>Use of thought-provoking clicker questions in all lectures<br><br>Pre-post question "wrappers" around video clips to focus and assess student learning from videos<br><br>Custom text introduced.<br><br>Off-schedule pre-exam review/question sessions<br><br>Fall'09: Preliminary experiment with PeerWise in one section. Not continued beyond Fall'09.<br><br>Multiple sequential instructors with one lead instructor and administrative support. |

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| **EOSC 210: Earth Science for Engineers** (Jan '08 start)<br>Faculty: E. Eberhardt, U. Mayer, S. Sutherland<br>STLF: Brett Gilley<br><br>Transformation completed in Dec '09 with some ongoing support | Course-level goals: complete<br><br>Lecture-level goals: complete<br><br>Goals for all labs: complete | End-of-term survey<br><br>Mineral exam | Use of PeerWise (http://peerwise.cs.auckland.ac.nz/) for student generation of questions<br><br>Widespread use of clicker questions (4-8 in each 1.5 hour lecture), focus attention, test understanding, and drive discussion<br><br>Small group or pair discussions in most classes<br><br>Many case studies relevant to lectures<br><br>Labs redesigned with new activities linked to learning goals |
| **EOSC 211: Computer Methods in Earth, Ocean & Atmosph. Sciences** (Jan '09 start)<br>Faculty: R. Pawlowicz, C. Johnson<br>STLF: Joshua Caulkins | Course-level goals: draft<br><br>Lecture-level goals: draft for all lectures<br><br>Learning goals for Labs/Assignments: draft | Pre-post assessment: Administered in Teach 1, currently undergoing revisions<br><br>Midterm and end-of-term surveys<br><br>New types of exam questions based on computer science concepts | In-class worksheets for every lecture<br><br>Pair-programming used in all labs and assignments.<br><br>Name-sticks used to call on students<br><br>Post-lecture Interviews |
| **EOSC 212: Topics in the Earth & Planetary Sciences** (Jan '08 start)<br>Faculty: M. Jellinek, M. Bostock<br>STLF: Francis Jones<br><br>Final transformation term was Fall'09, but further refinements of generic science thinking activities and assessments are expected | Course-level goals: complete<br><br>Focus is on science thinking skills rather than content | End-of-term survey for project evaluation<br><br>Quizzes on readings for both individual and teams, using Team Based Learning strategies<br><br>Two projects (presentation and poster), including feedback at multiple stages of delivery<br><br>Pre-post test related to model-based reasoning<br><br>Peer assessment of some homework and both projects<br><br>Regular graded abstract writing and question-posing assignments<br><br>Student participation in rubric design for reading, writing and questioning | Vista Course Management System used extensively for content delivery, quizzing, surveying, logistics<br><br>Team Based Learning elements: permanent teams, individual/team quiz protocols & in-class team activities<br><br>Content from Scientific American and other articles and lectures<br><br>Three modules chosen to highlight Departmental research strengths<br><br>Guest speakers for each module<br><br>Instruction and practice at developing science article reading, questioning & discussing skills<br><br>Project topics are student-determined<br><br>Question posing, abstract writing and model based reasoning rubrics are used<br><br>Capstone week introduced to revisit core skills and learning goals<br><br>Two instructors with roughly half the classes attended by both |
| **EOSC 220: Introductory Mineralogy** (Jan '08 start)<br>Faculty: M.L. Bevier<br>STLF: Joshua Caulkins | Course-level goals: complete<br><br>Lecture-level goals: complete | Midterm and end-of-term surveys<br><br>Lab quizzes | In-class activities and discussions are part of each lecture.<br><br>3x5 cards used for student responses and feedback.<br><br>Labs reworked and provided more structure to students and TAs<br><br>Students create their own reference "mineral book" that can be used later for studying. |

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| **EOSC 221: Introductory Petrology** (Sept '07 start)<br>Faculty: M. Kopylova<br>STLF: Brett Gilley<br><br>Transformation completed in April '09. | Course-level goals: complete<br><br>Lecture-level goals: complete<br><br>Lab goals: Complete | Pre/post assessment | Labs rewritten - more structure activities linked to goals<br><br>Small group lecture activities in each lecture<br><br>3x5 cards for ongoing assessment of students and the course<br><br>Many smaller quizzes after each module<br><br>Improved course framework (spaced lectures that do more to highlight differences rather than massed lectures, covering all of one rock type). |
| **EOSC 252: Introduction to Experimental Geophysics** (Sept '09 start)<br>Faculty: F. Herrmann<br>STLF: Francis Jones<br><br>Being taught for the first time in Jan '10 | Course-level goals: agreed upon<br><br>Lecture-level goals: first versions. | Weekly lab or homework exercises<br><br>One midterm<br><br>One final exam<br><br>In-class demonstrations assessed for "participation".<br><br>The beginnings of regular on-line self-test quizzing based on assigned readings. More to come the time the course is taught<br><br>Extensive end of term survey about initiatives and preferences | Enhanced context for all material by:<br><br>1. reworking four Lab exercises<br><br>2. dropping two 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).<br><br>3. projects involving student-chosen topics, and 3-stage deliverables with TA and peer feedback.<br><br>Guided demonstrations introduced to four class lectures, including pre-demonstration "prediction" worksheets. |
| **EOSC 321: Igneous Petrology** (Jan '10 start)<br>Faculty: M. Kopylova<br>STLF: Brett Gilley | Course-level goals: draft<br><br>Lecture-level goals: under development | End-of-term survey | Student focus group completed in January.<br><br>Development of new labs |
| **EOSC 322: Metamorphic Petrology** (Sept '08 start)<br>Faculty: G. Dipple<br>STLF: Erin Lane | Course-level goals: complete<br><br>Topic-level goals: complete | Midterm survey<br><br>Pre-reading quizzes | Rock sample and relevance in lectures<br><br>Just-in-Time-Teaching (pre-readings and online quizzes given prior to module) |
| **EOSC 326: Earth and Life Through Time** (Jan '10 start)<br>Faculty: S. Sutherland,<br>STLF: Francis Jones<br><br>First teach term of the transformation - Sept 2010 | Course-level goals: draft<br><br>Lesson-level goals: pre-transformation goals exist; these are being adjusted. | Online quizzing being added.<br><br>Two "lab" exercises exist as substitutes for 2 weeks of lectures.<br><br>Midterm & final exams<br><br>Clicker use will be introduced. | In pre-teaching phase - June 2010<br><br>New text<br><br>Key concepts and misconceptions being catalogued from old exams and corresponding learning activities being developed. |
| **EOSC 329: Groundwater Hydrology** (Jan '10 start)<br>Faculty: R. Beckie<br>STLF: Joshua Caulkins | Course-level goals: draft<br><br>Lecture-level goals: drafting<br><br>Learning goals for Labs/Assignments: drafting | Development of diagnostics and a pre-post assessment are underway<br><br>Intend to use midterm and end-of-term surveys to obtain student feedback.<br><br>Some lab material will be moved to Vista for automated marking and immediate feedback for students. | Introducing case studies, worksheets and small-group work during lectures.<br><br>Labs have been re-designed with a focus on aligning activities with learning goals.<br><br>Name-sticks to be used during lectures.<br><br>Classroom observations and post-lecture interviews |

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| **EOSC 331: Mineral Deposits** (Jan ' 10 start)<br>Faculty: J. Scoates, K. Hickey<br>STLF: Brett Gilley | Course-level goals: draft<br>Lab-level goals: draft | End-of-term survey | New course frameworks developed.<br>Sample room and existing lab samples reorganized. |
| **EOSC 332: Tectonic Evolution of North America** (Sept '08 start)<br>Faculty: J. Mortensen<br>STLF: Brett Gilley | Course-level goals: draft<br>Module-level goals: draft | Pre/Post Assessment rewritten for Jan 2010 (validated with former students)<br>Midterm survey<br>Peer Review Essay assignment<br>End-of-term survey | Activities and discussions planned for some lectures.<br>Just-in-Time-Teaching (pre-readings and online quizzes given prior to each module) |
| **EOSC 355: The Planets** (Sept '08 start)<br>Faculty: C. Johnson<br>STLF: Francis Jones<br>New course, taught 1st time in Spring 2009. Second teaching term Spring 2010 | Course-level goals: complete<br>Module-level goals: Finalized for Spring 2010 term. | Pre-course skills diagnostic and "attitudes toward planetary sciences"<br>Midterm survey for improving course delivery and focus<br>Frequent in-class quizzes<br>Clickers, major capstone homework exercises for each of 3 modules, in-class team-based worksheets used to set up or practices lecture content and skills.<br>Major project, including 3-stage deliverables, and peer assessment. | Vista Course Management System used for content delivery, quizzing, surveying, logistics.<br>Use of permanent teams for quizzes and in-class worksheet-based activities<br>Clickers used for pre-lecture prediction and mid-lecture discussions.<br>Online and in-class quizzes, especially to ensure accountability and assess comprehension of basic content, thus permitting higher level in-class activities & lectures.<br>No final exam<br>Major poster presentation projects are a primary source of grades. |
| **EOSC 372: Introductory Oceanography: Circulation and Plankton** (Jan '09 start)<br>Faculty: S. Allen, K. Orians, M. Maldonado<br>STLF: Erin Lane | Course-level goals: complete<br>Lecture-level goals: draft<br>Assignment learning goals: draft | Mid-term survey<br>End-of-term survey<br>Daily online quizzes<br>Pre-requisite knowledge diagnostic quiz<br>Draft post test<br>Student workloads questions | In class clicker questions<br>Daily assignments with online quizzes |
| **EOSC 373: Introductory Oceanography: Climate and Ecosystems** (Sept '09 start)<br>Faculty: M. Maldonado, S. Allen, R. Francois<br>STLF: Erin Lane<br>Being taught for the first time in Jan '10 | Course-level goals: draft<br>Lecture-level goals: under development | Mid-term survey<br>Draft diagnostic test<br>Daily online quizzes | In class clicker questions<br>Daily assignments with online quizzes |
| **EOSC 472: Introduction to Marine Chemistry and Geochemistry** (Sep '09 start)<br>Faculty: K. Orians<br>STLF: Joshua Caulkins | Course-level goals: draft<br>Lecture-level goals: under development | Midterm and end-of-term surveys<br>Reading quizzes introduced.<br>Reworked homework sets. | Weekly worksheet activities<br>Anonymous peer-reviewed writing assignment with instructor feedback<br>Post-lecture student interviews<br>Investigating new textbook options, perhaps introducing a packet of articles |

**The following courses have undergone improvement without specific STLF help, or with ad-hoc support**

**EOSC 110:** Using the Geoscience Concept Inventory to measure student learning - Faculty: M. Bevier

**EOSC 116:** Faculty: S. Sutherland

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

**EOSC 223:** Pre-post assessments and in-field assessments - Faculty: M. Bevier, STLF: J. Caulkins

**EOSC 315:** Clickers - Faculty: M. Lipsen

**EOSC 324:** No longer offered - Faculty M. Bevier

**EOSC 328:** GPS tracking of students, in-field assessments - Faculty: K. Hickey, STLF: J. Caulkins

**EOSC 340:** Just-in-Time Teaching and clickers - Faculty: S. Harris & P. Austin

**EOSC 350:** Team Based Learning - Faculty: D. Oldenburg

**ENVR 200 & 300:** Team projects, studying metacognition 0 Faculty: K. Chan, S. Harris, T. Ivanochko, M. Johnson, D. Steyn

## 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** is actively working to define program goals. (S. Allen, chair)

**Environmental Science Curriculum Committee** conducted student focus groups and extensive data analysis on student enrollment data. A set of recommendations and a revised curriculum has come out of this work (D. Steyn, chair)

**Geophysics Curriculum Committee** proposed reinstating the Geophysics Majors program (E. Hearn, chair)

**Geology Curriculum Committee** proposed reinstating the Geology Majors program (K. Russell, chair)

**Oceanography Curriculum Committee** is actively working to define program goals, build links among courses, and propose combined majors programs with Biology, Chemistry, and Physics (S. Allen, chair)

## 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

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
Methods and materials: Mini-lesson practice, Group discussions, Lab redesign project

## Research

**Student Attitudes about Earth Science Survey (SAESS):** Survey developed to gauge the students' attitudes and beliefs about learning earth & ocean sciences. Administered in both majors- and non-majors courses early in the term (pre-) and late in the term (post-) to measure the effects of courses on student attitudes. The survey has been administered in >25 courses both at UBC and other institutions. More than 6000 students have participated over the past 2 years.

**Classroom Observations, Protocol & Results:** We developed an objective, quantitative classroom observation protocol to measure student engagement in a large first year Oceanography course. Observation data show that student engagement is strongly correlates to teaching practices and is higher when instructors employ active learning techniques. Observations of three instructors with different teaching expertise showed similar trends in engagement. The classroom observation data help identify best teaching practices and provide continual feedback to instructors.

**Undergraduate Thesis Research:** Jamil Rhajiak completed an Honours thesis entitled "Understanding Geological Time: A Proposed Assessment Mechanism for Beginner and Advanced Geology Students" (2009). Alison Jolley completed and honours thesis entitled "Identifying Landscapes and their Formation Timescales: Comparing Knowledge and Confidence of Beginner and Advanced Geoscience Undergraduate Students" (2010).

**Other Research:** Effects of Multiple Instructors in Single Courses, Using Pair Programming in EOSC 211, pre-post test results from various courses, effects of instructor interventions on low-performing students.

## Other

**EOS-SEI Times:** Approximately monthly newsletter containing results from courses, tips and information for instructors (15 editions so far)

**Brown Bag Seminars:** Both weekly drop-in sessions called "The STLF is IN" and special topics discussions.

**Learning Goals Workshops:** 3 facilitated by STLFs for participants outside EOS.

**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

**Exit Survey:** An online survey has been developed for graduating 4th year EOS students from all streams. The exit survey will provide us with student perspectives on the EOS academic program, 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. Future considerations may include an alumni survey.

## Life Sciences Program

The Life Sciences Program (Depts. of Zoology, Botany, and Microbiology & Immunology) received funding from CWSEI in 2007 and began the efforts listed below in the Fall. We are currently testing survey tools in first year to measure development of expert attitudes; developing and testing an alternative form of tutorials in a large first year class; developing and testing attitudes toward the environment in ecology courses, testing student learning in natural selection using a concept inventory test, developing and applying a 4th year satisfaction survey, and aiding in the development of the upper level ecology courses.

**SEI Director:** G. Spiegelman

**STLFs:** J. Taylor, M. Hansen, H. Yurk (emeritus), T. Kelly (emeritus)

**Faculty participating currently: First Year Surveys:** W. Goodey, T. Kion, J. Klenz, K. Nomme, R. Redfield, G. Spiegelman, K. Smith **Evolution Concept Surveys (2008-09):** G. Bradfield, C. Brauner, W. Goodey, M. Hawkes, D. Irwin, C. Leander, R. Redfield, E. Taylor, J. Whitton **Ecological Attitude Survey (2008-09):** G. Bradfield, W. Goodey, D. Irwin, T. Sinclair, R. Turkington, M. Vellend **Upper Level Ecology Course Transformation:** D. Srivastava, G. Bradfield, J. Goheen, W. Goodey, R. Turkington, M. Vellend

**Invention Activities:** J. Taylor, K. Smith, G. Spiegelman

**Skylight Affiliate:** G. Birol

**Students:** Peter van Stolk

### Course Transformation

| Course | Learning Goals | Assessments | Improved methods |
|---|---|---|---|
| **BIOL 111: Cell and Organismal Biology** (Sept '07 - Sept '08)<br>Faculty: K. Nomme, J. Klenz<br>Skylight Liaison: G. Birol | Course-level goals: complete<br>Topic-level goals: complete | Midterm student evaluations<br>Focus groups<br>Biology attitudinal survey<br>Clicker questions | Case studies<br>Group activities<br>Vista reading quizzes<br>Peer tutor support<br>Intentional alignment of topics with student work and assessment |
| **BIOL 112: Cell Biology** (Sept '07 – April '10)<br>Faculty: G. Spiegelman, E. Gaynor, T. Kion<br>STLF: Jared Taylor | Course-level goals: complete<br>Topic-level goals: complete | End-of-term surveys<br>Student interviews to assess problem solving abilities<br>End-of-term assessment of learning and invention groups to assess transfer abilities<br>Biology attitudinal survey | Developed and refined 8 invention activities for in class once per week.<br>Just-in-Time Teaching incorporated with pre-class readings.<br>In-class writing assignments, iClickers<br>End of week problems<br>PeerWise used in all sections |
| **BIOL 121: Ecology, Genetics and Evolution** (Sept '07 –08)<br>Faculty: C. Pollock, Teaching Team, A. O'Neill<br>Skylight Liaison: G. Birol | Course-level goals: complete<br>Topic-level goals: complete | Mapping of multi-section course outcomes onto assessments<br>Biology attitudinal survey<br>Meiosis concept inventory (in preparation) | Peer tutors<br>Learning centre<br>PeerWise used in some sections.<br>Writing project with Rosie Redfield, 2008/09 |
| **BIOL 201: Cell Biology II: Introduction to Biochemistry** (Jan '08 – Sept '08)<br>Faculty: W. Bingle, S. Chowrira, J. Richards<br>STLF: Jared Taylor | Lecture -level goals: complete | Chemistry concept pre-test<br>Focus group interviews<br>Focus group follow-up survey (entire class)<br>Biology attitudinal survey | Recommendations provided to faculty. |

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| **BIOL 204: Vertebrate Structure and Function**<br>(Jan '08- May '08)<br>Faculty: B. Milsom, A. O'Neill | Course-level goals: complete<br>Topic-level goals: complete | Clicker questions<br>Post test: Vista Reading/Content quizzes<br>New study questions<br>Midterm teaching evaluation | Improvement of group activities and discussions in class<br>Revised course content and lecture materials incorporating real life examples.<br>Enhanced problem solving approach including comparisons. |
| **BIOL 304: Fundamentals of Ecology**<br>(Sept '09 start)<br>Faculty: R. Turkington, J. Goheen, W. Goodey, M. Vellend, D. Srivastava<br>STLF: Malin Hansen | Course-level goals: complete | Pre and post attitude surveys<br>Pre and post conceptual surveys were developed and used.<br>Student interviews were conducted to assess class activities and methods.<br>Midterm survey was developed and used to assess class activities and methods. | iClickers were used.<br>Pre-reading assignments with multiple choice and open ended question (with feedback) were issued each week.<br>Small group discussions were incorporated.<br>Mandatory field labs were implemented.<br>Two tutorials were designed and implemented. |
| **BIOL 306: Advanced Ecology**<br>(Jan '10 start)<br>Faculty: G. Bradfield, W. Goodey<br>STLF: Malin Hansen | Topic-level goals: complete | Pre and post attitude surveys used.<br>Pre and post conceptual surveys were developed and used.<br>Student interviews were conducted to assess class activities and methods.<br>Mid-term survey was used to assess class activities and methods. | iClickers were used.<br>Pre-reading assignments with multiple choice and open ended questions (with feedback) were issued each week.<br>Small group discussions were incorporated.<br>Four learning activities (paper to read, questions to prepare at home and group discussion in class) were developed and implemented.<br>Mandatory field labs were implemented.<br>Two tutorials are under development |

Transformations in the following courses have been undertaken by individual faculty members (with advice provided by CWSEI-Life Science Departmental Director, George Spiegelman)

**Microbiology 300: Microbial Ecology** (Faculty: W. 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 409: Advanced Microbial Genetics** (Faculty: S Hallam) – Course-level and topic-level learning goals completed, student survey, in-class workshops suing groups of students, clickers.

## Curriculum

**Evidence Based Approach to Curriculum Design:**

- **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:** First year pre-post survey
- **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 (CB&G) 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.
- **Concept Tests:** Investigating Conceptual Understanding of Natural Selection: Harald Yurk has been assessing 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.

- **UBC PAIR data**

- **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 other 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.

**Organizational Planning:**

- Biology Program curriculum working group has 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.

## Research

**CWSEI funded:**

- **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 accepted for publication in the Journal of College Science Teaching.

- **Invention Activities:** Jared Taylor, George Spiegelman and Karen Smith are conducting a study of the effectiveness of invention activities and learning group activities in developing students' reasoning/problem solving skills and ability to transfer knowledge to novel situations.

- **Biology Attitudinal Survey:** Gülnur Birol administered the Biology attitudinal survey in all sections of BIOL 111, 112, 121 classes this year. . Survey has been used for two years running. Two manuscripts are in preparation one in collaboration with the Colorado group and one that Gulnur Birol, Malin Hansen and Kathy Nomme are working on that compares student attitudes in first and third year courses.

- **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. The analysis of the data is completed. As part of the project, we are planning to conduct surveys with potential employers of life science graduates to assess needs of employers with regard to the biology curriculum and general scientific skill sets. A special assistant has been hired for this latter project.

- **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.

**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:** Two Skylight grants were obtained to begin 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.

## 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.

## Mathematics Department

Starting in 2008, the UBC Mathematics Department is participating in the Carl Wieman Science Education Initiative (CWSEI) to improve undergraduate science education. Currently projects are concentrated in two areas:

The first area is computing and computer labs in Math 152, Math 257, Mech 221 (Math 256), Mech 222 (Math 253) and Math 307. These courses have all recently introduced computing as an intrinsic part of the course. The Math CWSEI will help in the creation of tutorials and lab materials, assist in integrating the computational component into the course material and developing testing methods, and assess the effectiveness of the computational component.

The second area is support for the workshops and the basic skills test in Math 180/184. The Math CWSEI will help to assess the effectiveness of the workshops and assist in the study of how well the basic skills test predicts success in the course.

In 2009-2010, the focus will be mainly on 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.

In addition to the existing projects, the Math CWSEI will also help in developing and implementing assessment strategies to measure students' attitudes toward computer labs in Math 102 and Math 103, as well as the effectiveness of a new online homework system in use in Math 104 and Math 105. The Math CWSEI will also provide resources to help with the course transformation currently underway in Math 318.

The Math CWSEI will also be preparing for a substantial expansion of its program, which includes extending the workshops and basic skills test to Math 110, developing project based courses Math 305 and the General Science Modeling course, and tracking skill development and retention through the curriculum with a preliminary focus on mathematical proof.

**SEI Director:** Stephanie van Willigenburg

**STLF:** Costanza Piccolo, Warren Code, , Sandra Merchant, Joseph Lo, Paul Ottaway (emeritus)

**Faculty:** R. Froese, R. Gupta, L. Keshet, P. Loewen, M. MacLean, A. Peirce, G. Slade, B. Wetton

**TA's and Postdocs:** M. Berube, R. Liang, A. Lindsay, M. Willoughby

### Course Transformation

| Course | Learning Goals | Assessments | Improved methods |
|---|---|---|---|
| **MATH 180/184: Differential Calculus (Workshop component)**<br>(Sept '08 start)<br>Faculty: R. Gupta<br>STLF: Costanza Piccolo | Course-level goals: drafts completed<br>Workshop goals: complete | Student surveys on workshop activities<br>Weekly quizzes<br>Midterm and end-of-term survey | Workshops 1-12 completed: added workshop-level learning goals and list of required basic skills; created new workshop problems with subject-specific applications.<br>Program Structure: Expanded the administrative structure and TA training. |
| **MATH 152: Linear Systems (Computer Labs component)**<br>(Sept '08 start)<br>Faculty: B. Wetton<br>STLF: Warren Code | Topic-level goals: second revision completed | Pre- and post-tests on linear systems (Jan-Apr 09)<br>End-of-term student survey on computer labs (Jan-Apr 09, 10)<br>Pre- and post-tests on Matlab syntax and basic structures (Jan-Apr 10)<br>Lab observations and TA interviews (Jan-Apr 10) to determine common problems and completion rates | Labs rewritten to tie in more closely with the course material, and revised after a full term of use (minimal changes were needed).<br>Paper-based homework, midterm exam and final exam questions developed to test/practice Matlab syntax and basic structures. |
| **MATH 220: Mathematical Proof**<br>(March '10 start)<br>Faculty: A. Rechnitzer<br>STLF: Sandra Merchant | Course-level goals: first draft in progress<br>Topic-level goals: first draft in progress | Student surveys and interviews on course content and study habits<br>Faculty interviews on student difficulties and to determine essential proof skills | A series of targeted in-class proof activities are being developed. |

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| **Math 253 (Mech 222): Multivariable Calculus (Computer Labs component)** (Sept '08 start)<br>Faculty: P. Loewen<br>STLF: Warren Code<br>TA: M. Willoughby | Incorporated into weekly learning guides and lab documents. | Weekly surveys of student completion rates and attitudes.<br><br>Lab observations and TA interviews to determine most significant student difficulties | Labs have been revised to tie in more closely with the course material. |
| **Math 256 (Mech 221): Differential Equations (Computer Labs component)** (Sept '08 start)<br>Faculty: B. Wetton<br>STLF: Costanza Piccolo, Paul Ottaway (Sept-Dec '09)<br>TA: W. Thompson | Learning goals: first draft completed. Revisions started. | Student observation during lab periods<br><br>End of term student attitude surveys; survey results have been compared to last year's data.<br><br>Targeted questions designed for the final exams and used to assess learning in the lab sessions; student scores on these questions have been analyzed. | All labs are being edited based on feedback from last year's offering as well as input from the STLF and the lab TA.<br><br>Final exam questions have been designed based on the mutually agreed upon learning goals. |
| **Math 257/316: Partial Differential Equations (Computer Labs component)** (Sept '08 start)<br>Faculty: A. Peirce<br>STLF: Costanza Piccolo | Topic-level goals: complete | Student survey regarding attitudes towards the use of spreadsheets in the course. | Course-specific, online Excel tutorials are completed; sets of homework assignments and in-class demos using spreadsheets have been developed. |
| **Math 307: Applied Linear Algebra (Computer Labs component)** (Sept '08 start)<br>Faculty: R. Froese<br>STLF: Costanza Piccolo | Course-level goal: revision is completed<br><br>Topic-level goals: revision is completed | Student surveys<br><br>Pre-reading quizzes<br><br>Special homework assignments with extensive use of Matlab | Lecture Notes have been updated extensively.<br><br>Matlab/Octave resource page has been developed. |
| **MATH 318: Probability with Physical Applications** (January '10 start)<br>Faculty: G. Slade<br>Postdoc: Richard Liang | Course-level and topic-level goals: Fourth draft completed. | Tracked scores on computer-based homework exercises and exam questions.<br><br>Mid-semester and end-of-semester attitude surveys | Octave/MATLAB-based questions drafted for each of the eight assignments, as well as to each of the two midterms and the final exam.<br><br>Two attitude surveys written and ready for future re-use.<br><br>Octave resource webpage constructed (based on the 307 resource page built by Costanza Piccolo) to assist the students in getting started with using Octave. |

## 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 and now has a complement of five STLFs: Peter Newbury and Louis Deslauriers are full-time, Jim Carolan is an emeritus faculty member, and James Day and Ido Roll are part-time.

**SEI Director:** Doug Bonn, Mona Berciu

**STLFs:** Jim Carolan, James Day, Louis Deslauriers, Peter Newbury, Ido Roll

**Faculty:** D. Bonn, J. Folk, B. Gladman, J. Iqbal, D. Jones, A. Kotlicki, K. Madison, J. Matthews, H. Richer, I. Stairs, M. Van Raamsdonk, S. Reinsberg, G. Rieger, L. Van Waerbeke, C. Waltham, C. Wieman, J. Zibin

**Students:** S. Martinuk, D. Mazur, B. Ramshaw, M. Warren, S. Vafaei, C. Veenstra, R. Wong, N. Holmes, E. Schelew

### Course Transformation

| Course | Learning Goals | Assessments | Improved methods |
|---|---|---|---|
| **ASTR 310: Exploring the Universe I: The Solar System** (Summer '08 start)<br>Faculty: H. Richer, B. Gladman<br>STLF: Peter Newbury<br>Grad Student: M. Gendre | Course-level goals: complete<br>Topic-level goals: complete | Improved midterm and final exam questions based on assessing learning goals.<br>Developing concept inventory linked to tutorials for use as pre-, post-test | Created 6 activities for tutorials including guidelines for TAs for facilitating the activities.<br>Began using clickers (Richer), Just-in-time teaching (JITT)(Gladman).<br>Aligning lecture material with learning goals |
| **ASTR 311: Exploring the Universe II: Stars and Galaxies** (Summer '09 start)<br>Faculty: L. Van Waerbeke, J. Zibin<br>STLF: Peter Newbury<br>Grad Student: S. Vafaei | Course-level goals: complete<br>Topic-level goals: 95% complete | Developing pre/post concept test for tutorial activities<br>Improved final exam questions based on tutorial activities. | Developed 7 50-minute activities for tutorial sessions including guidelines for TAs for facilitating the activities.<br>Began using clickers in classroom (Van Waerbeke). |
| **PHYS 100: Introductory Physics** (Sept '07 start)<br>Faculty: G. Rieger, A. Kotlicki<br>STLF: Louis Deslauriers, Jim Carolan<br>Grad Student: S. Martinuk | Course-level goals: complete<br>Topic-level goals: complete | Conducting study on impact of learning goals on student self assessment of understanding | Provided feedback for clicker question improvement and more student engagement in lectures. |
| **PHYS 101: Energy and Waves** (Sept '07 start)<br>Faculty: F. Bates, G. Rieger<br>STLF: Peter Newbury | Course-level goals: draft<br>Topic-level goals: draft | | Developed new lab experiments on measurement/uncertainty and interference.<br>Developing in-class activities and worksheets (Rieger) |
| **PHYS 102: Electricity, Light and Radiation** (Sept '09 start)<br>Faculty: F. Bates<br>STLF: Peter Newbury | | Creating pre-lab exercises using PhET simulations | Revising lab experiments |
| **PHYS 107 & 109: Physics 1 lab and Intro to Experimental Physics** (Sept '07 start)<br>Faculty: D. Bonn<br>STLF: James Day, Ido Roll<br>Grad Student: N. Holmes | Course-level goals: complete<br>Topic-level goals: complete | Developed & validated physics lab pre-post diagnostic.<br>Conducted study on the impact of invention activities completed preceding versus following a lesson.<br>End-of-term survey<br>Conducting study on the impact of structure in invention activities<br>Conducting study on how students | Developed 15 invention activities on data interpretation and analysis<br>Developed marking rubrics for all labs and for formal reports.<br>Incorporated classroom discussion of pros and cons of novel student solutions to invention activity problems. |

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| | | practice their scientific reasoning skills during invention activities and whether these skills improve over the term | |
| **PHYS 200: Relativity and Quanta** (Sept '08 start)<br>Faculty: M. Van Raamsdonk<br>STLF: Louis Deslauriers | Course-level goals: complete<br>Topic-level goals: complete | Lecture observations<br>Final exam questions<br>Analyze Mid-term<br>Midterm & end-of-term survey<br>Observe HW sessions | Weekly tutorials developed<br>Improved clicker questions |
| **PHYS 250: Introduction to Modern Physics** (Jan '09 start)<br>Faculty: C. Wieman<br>STLF: Louis Deslauriers | Course-level goals: complete<br>Topic-level goals: complete | Development of a Quantum Mechanical Conceptual Survey<br>Lecture observations<br>Final exam questions<br>Analyze Mid-term<br>Midterm & end-of-term survey<br>Observe HW sessions<br>Measuring long term retention of quantum concepts | Weekly tutorials developed<br>Improved clicker questions<br>Intervention study aimed at significantly improving the performance of lower performing students |
| **PHYS 257: Thermodynamics Mechanics** (Jan '10 start)<br>Faculty: S. Reinsberg<br>STLF: Louis Deslauriers | Course and topic-level goals: first draft started | Measured the long term (11 month) retention of factual thermo information | Design a Thermo Conceptual survey |
| **PHYS 304: Quantum Mechanics** (Jan '10 start)<br>Faculty: K. Madison<br>STLF: Louis Deslauriers | Course-level goals: complete<br>Topic-level goals: complete | Lecture observations<br>Observe HW sessions<br>Measured effect of BONUS clicker questions on student engagement during voting period.<br>Compared student performance to previous terms – transformed course scores are consistently higher.<br>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<br>Designing in- class activities for lecture<br>Improved engagement during clicker questions by adding BONUS questions. |
| **PHYS 408: Optics** (Sept '09 start)<br>Faculty: D. Jones<br>STLF: Louis Deslauriers | Course-level goals: complete<br>Topic-level goals: complete | Development of a Optics Conceptual Survey<br>Lecture observations<br>Final exam questions<br>Analyze Mid-term<br>Observe HW sessions<br>Compared student performance to previous terms – transformed course scores are consistently higher.<br>Measured student engagement in general. Compared it to other course the Eng Phys cohorts were taking at the same time. | Created a bank of clicker questions<br>Design in class activities for each lecture<br>Developed a remedial tutorial for students lacking pre-requisite in signal processing (Fourier Transforms) |

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| **PHYS 450: Quantum Mechanics** (Jan '09 start)<br>Faculty: J. Folk<br>STLF: Louis Deslauriers | Course and topic -level learning goals: 95% complete | Lecture observations<br>Analyze Mid-term<br>Observe HW sessions<br>Conducting 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** – A mechanics diagnostic survey was administered to determine conceptual learning gains and aid future course development. Clicker usage is being developed in this large multi-section engineering course with extensive observation and advice from STLF Jim Carolan
**PHYS 101 & 108** - clicker usage is being developed and improved in these large freshman courses with extensive observation and advice from STLF Jim Carolan

## Curriculum

Extensive diagnostic testing by Jim Carolan and Louis Deslauriers is starting to uncover information that will inform upcoming curriculum decisions. These will likely include a new 'terminal' physics stream that starts with PHYS 100, but does not then go into the usual 101/102 sequence for which the students' mechanics preparation is insufficient. 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 will also feed into upcoming decisions about the freshman treatment of E&M concepts. Efforts are also getting underway to write learning goals for all our upper year courses, and by so doing to insure that the various courses cover the expected curriculum in a consistent manner.

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. We'll develop and test several activities and pre-lab exercises in the small, Summer PHYS 102 section, in preparation of the full PHYS 102 course in January 2011.

## TA Development

Graduate student Mya Warren spearheaded this effort and assembled a strong team (Joss Ives, Sandy Martinuk) to develop and run a very successful two-day workshop, which started in the beginning of 2007 Fall Term. The workshop was required for incoming graduate students and available to veterans as well. A system of mentor TAs was initiated to provide a structure in which senior graduate students can oversee other graduate students in the first year undergraduate courses and help to develop their teaching skills.

Further improvements to the TA training program have been implemented in Fall 2008 with more students contributing to the development and long-term continuity (Veenstra). An addition to the program in 2008 was the mentor TAs taking TAG's course in Peer Evaluation to prepare them for providing feedback to the TAs under their supervision. This program is enhanced by a new graduate course in pedagogy in Physics & Astronomy: PHYS 520, Teaching Techniques in Physics and Astronomy. This course exposed students to current PER literature and culminated in the development of a set of Invention Activities that will be deployed in courses next year.

In 2009, the TAs were asked for input on how to improve TA retention in first year labs and solve various other TA-raised issues. A major outcome of this process was the creation of a departmental committee with both faculty and TA representation, that will start operating beginning with the '10-'11 academic year, and whose tasks are to maintain the continuity and quality of the TA training program, to decide the assignment of TA jobs, to reward outstanding TAs and to solve various other TA issues. The TA training program took place again very successfully this year with a change to the model. There was a one day introductory workshop. Then 'super-TAs' were deployed in each of the large multi-section courses and given the task of developing a course-specific training as a follow-up through the early weeks of the term.

The TAs play a critical role in facilitating the new tutorial activities in ASTR 310 and ASTR 311. Each tutorial package includes extensive "TA Guidelines" for running the lab which not only list the steps necessary to run the activity but, when possible, explain the pedagogical justification for how and why each step is included. Before each tutorial, the TAs meet with the course instructor and STLF Peter Newbury to review the activity, with emphasis on why the steps are important and if necessary, what *not* to do because it could defeat the goal of the activity (for example, by describing an expert solution before beginning an invention activity.) We try to make the tutorials an authentic teaching experience for the TAs, by monitoring their presentation, giving them immediate feedback and welcoming their "colleague-to-colleague" feedback on the activity.

## Research

James Day & 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 and data-mining of students' laboratory notebooks. The latter activity is being used to uncover evidence of transfer that may not be apparent in a multiple choice pre/post test. One paper on invention activities already submitted to the Physics teacher.

Peter Newbury has completed pre- and post-testing of ASTR 310 and ASTR 311 tutorial exercises, such as the Human Orrery. The results were presented at AAS 216, May 23-27, 2010 in Miami, FLA.

Louis Deslauriers, Joshua Folk, and Georg Rieger are studying the impact of learning goals on student self assessment of their understanding in

Physics 100 and Physics 101.

Louis Deslauriers and Joshua Folk are conducting 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.

Participating in CWSEI-wide study on why some students do poorly (particularly focusing on high-failure-rate courses)

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.

An archive system has now been developed and extensively tested as a tool to store course information.