



# Carl Wieman Science Education Initiative

## Achieving highly effective university science education

Sarah Gilbert, Acting Director



### Introduction

The Carl Wieman Science Education Initiative (CWSEI) is a 6-7 year program (2007—~2013) at the University of British Columbia aimed at achieving sustainable institutional change towards effective, evidence-based undergraduate science education. This program funds departments to take a scientific approach to undergraduate education:

- 1) Establish what students should learn;
- 2) Scientifically measure what students are actually learning;
- 3) Use instructional approaches guided by research on learning and measures of student learning;

In this poster, we discuss the design of the SEI model and the departmental activities.

### Underlying Reasoning

#### Logical unit of change is the Department

Department is the cultural unit. Small scale change (one or a few courses involving a few faculty) is an important research step, but does not result in widespread changes in instructional practices. Need change to involve majority of faculty in department.

**Change must be driven by department** – Faculty are experts in their science fields. The faculty and department as a whole need to decide what students should learn, adopt or develop good measures of relevant learning, and change instructional approaches.

**Evidence is key** – Most faculty will feel that change is necessary if there is good data showing students aren't getting important ideas/concepts, or evidence of students seeing subject as less interesting and/or useful after taking course.

**Additional resources are needed to support the process of change** – These changes take faculty time.

#### Effective teaching can be more efficient than current practices (and more fun!)

Re-use of good materials, less repetition/overlap of material, team teaching large courses, effective use of technology, etc. can result in lower resource requirements in long-term.

### Approach

#### Significant 1-time investment of resources

Concentrated (~1-2 M\$/dept. over 6 years) to fund change activities; maintenance of change should not require extra resources.

**Departments compete for funding** – Criteria: commitment and readiness to undertake widespread sustained effort to improve undergrad education

**Science Teaching & Learning Fellows (STLF)** – Temporary positions funded by CWSEI; work with faculty to measure learning, change courses, evaluate curriculum, ...

**Departmental culture change** – Need majority of the faculty and courses to be involved and mechanisms to sustain change

**Archive, Re-use, Improve materials** – Developing SEI course materials archival system

### SEI Central

#### STLF Development

Frequent meetings with considerable effort and emphasis on:

- Development of STLF's understanding of how people learn, effective pedagogy, evidence supporting educational approaches
- Science education research base & how to do research
- Effective ways to work with faculty & communication of good practices

#### Faculty/Department Interactions

- Regular meetings with CWSEI departmental Directors, department Heads/Chairs, Dean, some meetings with individual faculty & whole depts.
- Lecture series, workshops (learning goals..), yearly event - SEI activities

#### Materials Archive System (sei.ubc.ca)

Developed online course materials system:

- Course materials (e.g. lecture notes, clicker questions, assignments, ...)
- Instructor comments on use of materials and reflections on course
- Common student difficulties & how to address them

What should students learn?

What are students learning?

Which instructional approaches improve student learning?

### STLF Model

Department-based Science Teaching & Learning Fellows as agents of change in university education

STLF = Science Teaching and Learning Fellow

#### An STLF:

- Is expert in particular science discipline (usually recent PhD),
- Hired by the science dept.,
- Given considerable ongoing training & guidance on science education fundamentals by CWSEI central & other STLFs,
- Works with faculty to develop learning goals, measure learning, change assessment & instruction...

#### Examples:

- Facilitate course working groups (group of faculty teaching course and subsequent course if applicable) – develop learning goals and pre-post assessments
- Gather data on student thinking about topics (difficulties, misconceptions) via interviews, analyzing exams, homework, conducting & observing informal problem solving sessions, listening to student discussions during in-class activities, pre-post concept tests and attitudinal surveys ...
- Develop course materials with faculty
- Serve as department resource on pedagogy – ranging from casual discussions to conducting seminars/workshops



### Departmental Activities

www.cwsei.ubc.ca/departments

#### Typical new aspects incorporated in courses (each course will not necessarily have all of these):

- ❖ Clearly articulated learning goals for students & faculty
- ❖ Pre-reading assignments & quizzes
- ❖ Efforts to increase student interest and motivation to learn subject
- ❖ Interactive engagement targeted at learning goals (deliberate practice to develop expertise)
  - Clicker questions and peer discussion – especially in large classes
  - In-class group activities – effective even in large (250 student) classes
- ❖ Homework problems targeted at learning goals
- ❖ Pre-post testing to measure learning, surveys to gauge perceptions about science ...

#### Earth & Ocean Sciences

- Full funding 2007, currently 2 **STLFs**, over 70% of faculty have used SEI support to improve their teaching, and the majority have made substantial changes to multiple aspects of how they help students learn
- Systematic approach to changing undergrad education
- Completed 23 course transformations & 10 more courses "unofficially" improved
- Many faculty spontaneously incorporating interactive engagement in other courses
- Program now concentrating on consultations and sustainability
- Developed TA training program and attitudinal survey
- Conducted exit survey of graduates & employer survey
- In process of determining curriculum goals for different majors streams

#### Physics & Astronomy

- Seed funding 2007, full funding 2008; currently 4+ **STLFs**, ~25 faculty involved
- Working on 15 courses, 1<sup>st</sup> year – 4<sup>th</sup> year
- Developed successful TA training program
- Administered extensive diagnostic testing of conceptual understanding
- Several extensively transformed courses (little or no lecturing), including 1<sup>st</sup> year and upper level courses.
- Developed learning goals for electricity and magnetism multi-year curriculum

#### Math

- Seed funding 2008, full funding 2010, currently 4 **STLFs**, ~14 faculty involved
- Calculus courses undergoing transformation; developed learning goals, incorporating interactive engagement
- Assessed & improved calculus workshops and computer labs in 6 courses
- Proofs skills: developing pre-post diagnostic, plan to track development & retention of proof skills & expertise through curriculum
- Incorporating online homework in multiple courses

#### Life Sciences (Depts. of Botany, Microbiology & Immunology, and Zoology)

- Funding 2007, recent ramp-up of efforts to full program level, currently 5 **STLFs**
- Concentrating on 2<sup>nd</sup> & 3<sup>rd</sup> year fundamentals courses in the newly-defined Biology curriculum: Cell Biology, Ecology, Genetics, Physiology, and Evolution
- Developing numerous tests of conceptual understanding

#### Computer Science

- Seed funding 2007, full funding 2008; currently 1 **STLF**, ~25 faculty involved
- Working on courses ranging from 1<sup>st</sup> to 4<sup>th</sup> year level
- Developed learning goals (both course-level and topic-level) for all 1<sup>st</sup> & 2<sup>nd</sup> year core courses
- Planning a longitudinal study of knowledge/skill retention and expertise development in a majors stream
- In the process of developing and validating the Computing Attitude Survey.

#### Chemistry

- Seed funding 2008, 3 faculty involved
- Concentrated on evaluation and redesign of large first year lab courses – extensive assessments developed
- Developed lab learning goals
- Implemented modified TA training
- Administered C-LASS CHEM (Attitudinal Survey) in multiple courses

#### Statistics

- Seed funding 2007, currently 1 **STLF**, ~5 faculty involved
- Working on 3 courses with focus on introductory statistics and introductory probability courses
- Conducted student interviews, developing learning goals, administered pre and post term student attitude surveys, introducing in-class activities and clicker questions
- Incorporating context-rich problems, adding homework assignments, improving labs
- 3 other courses now incorporating interactive engagement

#### Good:

**LOTS happening** (see above list of activities) rapidly growing # faculty involved, many courses being improved, new data from multiple disciplines on what is working and not.

**STLF Model works well in many circumstances**

**Pool of excellent STLF candidates out there**

**A number of examples of spontaneous adoption/involvement**

- Individuals trying out new teaching methods with minimal assistance
- Groups tackling curriculum issues following discussions about a course

#### Help from higher up

UBC Science Dean & Provost very supportive

#### Not so good:

##### Change is hard!

OK, we knew that, but it's harder than we thought; can be frustrating and discourage STLFs

**Significant minority of faculty resisting** (expected)

##### Particularly difficult if:

- Many faculty teach different sections of same course without coordination (hard to reach consensus)
- Don't have a critical mass of faculty who are open-minded about change
- Strong sense of personal "ownership" of course (rather than department ownership)
- Faculty lay all the blame for lack of learning on students

**Tyranny of content** – some faculty think that "covering" material is the same as "teaching" it