# 2009-10 End of Year Event

## Talks

**Overview of CWSEI progress (lots of data!)**— Carl Wieman

**Improving Student Study Habits: results of interventions**
Sara Harris & Louis Deslauriers

**Interactive Engagement: examples from UBC classes (video)**
Sarah Gilbert & department members

## Poster session 11-1:30 room 101

Details on everything being done and learned

## Workshop & Discussion

1:30 – 3:00pm, room 101 – **How to Most Effectively Measure the Learning that Matters** (workshop led by Carl Wieman)

3:15 – 4:30pm, room 101 – **Incorporating Writing in the Science Curriculum; what and how?** (discussion)
CWSEI “Trinity” for each course

1\textsuperscript{st}: Learning goals. (what should students be able to \text{\textit{do}}?)

2\textsuperscript{nd}: Good assessment (validated tests)

3\textsuperscript{rd}: Improved teaching methods (research based, improve learning)

Materials, assessment tools, homework, notes ... saved, reused, improved.

Making teaching more effective, and more rewarding for faculty and students
Carl Wieman Science Education Initiative
Started 3 years ago ⇒ widespread improvement in science education.
Departments at various scales and levels of maturity
Large scale mature-- Earth and Ocean Sciences
Large scale younger-- Physics and Astronomy
Computer Science
Math
Smaller scale programs -- Chemistry, Statistics, Life Sciences

$2 M gift from David Cheriton for math and comp. sci.
Today--focus on data

1. How many courses/faculty transformed?

2. How much better is the learning?
   a. learning
   b. engagement
   c. innovative problem solving

3. But does it stay learned? (retention)

4. Reaching all students. Turning low performers into high

5. Blizzard of data on improvement from across the departments (appetizer for posters)
1. How widespread is the change-- EOS, most mature, full 3 year effort.

24 courses transformed.
18 with formal CWSEI support
6 with strong informal and moral support

~ 26 faculty involved

**typical new things**
- clearly articulated learning goals for students and faculty
- pre-reading assignments & quizzes
- clicker questions and peer discussion
- worksheets & in-class group activities
- group exams
- team projects
- pre-post testing to measure learning, ...

**much more active learning and feedback,**
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Description</th>
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<tbody>
<tr>
<td>EOSC 111</td>
<td>Laboratory Exploration of Planet Earth</td>
<td></td>
<td>- Completed - First yr Lab - approx 100 per semester</td>
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<tr>
<td></td>
<td>Sara Harris</td>
<td></td>
<td>- All hands on, - lots of group work, - individual and group quizzes</td>
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<tr>
<td>EOSC 112</td>
<td>The Fluid Earth: Atmosphere and Ocean</td>
<td></td>
<td>- been through about 2 years of EOS-SEI - service course for anyone at UBC - about 350/year (split between 2 sections)</td>
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<tr>
<td></td>
<td>Sara Harris, Roger Francois, William Hsieh</td>
<td></td>
<td>- clickers - online quizzes - article readings, quizzed, with feedback (rubrics)</td>
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<tr>
<td>EOSC 114</td>
<td>Natural Disasters</td>
<td></td>
<td>- Completed June’08 - 1st year exploratory course - over 1000 stu. per year</td>
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<tr>
<td></td>
<td>R. Stull and many others</td>
<td></td>
<td>Clickers on-line assignments</td>
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<tr>
<td>EOSC 210</td>
<td>Earth Science for Engineers</td>
<td></td>
<td>- Completed - Lecture and lab - 230 each September</td>
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<td></td>
<td>Erik Eberhardt, Uli Mayer, Stuart Sutherland</td>
<td></td>
<td>Clicker Qs, in each lecture. Activities and discussions in most lectures. Labs with group work and hands on activities</td>
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<tr>
<td>EOSC 211</td>
<td>Computer Methods in the Earth, Ocean and</td>
<td></td>
<td>- Second teaching term Sept. 2010 - 2nd year programming course lecture/lab - 55 students enrolled last term</td>
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<td></td>
<td>Atmospheric Sciences</td>
<td></td>
<td>In-class worksheets, pair-programming, name-sticks, pair and small group discussions, class discussions</td>
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<td></td>
<td>Richard Pawlowicz, Catherine Johnson</td>
<td></td>
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<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Delivery Method</td>
<td>Student Activities and Evaluation Tools</td>
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<tr>
<td>EOSC 212</td>
<td>Topics in Earth and Planetary Sciences</td>
<td>Completed June ‘09, 2nd year “science thinking” course</td>
<td>Team-based quizzes and inclass activities &amp; discussions, article reading and question posing workshop style classes, peer assessed presentations &amp; posters</td>
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<tr>
<td></td>
<td>M. Bostock, M. Jellinek</td>
<td>20 to 40 students per year</td>
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<tr>
<td>EOSC 220</td>
<td>Introduction to Mineralogy</td>
<td>Complete</td>
<td>3x5 cards used to answer questions in class, in-class activities, class discussion, labs have group work and group quizzes</td>
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<tr>
<td></td>
<td>Mary Lou Bevier</td>
<td>Mandatory intro. lab course for EOS students, 120 students enrolled</td>
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<tr>
<td>EOSC 221</td>
<td>Petrology</td>
<td>Completed</td>
<td>Wake up exercises (integrating activities into each lecture), some 3x5 cards, labs with group work and hands on, some &quot;authentic activity&quot; labs</td>
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<td></td>
<td>Maya Kopylova</td>
<td>Lecture and lab, 100 each January</td>
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<tr>
<td>EOSC 223</td>
<td>Field techniques</td>
<td>Minor support summer 2009</td>
<td>Lectures have regular activities and 3x5 cards to get feedback, Field activities</td>
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<tr>
<td></td>
<td>Mary Lou Bevier</td>
<td>Lectures and Field component</td>
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<tr>
<td>EOSC 252</td>
<td>Physics of geologic materials</td>
<td>First teach term completed</td>
<td>Lab exercises, in-class demonstrations with worksheets, aiming for interactive lecturing next yr.</td>
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<td></td>
<td>F. Herrmann</td>
<td>2nd yr “physics” course, 20 – 30 students each year</td>
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etc. for 3 more pages
2. But do these changes improve student outcomes? (learning, engagement, ...)
Hard to tell in most courses because no pre-transform data.

Data from example courses where similar transformations, and good pre transform and post transform data.

Louis Deslauriers and Ellen Schelew (physics)--- cleanest comparison study of teaching methods ever done. Will be landmark in science education research (as soon as they write it up for publication)
new-- *Louis Deslauriers (PD) and Ellen Schelew (grad std)*

**Perfect comparison of teaching methods:** identical sections (260 each), intro phys. 153, same material & time.

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**I**

Experienced highly rated instructor-- trad. lecture & ~2 cl. questions

same preparation
same attendance
same engagement
same midterm 1 & 2 grades

wk 1-11

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**II**

Experienced highly rated instructor--trad. lecture & ~2 cl. questions

wk 1-11

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**Wk 12-- competition**

**elect-mag waves**
Louis and Ellen (inexper.)
research based teaching

common exam on EM waves

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**elect-mag waves**
regular instructor
intently prepared lecture
transformed section

• pre-class reading assignments with quizzes
• in-class small group activities
• clicker questions with student-student discussion
• targeted instructor feedback guided by observations of student thinking
### Results

<table>
<thead>
<tr>
<th></th>
<th>II. Trad</th>
<th>I. Transformed.</th>
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</thead>
<tbody>
<tr>
<td>1. Attendance</td>
<td></td>
<td></td>
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<tr>
<td>pre</td>
<td>58%</td>
<td>58% (wk 10 &amp; 11)</td>
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<tr>
<td>during</td>
<td>58%</td>
<td>81%</td>
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<tr>
<td>2. Engagement</td>
<td></td>
<td></td>
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<tr>
<td>pre (back ½ room)</td>
<td>50%</td>
<td>50% (wk 10 &amp; 11)</td>
</tr>
<tr>
<td>during</td>
<td>50%</td>
<td>85%</td>
</tr>
<tr>
<td>3. Learning (test)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>above guess (23%)</td>
<td>41(1)%</td>
<td>74(1)%</td>
</tr>
<tr>
<td>S. D. = 13%</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>trad. ⟹ 0.58 x 0.5 = <strong>29% engaged</strong> for above average instructor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>trans. ⟹ 0.81 x 0.85 = <strong>69% engaged</strong></td>
<td></td>
</tr>
</tbody>
</table>

*other things practiced: scientific discourse, critiquing scientific arguments, sense-making, collaboration.*
But how did students feel about it?

“Q1. I really enjoyed the interactive teaching technique during the three lectures on E&M waves (Ch32).”

Q2 I feel I would have learned more if the whole phys153 course would have been taught in this highly interactive style.
Q6  I found the pre-reading to be very helpful to my learning:

Q5  What contributed most to my learning during these three lecture on E&M waves:
Q8  In class, the group discussions with my neighbors were very helpful to my learning:
What does such a class look like?

See upcoming video clips session.
Measuring student (dis)engagement. Erin Lane
Watch random sample group (10-15 students). Check against list of disengagement behaviors each 2 min.
What about advanced upper division courses?

Physics 408-- advanced optics

Taught by same instructor for several years-- continually working to improve.
He radically transformed this year.
Ended up covering same material in less time.

**Midterm exam grades:**

- Pre transformation (lecture) 56 +/- 3.1%
- Post transformation 77%

(Exams different, but three experts did blind rating of the exams. All concluded post transformation exam more difficult)
What about learning to think more innovatively? Learning to solve challenging novel problems

Jared Taylor and George Spiegelman

“Invention activities”—practice coming up with mechanisms to solve a complex novel problem. Analogous to mechanism in cell.

2008-9-- randomly chosen groups of 30, 8 hours of invention activities. This year, run in lecture with 300 students. 8 times per term. (video clip)
Plausible mechanisms for biological process student never encountered before

Average Number

Control
Structured Problems (tutorial)
Inventions (Outside of Lecture)
Inventions (During Lecture)
3. So research based teaching achieves much better learning & much greater engagement.

Does it stay learned?
(retention)
3. Mastery of quantum mechanics concepts—short & long term  Deslauriers & Wieman to be published

![Retention chart for quantum mechanics concept survey scores](chart_image)

- **Interactive engagement/practice:**
  - Score: 88%

- **Superb traditional lecturer:**
  - Score: 68%

Retention interval (Months)
4. Bringing up the bottom of the distribution

“*What do I do with the weakest students? Are they just hopeless, or is there anything I can do to make a difference?*”

a. To get such big improvements in average, have to impact entire distribution

b. Data on how to transform lowest performing students into medium and high.

Intervened with bottom 25% of students after midterm 1.

- Phys250 (engphys program, high selective and demanding), bottom 25% **averaged +20% improvement** on midterm 2!
- EOS climate science course. Very broad range of students.
- **Averaged +30% improvement!**
What magic does this?

Listen to next talk.

- All UBC science students can be successful
- A little help on how to learn goes a long way
Large scale survey (~ 600) and interviews on factors that UBC science students perceive as affecting academic performance

Ashley Welsh

An early finding
•Students overwhelmingly recognize they do not know how to study effectively. Is seen as major barrier to success, but find little help in learning how to study.
masses of other data
will overwhelm you with blizzard of info

Go to posters to get details and more results
Math 152 - Assessment of Matlab “for” loop mastery

- Correct: 60% (2008), 70% (2009)
- Incorrect: 30% (2008), 40% (2009)
- Blank: 10% (2008), 20% (2009)

Bar chart showing the distribution of correct, incorrect, and blank responses for the assessment of Matlab “for” loop mastery in 2008 and 2009.
Math 184--
intro calculus “workshops” part of course.
Last year collected data on how they were functioning,
(observations, surveys, examine correlation of student
marks with numerous factors.)

This year, made changes based on the data.
Math 184 Workshops – Correlation between workshop attendance and course grades

relevant # is (corr. coeff.)^2
Math 184 Workshops
Student Survey

The workshop problems ….

"... provide useful practice for solving problems on tests"

"... are related to material covered in class"
EOSC 211: Computer Methods in the Earth Sciences

Introduced technique of “Pair-Programming” from comp sci ed research:

Compared to previous year:
• Labs are completed about 15% faster
• Lab marks are about 10% higher
• Students are MUCH happier with the transformed course
6. I consider myself to be an effective teacher.

2008

2009
EOS 212-- using model based reasoning

**Pre & post-test scores**

<table>
<thead>
<tr>
<th>Score (%) bins</th>
<th>Number of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>90-100</td>
<td>2</td>
</tr>
<tr>
<td>80-89</td>
<td>10</td>
</tr>
<tr>
<td>70-79</td>
<td>12</td>
</tr>
<tr>
<td>60-69</td>
<td>10</td>
</tr>
<tr>
<td>50-59</td>
<td>4</td>
</tr>
<tr>
<td>&lt;49</td>
<td>2</td>
</tr>
</tbody>
</table>

EOS collecting data on time students studying in courses.

Relative amount of time for different courses across sci.
Phys 109 & Sci 1 Intro physics lab

“invention” activity to develop scientific reasoning

![Bar chart showing the fraction of students using histograms and standard deviation before and after the activity.](chart.png)
see posters to learn more about these and many more

Conclusions

1. It is possible to make widespread transformation in UBC science teaching-- many courses, many faculty.

2. CWSEI transformations lead to
   • much greater engagement,
   • much greater learning,
   • happier students.

Looking forward to great progress in coming year
third year quantum mechanics course--

Common questions on QM spin
pre-transform 2009 final exam  68%+/-3%

2010 midterm  76%+/-2%
(spent half as much time on topic)
physics lab diagnostic measurements

showing improvements, but more work needed
EOSC 211 Lab marks

Average mark on Lab

Lab number