

# ADVANCEMENT of SCIENCE EDUCATION in EARTH AND OCEAN SCIENCES

## A Proposal to the Carl Wieman Science Education Initiative

### INTRODUCTION

The Department of Earth and Ocean Sciences (EOS) is uniquely situated to partner with CWSEI to significantly improve science teaching and learning and meet UBC's Trek 2010 goals. EOS is the largest interdisciplinary department at UBC, with teaching and research that encompass biological, chemical, physical, and mathematical sciences and integrate globally relevant topics critical to human society. Our courses reach many non-science students in addition to serving our majors and honours programs in atmospheric science, geology, geological engineering, geophysics, and oceanography. In 2007, the Environmental Science Program will join EOS, further broadening our scope. We are an important contributor to producing a scientifically literate citizenry with an understanding of today's major environmental issues, in addition to training future earth science professionals.

EOS's commitment to innovation and excellence in teaching and learning is articulated in the EOS "[10-year Academic Plan](#)" (2001), and an [external departmental review](#) conducted in 2005 highlights subsequent improvements in the undergraduate curriculum. We have specifically hired tenure-track teaching-focused faculty members; designed new, highly successful first year service courses; reorganized lab and field courses to give students more ownership of their learning experiences; developed web-based learning tools; transferred successful courses into distance education formats; and established a help centre for undergraduates run by teaching assistant (TAs). EOS faculty currently use a wide variety of progressive teaching methods including clickers, team-based learning, in-class debates, peer assessment, interactive models, and student-built websites. A new EOS Undergraduate Learning Centre will be completed in 2007, and plans for a new building, with emphasis on appropriate and useful educational space, are well underway. Interviews with EOS undergraduates reveal that they value the widespread dedication to teaching in the department, faculty openness, and the collegial atmosphere among faculty, graduate students and undergraduates. These strong relationships throughout the department are important for fostering a culture of excellence and form a crucial backbone supporting success of the science education initiative in EOS.

The opportunity to work with CWSEI and develop a cohesive departmental structure to facilitate improvements in science education is tremendously exciting. Through this collaboration we will (1) formalize consistent use of learning objectives both for specific courses and within our curriculum, (2) make better use of proven tools and pedagogies, in addition to supporting innovations in teaching and learning, (3) implement appropriate assessments to ascertain whether we're meeting our objectives, and (4) coordinate and build on present expertise and initiatives within the department, to sustain our long-term commitment to teaching excellence. Formal departmental votes and extensive consultation with faculty, staff, graduate students and undergraduates demonstrate unanimous support for this proposal and participation in CWSEI.

### OBJECTIVES

EOS will promote student achievement of the following learning outcomes:

1. Develop skills for making reasoned judgments based on scientific evidence and organized knowledge.
2. Enhance the ability to transfer knowledge, skills and concepts to new situations or contexts, for professional, academic, or general societal purposes.
3. Develop the ability to assess and remedy one's own understanding.
4. Achieve an appropriate balance between breadth and depth of knowledge, in order to recognize and express linkages among systems and concepts.
5. Explore the interacting frameworks of economic development and environmental stewardship in the richly multi-disciplinary context of earth, ocean, and atmospheric sciences.

As a department, we will expand and coordinate our efforts in the following areas:

6. Increase teaching effectiveness and efficiency in our undergraduate courses and programs.
7. Raise university-wide levels of scientific literacy and global awareness.
8. Emphasize contemporary thought and new directions in science and science education.
9. Enable, facilitate, and support faculty and TAs to follow best practices for achieving departmental teaching and learning goals while retaining ownership of their courses.

## IMPLEMENTATION

### *General Approach:*

Our objectives will be achieved through coordination and guidance provided by the new, permanent Teaching Initiatives Committee (TIC). In addition to EOS personnel hired specifically for this initiative, the committee will include 2-3 long-term members, including the committee chair, who will remain with EOS throughout and beyond the duration of the initiative, graduate student/TA representatives, and undergraduate representatives. Instructors of courses targeted by the initiative will be adjunct members. We have identified eight practical, inter-related and overlapping areas of effort, each of which will be overseen by a specific TIC member. Numbers in square brackets provide links to objectives listed above.

- Majors/honours courses and programs [*Obj. 1-9*]
- Service courses [*Obj. 1, 2, 5-9*]
- TA training [*Obj. 6-9*]
- Attitudinal assessments [*Obj. 1-3, 7*]
- Web-based interactive learning tools [*Obj. 1-9*]
- Web-based archiving [*Obj. 6, 7, 9*]
- Communication within EOS [*Obj. 4-6, 8, 9*]
- External liaison [*Obj. 1-9*]

We will begin work within our existing curricular structure, which has two main parts: (1) 1<sup>st</sup> and 3<sup>rd</sup> year service courses aimed at general student audiences, many not for credit in our majors programs, and (2) majors/honours courses which encompass the 2<sup>nd</sup> to 4<sup>th</sup> year levels. Our majors may take any one of four wide-ranging first year courses (plus one integrated lab course) as part of their program. Students develop and carry important skills from these 1<sup>st</sup> year courses into their major programs, but our focus on specific content knowledge begins in the 2<sup>nd</sup> year.

We propose an evolving, directed approach by which improvement is course-focused with careful consideration of “adjacent” courses (explicit and implicit pre-, post-, and co-requisites) within the curriculum. By examining the curricular context of each targeted course, we will clarify connections among courses, and detect possible weak links in the overall structure, with reference to both cognitive skills and subject-area concepts. Our efforts will grow incrementally outward, both vertically and horizontally, to evaluate and modify adjacent courses until all undergraduate offerings, and teaching faculty, are reached. This process will create a permanent support structure and will gradually infuse the entire department with the tools, skills, and awareness required to effect lasting change.

During the first year of the initiative, we will target 5 courses: (1) [EOSC 111](#), our first-year integrated lab course, (2) [EOSC 114](#), “Natural Disasters”, a high enrolment service course with a parallel distance education version, (3) [EOSC 212](#), “Imaging the Earth”, an introduction to key research areas in Earth, atmospheric, oceanic, and planetary sciences, (4) & (5) [EOSC 220](#) & [221](#), “Mineralogy” and “Petrology”, a pair of core, linked courses taken by a significant portion of our majors and honours students. These 5 choices span a broad range of topics in biological, chemical, and physical sciences, include both majors/honours and service courses, and involve at least 10 faculty members.

For the second and subsequent years of the initiative, our path through the curriculum will be guided by linkages to previously targeted courses, enrolment, balance among the different EOS program streams, and our experience from previous years. We aim to impact 5+ courses per year, and involve the maximum possible number of faculty members over the lifetime of the initiative. All new courses will incorporate EOS-CWSEI objectives from the planning stages.

### *Some specifics:*

**Course development and revision.***[Obj. 1-9]* For each targeted course, instructors will collaborate with instructional designers, IT specialists, TIC, and CWSEI to achieve the following goals. Iteration for continued progress will be based on results of objective assessments.

- Identify measurable learning goals, including general science literacy, key disciplinary knowledge, and cognitive skills.
- Define prerequisite knowledge for incoming students and provide opportunities for students to identify and remedy their level of preparation. Design and develop interactive “review” modules addressing key concepts and skills whereby students can self-assess their individual level of preparation for the course. Discussions with other departments will be included as needed.
- Identify engaging, proven teaching practices that will best serve the class size and target audience while achieving learning objectives. We will use available tools and expertise (e.g. WebCT, the Office of Learning Technology (OLT), the Centre for Teaching and Academic Growth (TAG)), innovate where appropriate, test innovations, and tap expertise within CWSEI and Skylight for ideas from the science education literature.
- Design and develop interactive learning tools aimed at learning goals. Examples include interactive research games and models of different aspects of the Earth system. These tools may overlap with the review modules above.
- Provide opportunities for students to grapple with commonly challenging concepts and to practice the skills we expect them to master.
- Design, test, and implement objective assessments (formative and summative) that measure student understanding of earth, ocean, and atmospheric science concepts including broad topic areas such as “fields”, “fluxes”, and “complex systems”. Incorporate common misconceptions into assessments and structure assessments to reveal information about cognitive skill development, e.g., the ability to transfer concepts to new situations. Track results over time to gauge effectiveness of new techniques.

**Curriculum matrix.***[Obj. 1-9]* We will continually examine curricular goals with increasing detail as more courses become involved. An evolving, dynamic product of this effort will be a three dimensional curriculum matrix with axes of “learning goals”, “courses”, and “years” used to track how core concepts and skills (both cognitive and professional) link among courses. This ongoing exercise will stimulate discussion and allow us to identify and remedy gaps and overlaps in our curricular structure.

**Attitudinal surveys.***[Obj. 1-3, 7]* In collaboration with CWSEI, TIC will develop and test a survey, similar to the Colorado Learning Attitudes about Science Survey but broadly appropriate for general sciences, to track student attitudes and approaches to science compared to “expert” responses. The survey will be developed in year 1, then administered at all levels in the curriculum, with results partially guiding priorities in subsequent years. High enrolment 1<sup>st</sup> and 3<sup>rd</sup> year service courses will provide particularly useful information about our goal of increasing general science literacy and global awareness.

## **SUSTAINABILITY & SUPPORT**

Communication structures, training, and support in key areas (outlined below) will ensure the long term sustainability of this initiative.

**Internal communication.** *[Obj. 4-6, 8, 9]* Good intradepartmental communication, particularly among instructors and TAs of “adjacent” courses, is vital to the long term success of this initiative. TIC will act to disseminate information and to develop, facilitate, and maintain practical communication structures including discussion groups, demonstration sessions, seminars, and class visits where new techniques can be seen in action. TIC will report annually at the departmental retreat.

**External communication.** [Obj. 1-9] In order to effectively tap existing expertise at UBC, TIC will provide a liaison between EOS and relevant entities on campus such as CWSEI, TAG, OLT, LEAP, the Institute for the Scholarship of Teaching and Learning, and Skylight.

**TA training.** [Obj. 6-9] TIC and instructors will work with CWSEI and TAG to develop efficient and effective TA training modules for graduate students, specifically in our context. Training graduate students in best teaching practices will not only help our undergraduates and faculty, but will also disseminate this effort beyond UBC as graduate students finish their degrees and enter the work force elsewhere.

**Mentoring.** [Obj. 4-6, 8, 9] The department will actively incorporate the outcomes of this effort into mentoring new faculty and TAs.

**Faculty evaluation and credit.** [Obj. 4-6, 8, 9] Participation in the initiative will be explicitly acknowledged in faculty evaluations. Instructors will be members of TIC during the time of course restructuring, providing them a direct link to CWSEI, and will be compensated with decreased departmental commitments elsewhere. Faculty will drive the program (with knowledgeable support) and retain ownership of the courses they teach.

**Archiving and sharing resources.** [Obj. 6, 7, 9] A practical, dynamic electronic archive will be developed to improve teaching efficiency and facilitate sharing all types of course-related resources among instructors and TAs. TIC will collaborate with instructional designers and IT specialists to develop standard templates or course portfolios to archive learning goals, prerequisite knowledge, syllabi, assignments, activities, assessments, rubrics, interactive learning modules, methods, and any other relevant course resources. Once developed, these templates can serve as planning documents for future courses and help ensure that practical knowledge is retained and shared. Instructors will be able to post and change content, and universal content will be shared among courses, strengthening curricular linkages.

**IT support.** [Obj. 6, 9] The department will commit to providing IT support specifically dedicated to teaching efforts. Support will include training teaching faculty to use new technology and troubleshooting so that they can use tools efficiently. Ongoing IT support will be needed to maintain instructional tools and the archive system outlined above.

## CONCLUSION

The “Implementation” and “Sustainability & Support” strategies above are aimed at promoting widespread, lasting evolution in thinking about teaching. The opportunity presented by CWSEI will allow us to establish and nurture permanent departmental structures to support teaching initiatives into the future. We are excited to proceed in this direction and our breadth, diversity, and interconnectedness as a department uniquely position us to have a broad impact on undergraduate education at UBC.

## BUDGET (average annual distribution)

3 FTE: Instructional designers/teaching fellows/post-docs	\$180,000
8 Course Equivalents: Release time to be distributed among directly involved faculty	\$64,000
1 FTE: part-time graduate students (for assessment data collection and instructional support)	\$25,000
2 FTE: IT experts for design, creation, and support of archive, and teaching/learning/assessment tools (part could be subcontracting with OLT or Coop students for discrete projects)	\$120,000
Server(s) dedicated to teaching resources (one-time cost)	\$6,000
Operating costs, including travel for dissemination and learning	\$5,000
<b>Total:</b>	<b>\$400,000</b>