Carl Wieman Science Education Initiative at the University of British Columbia

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)

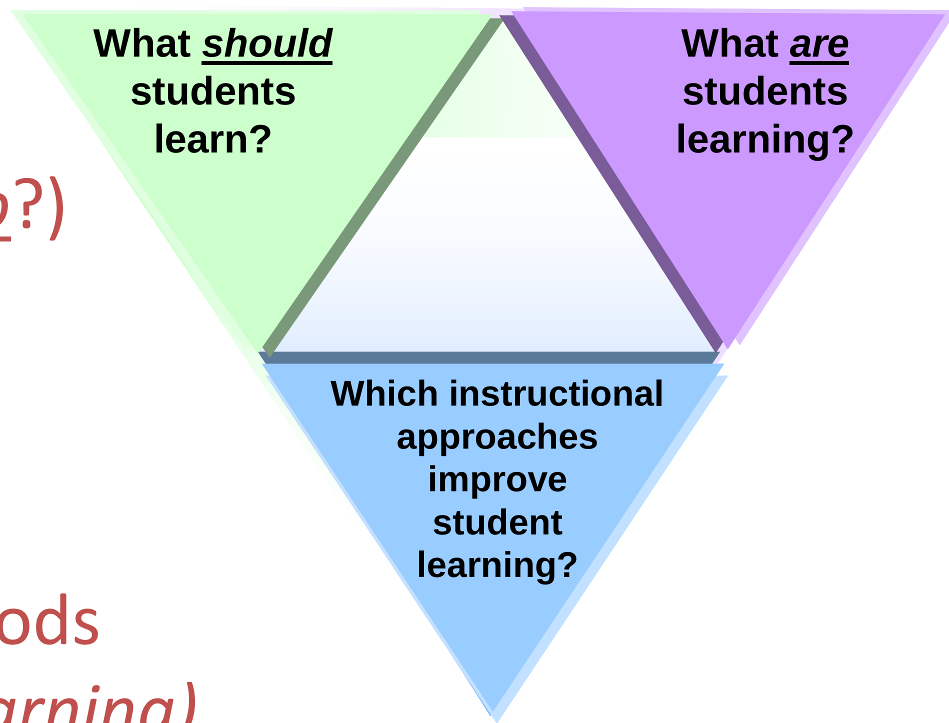
3:15 – 4:30pm, room 101 – **Incorporating Writing in the Science Curriculum; what and how?** (discussion)

CWSEI “Trinity” for each course

1st: Learning goals. (what should students be able to *do*?)

2nd: Good assessment (validated tests)

3rd: 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 $\Rightarrow$ 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

<u>typical new things</u>

- 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,

EOSC 111: Laboratory Exploration of Planet Earth Sara Harris	- Completed - First yr Lab - approx 100 per semester	- All hands on, - lots of group work, - individual and group quizzes
EOSC 112: The Fluid Earth: Atmosphere and Ocean Sara Harris, Roger Francois, William Hsieh	- been through about 2 years of EOS-SEI - service course for anyone at UBC - about 350/year (split between 2 sections)	- clickers - online quizzes - article readings, quizzed, with feedback (rubrics)
EOSC 114: Natural Disasters R. Stull and many others	- Completed June'08 - 1st year exploratory course - over 1000 stu. per year	Clickers on-line assignments
EOSC 210: Earth Science for Engineers Erik Eberhardt, Uli Mayer, Stuart Sutherland	- Completed - Lecture and lab - 230 each September	Clicker Qs, in each lecture. Activities and discussions in most lectures. Labs with group work and hands on activities
EOSC 211: Computer Methods in the Earth, Ocean and Atmospheric Sciences Richard Pawlowicz, Catherine Johnson	- Second teaching term Sept. 2010 - 2nd year programming course lecture/lab - 55 students enrolled last term	In-class worksheets, pair-programming, name-sticks, pair and small group discussions, class discussions

EOSC 212: Topics in Earth and Planetary Sciences M. Bostock, M. Jellinek	- Completed June '09 - 2nd year "science thinking" course - 20 to 40 students per year	- team-based quizzes and inclass activities & discussions - article reading and question posing workshop style classes - peer assessed presentations & posters
EOSC 220: Introduction to Mineralogy Mary Lou Bevier	- Complete - mandatory intro. lab course for EOS students - 120 students enrolled	3x5 cards used to answer questions in class, in-class activities, class discussion, labs have group work and group quizzes
EOSC 221: Petrology Maya Kopylova	- Completed - Lecture and lab - 100 each January	Wake up exercises (integrating activities into each lecture), some 3x5 cards, labs with group work and hands on, some "authentic activity" labs
EOSC 223: Field techniques Mary Lou Bevier	- Minor support summer 2009 - Lectures and Field component	lectures have regular activities and 3x5 cards to get feedback, Field activities
EOSC 252: Physics of geologic materials F. Herrmann	- First teach term completed - 2nd yr "physics" course - 20 – 30 students each year	- lab exercises - in-class demonstrations with worksheets - aiming for interactive lecturing next yr.

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.

I

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

II

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

wk 1-11

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

wk 1-11

Wk 12-- **competition**

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

elect-mag waves
regular instructor
intently prepared lecture

common exam on EM waves

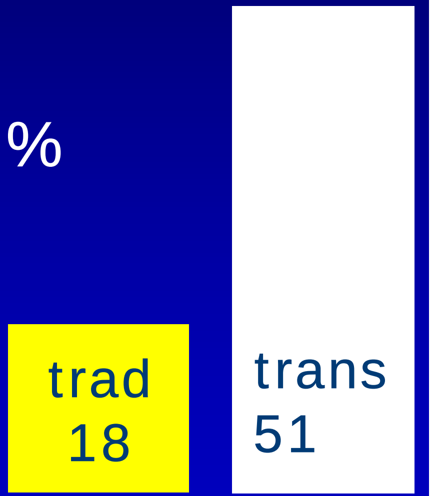
transformed section

- 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

		II. Trad	I. Transformed.	
1. Attendance	pre	58%	58%	*(wk 10 & 11)*
	during	58 %	**81%**	
2. Engagement (back ½ room)	pre	50%	50%	*(wk 10 & 11)*
	during	50 %	**85%**	
3. Learning (test)		41(1)%	74(1) %	
above guess (23%)		**18%**	**51%**	

S. D. = 13%



trad. ⇒0.58 x 0.5 = **29% engaged**

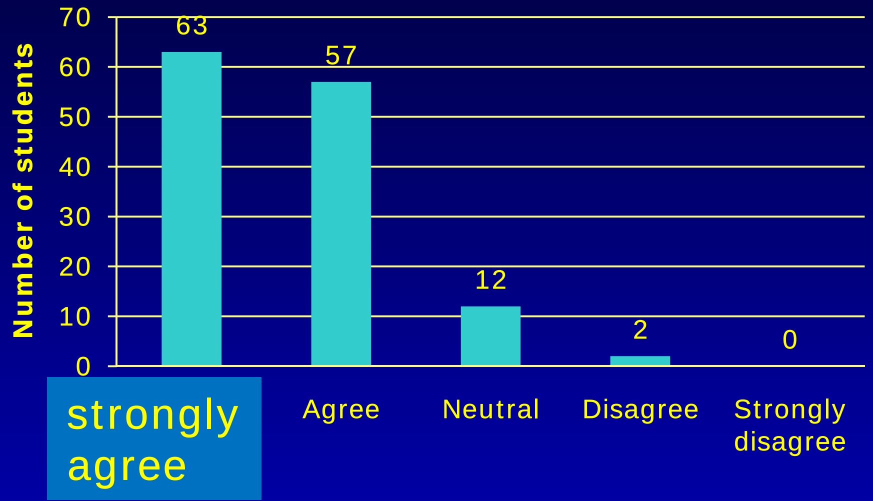
for above average instructor

trans. ⇒0.81 x 0.85 = **69% engaged**

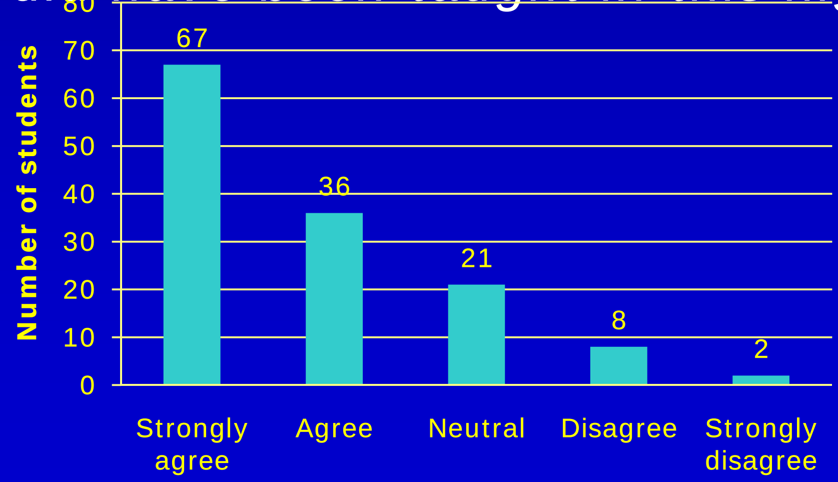
other things practiced: scientific discourse, critiquing scientific arguments, sense-making, collaboration.

But how did students feel about it?

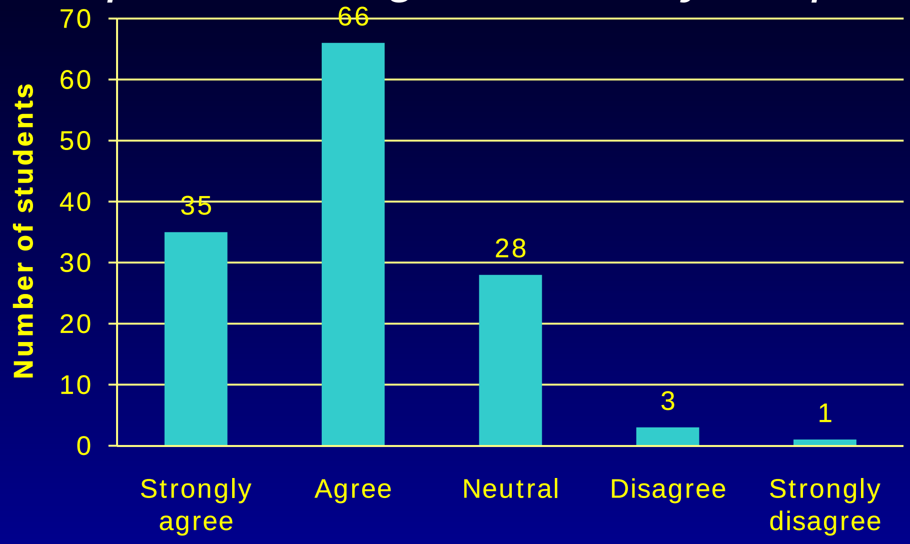
"Q1. I really enjoyed the interactive teaching technique during the three lectures on E&M waves (Ch32)."



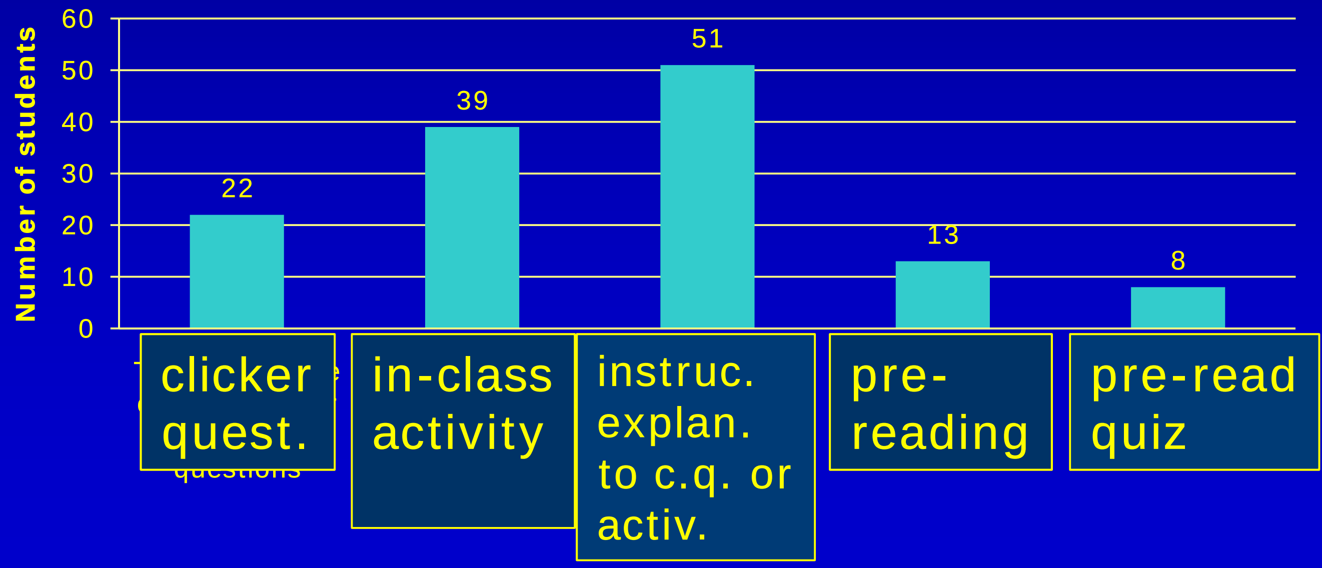
Q2 I feel I would have learned more if the whole phys153 course would have been taught in this highly interactive style.



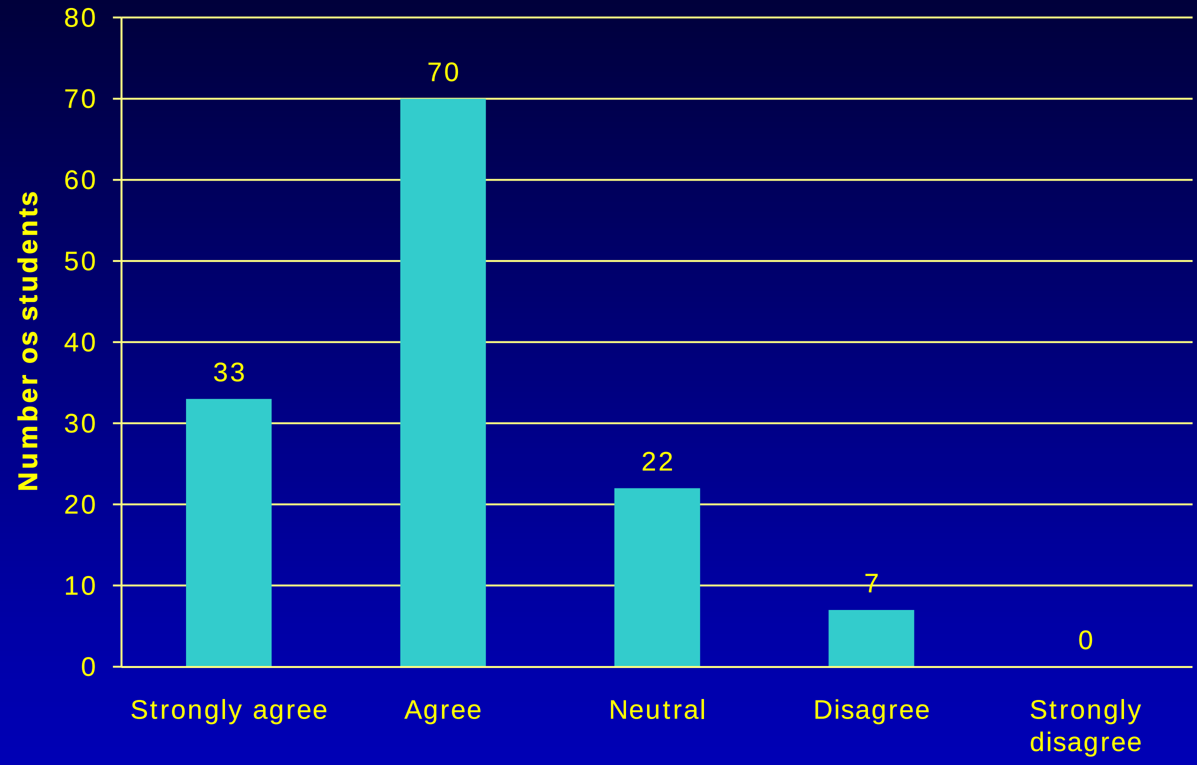
Q6 I found the pre-reading to be very helpful to my learning:



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:

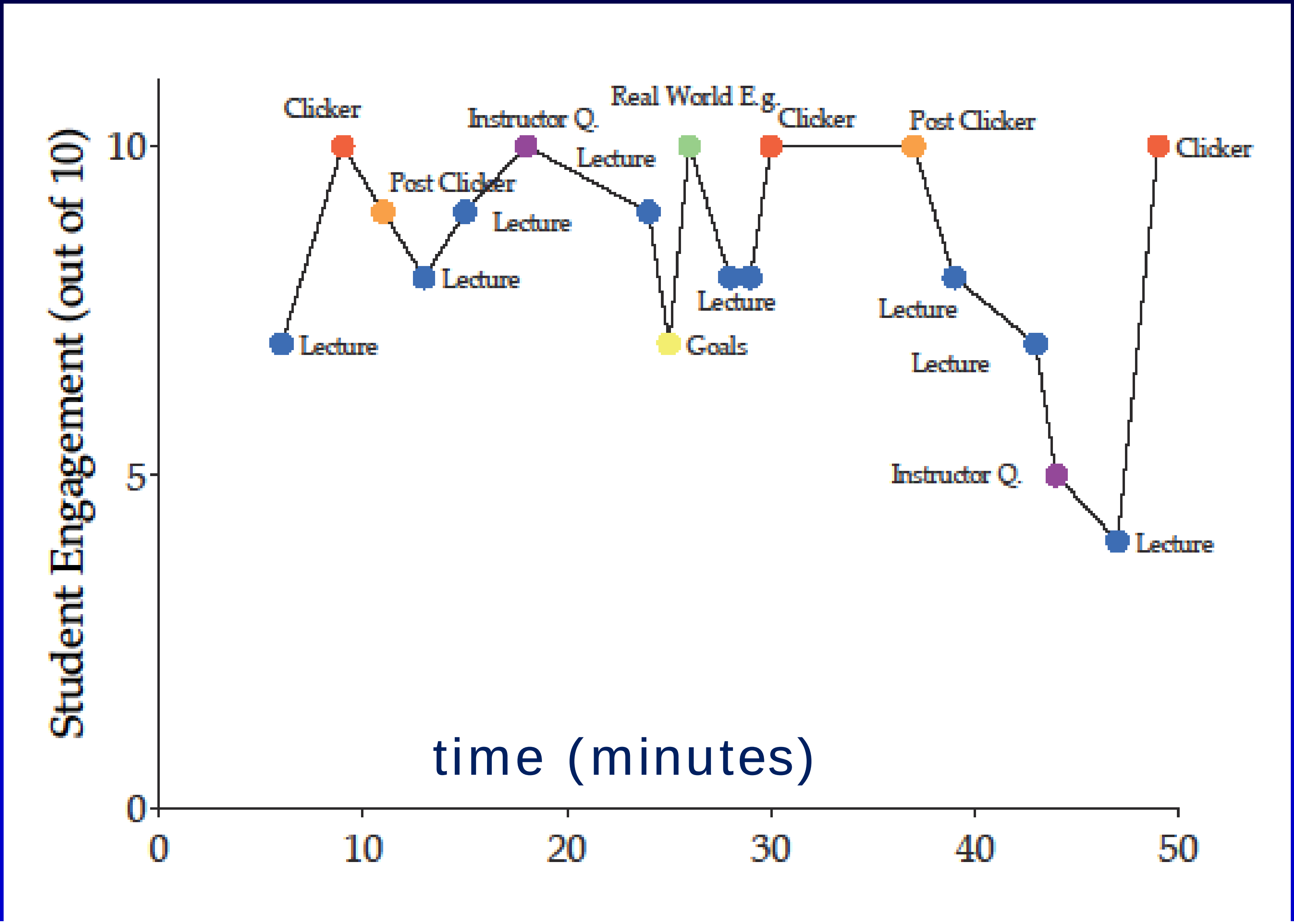


What does such a class look like?

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

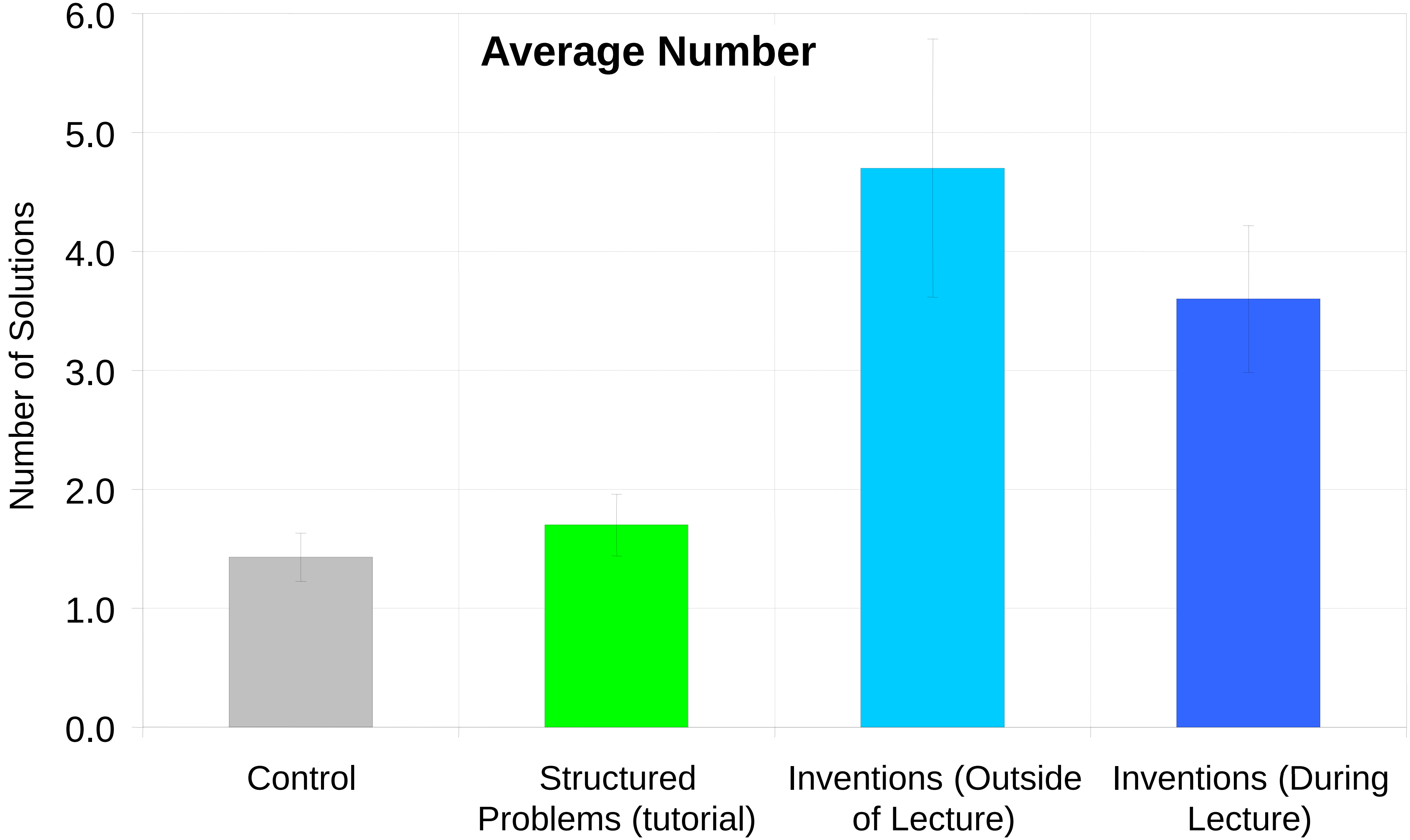
Jared Taylor and George Spiegelman

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

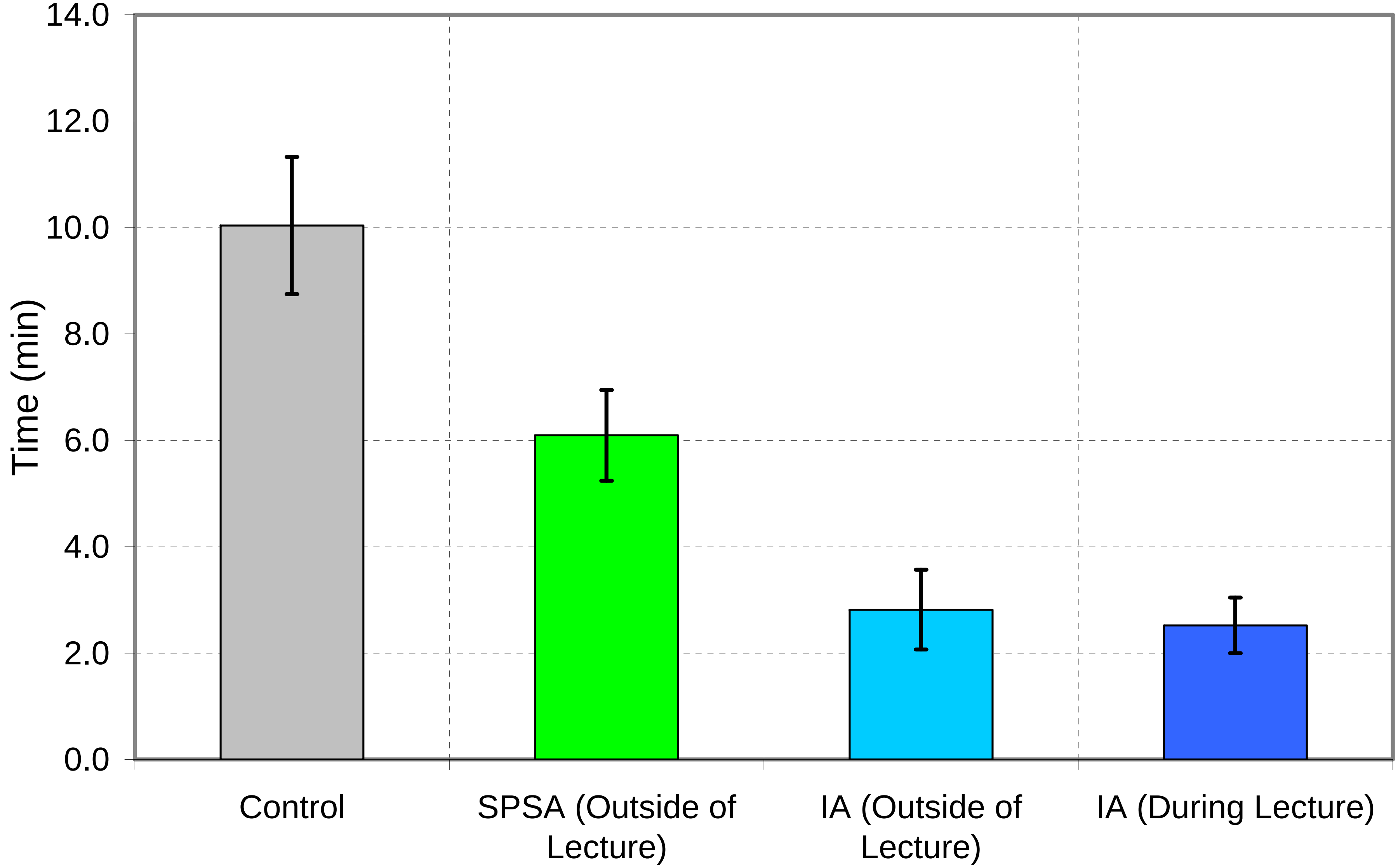
2008-9-- randomly chosen groups of 30, 8 hours of invention activities.

This year, run in lecture with 300 students. 8 times per term. (video clip)

Plausible mechanisms for biological process student never encountered before



Average Time to First

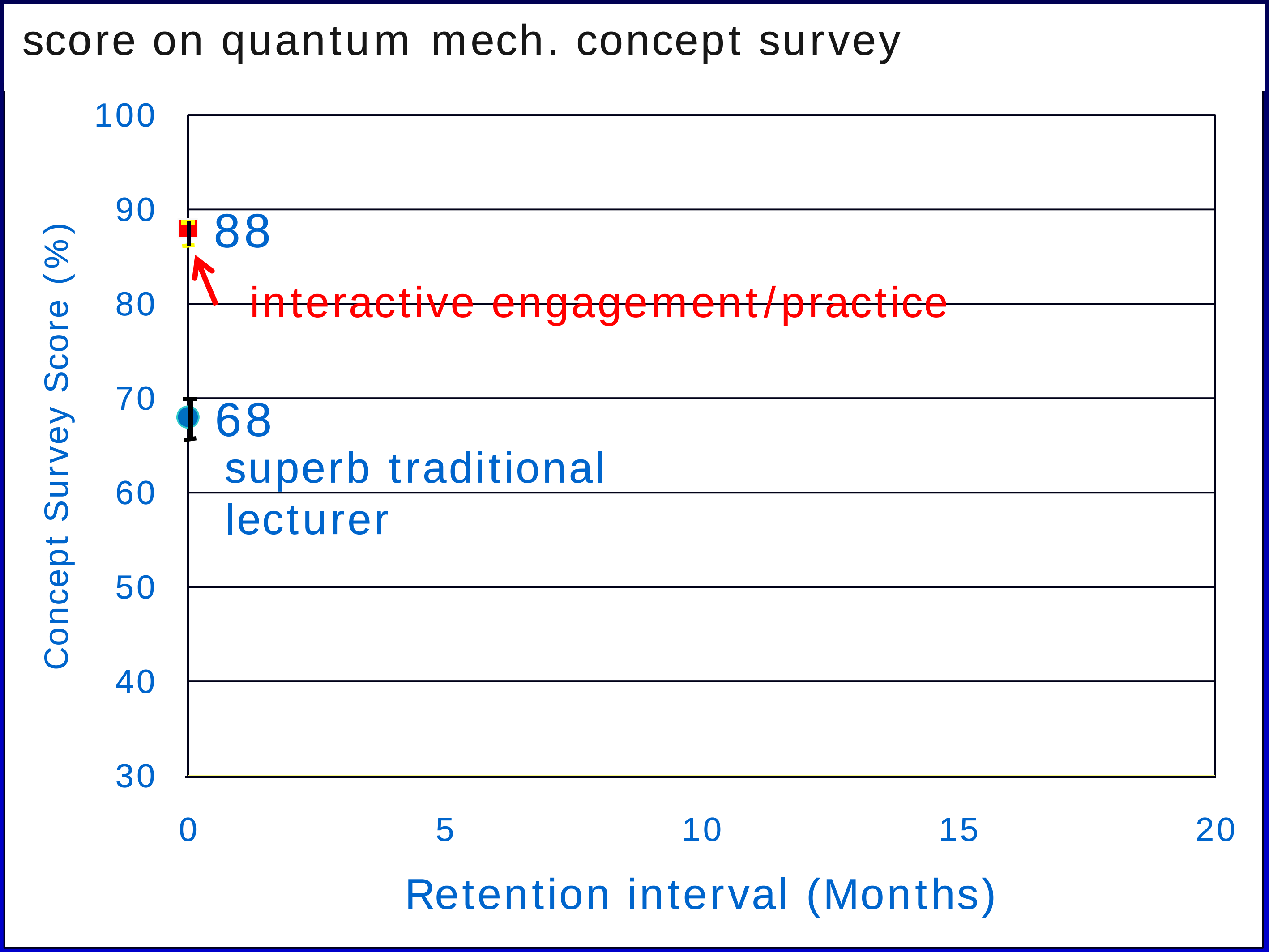


3. So research based teaching achieves much better learning & much greater engagement.

Does it stay learned?
(retention)

3. Mastery of quantum mechanics concepts-short & long term

Deslauriers & Wieman to be published



4. Bringing up the bottom of the distribution

Deslauriers, Lane, Harris, Wieman

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

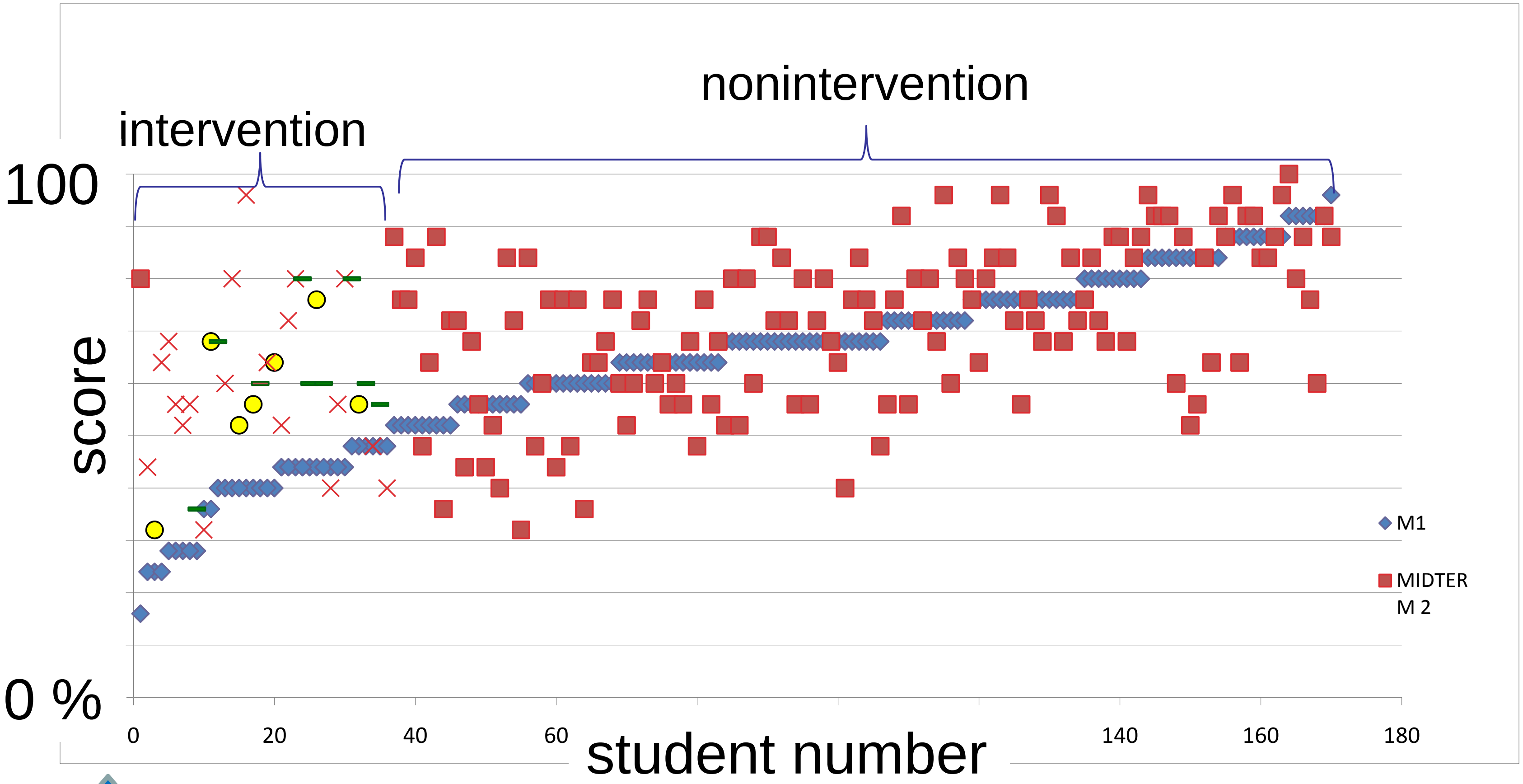
a. To get such big improvements in average, have to impact entire distribution

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!**



midterm 1 score

,& X, midterm 2 score

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

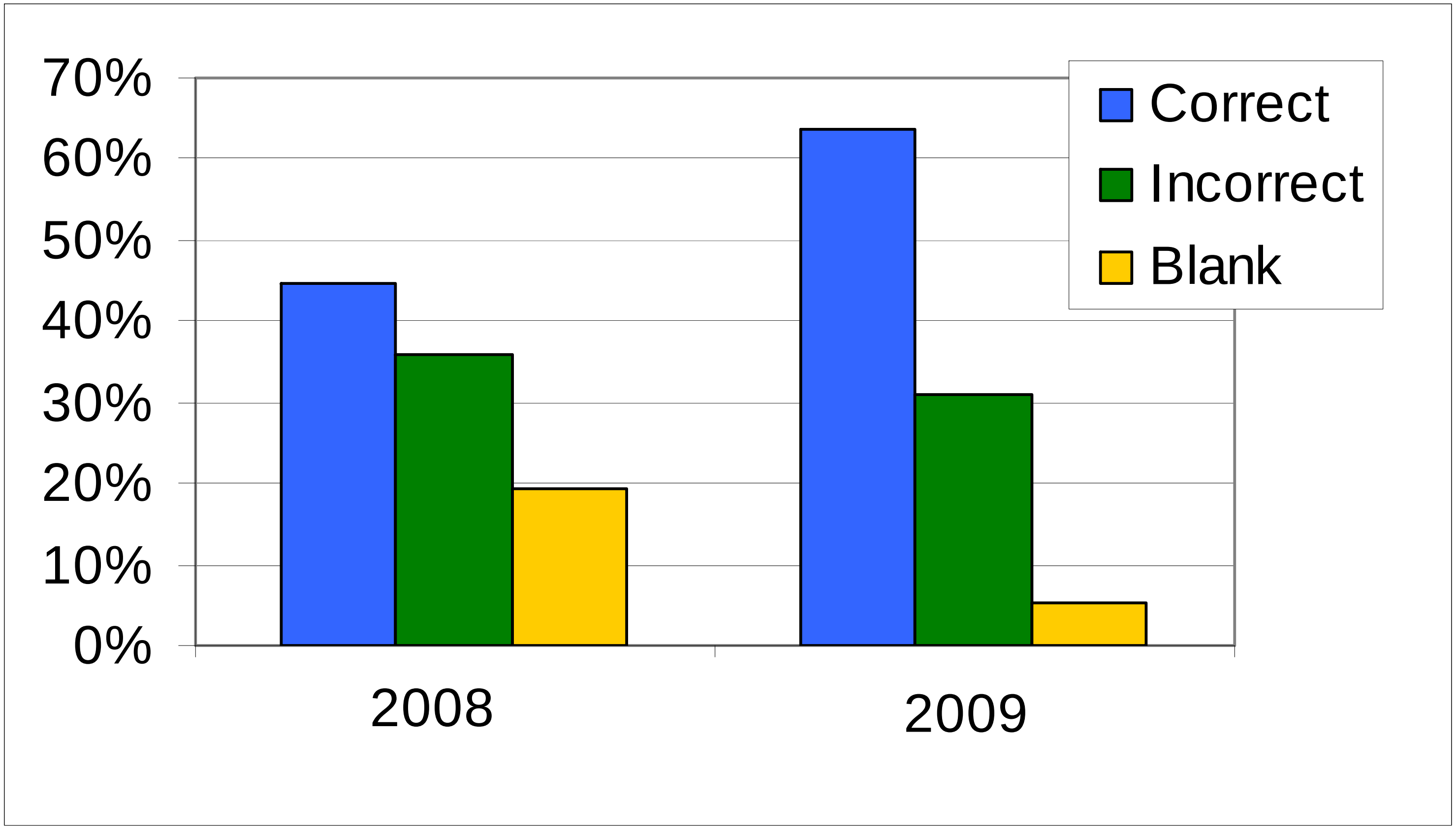
An early finding

- 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

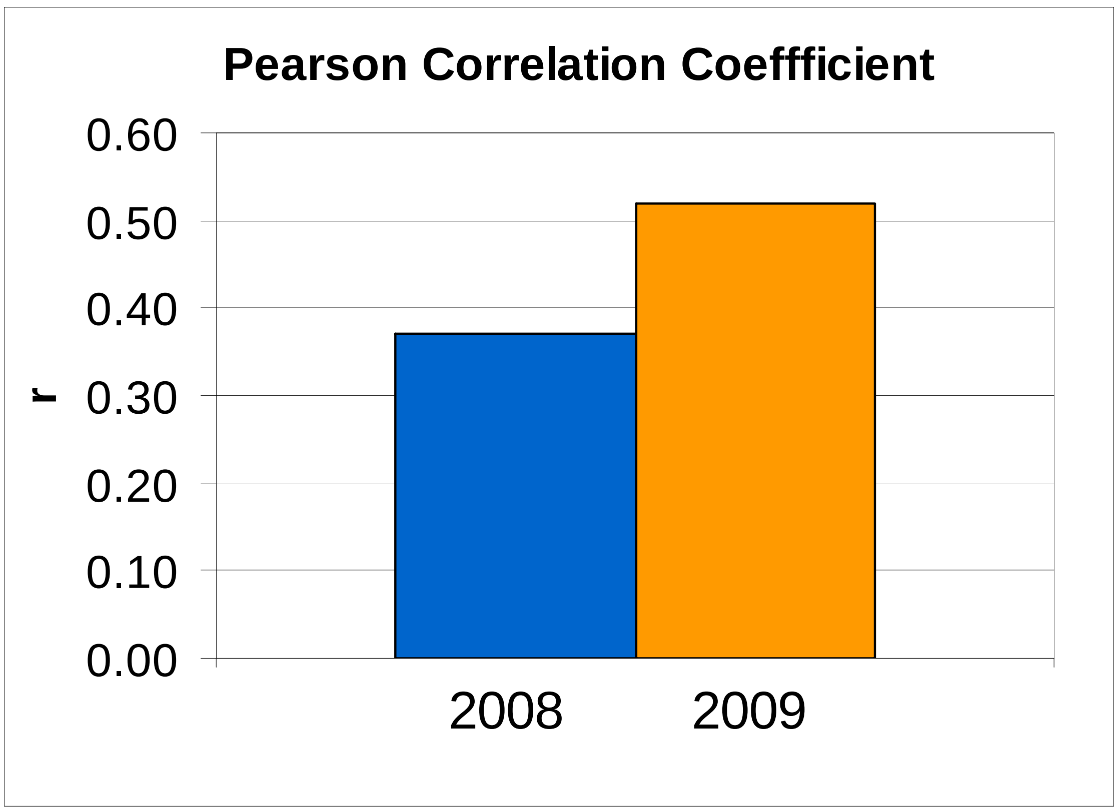
Math 152 - Assessment of Matlab “for” loop mastery



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.

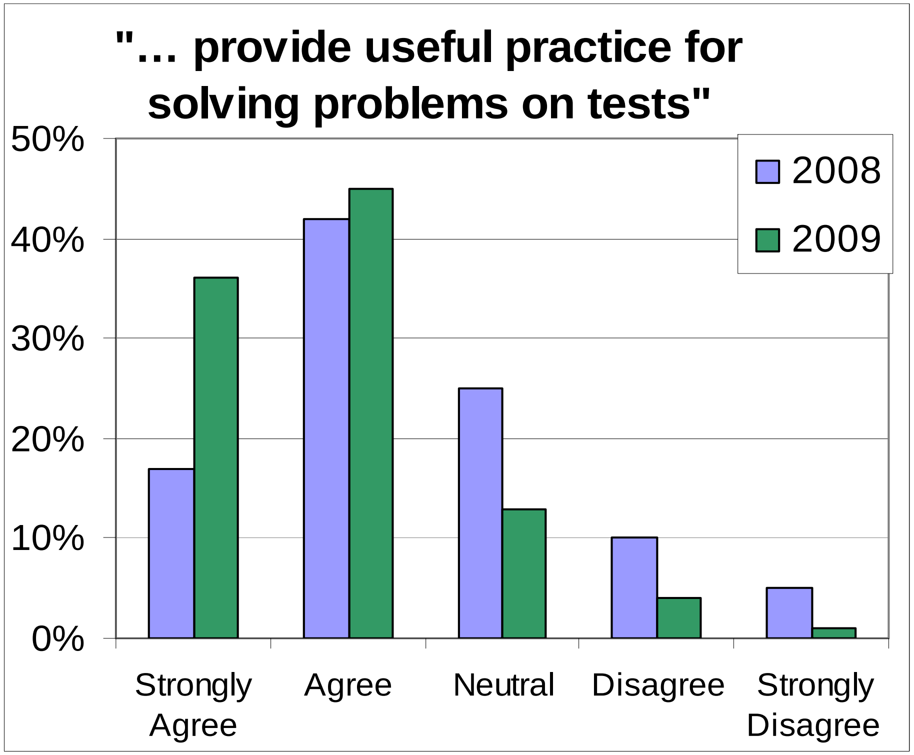
Math 184 Workshops – Correlation between workshop attendance and course grades

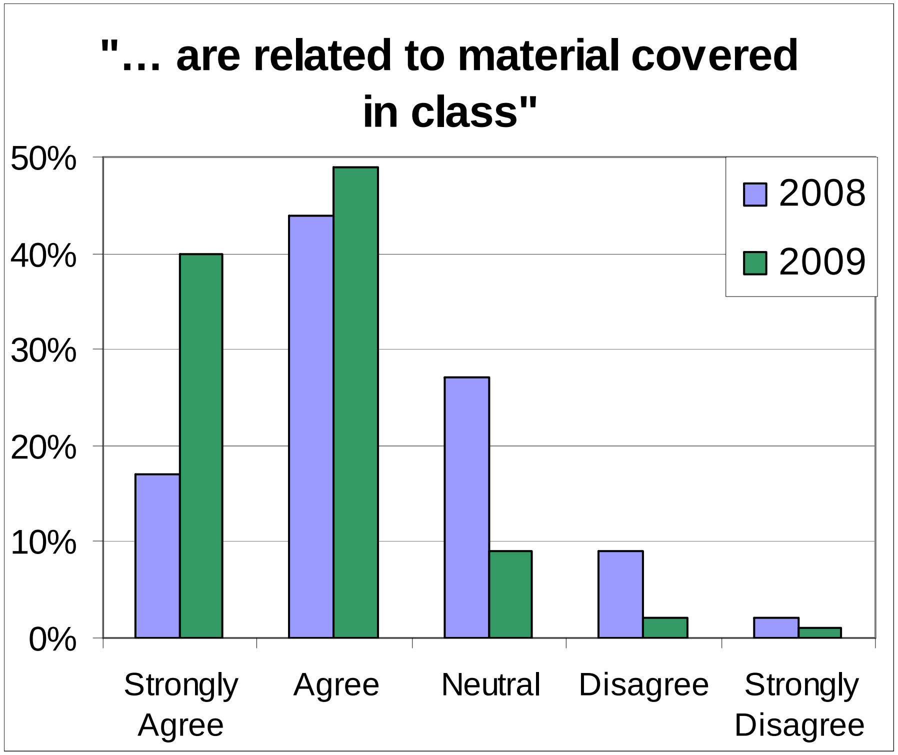


relevant # is (corr. coeff.)^2

Math 184 Workshops
Student Survey

The workshop problems ….





EOSC 211: Computer Methods in the Earth Sciences

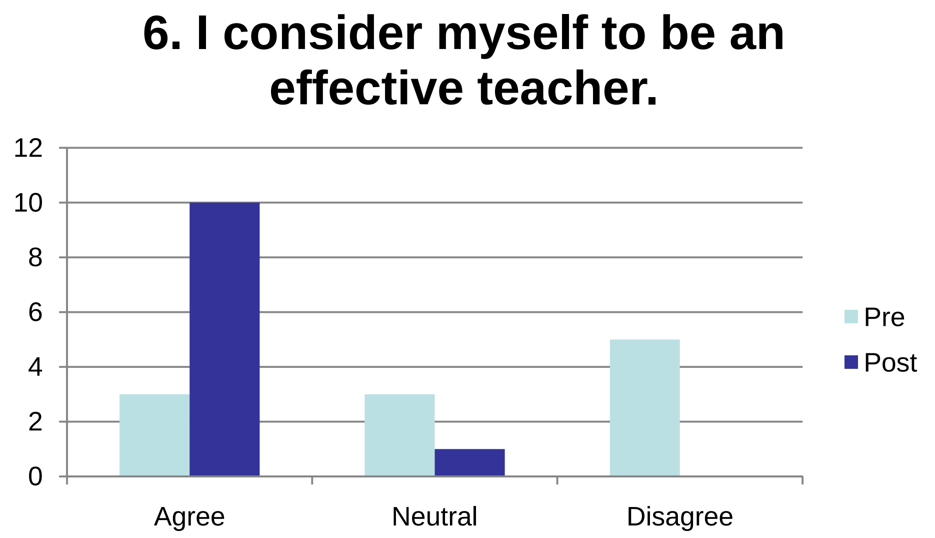
Introduced technique of "Pair-Programming" from comp sci ed research:

Compared to previous year:

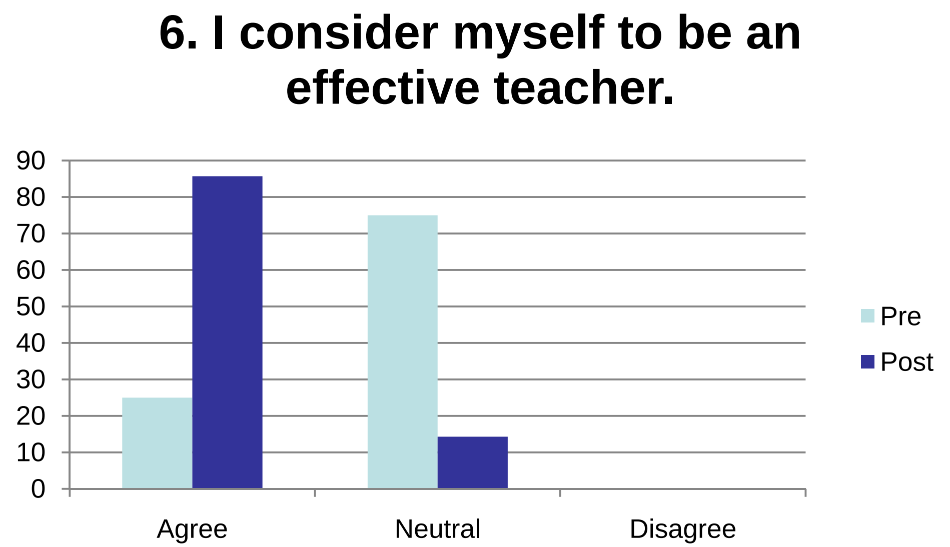
- Labs are completed about 15% faster
- Lab marks are about 10% higher
- Students are MUCH happier with the transformed course

EOS Impact of TA training program

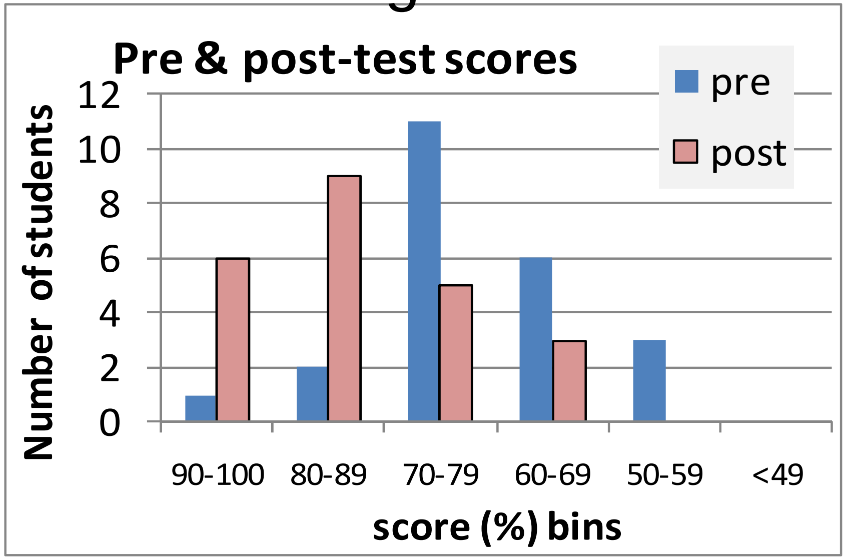
2008

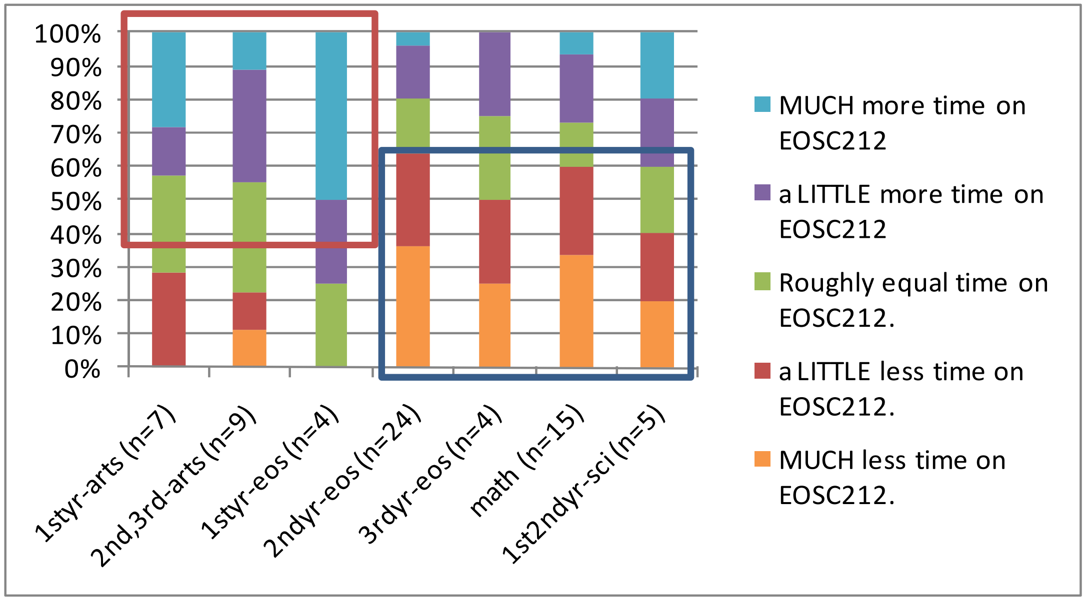


2009



EOS 212-- using model based reasoning



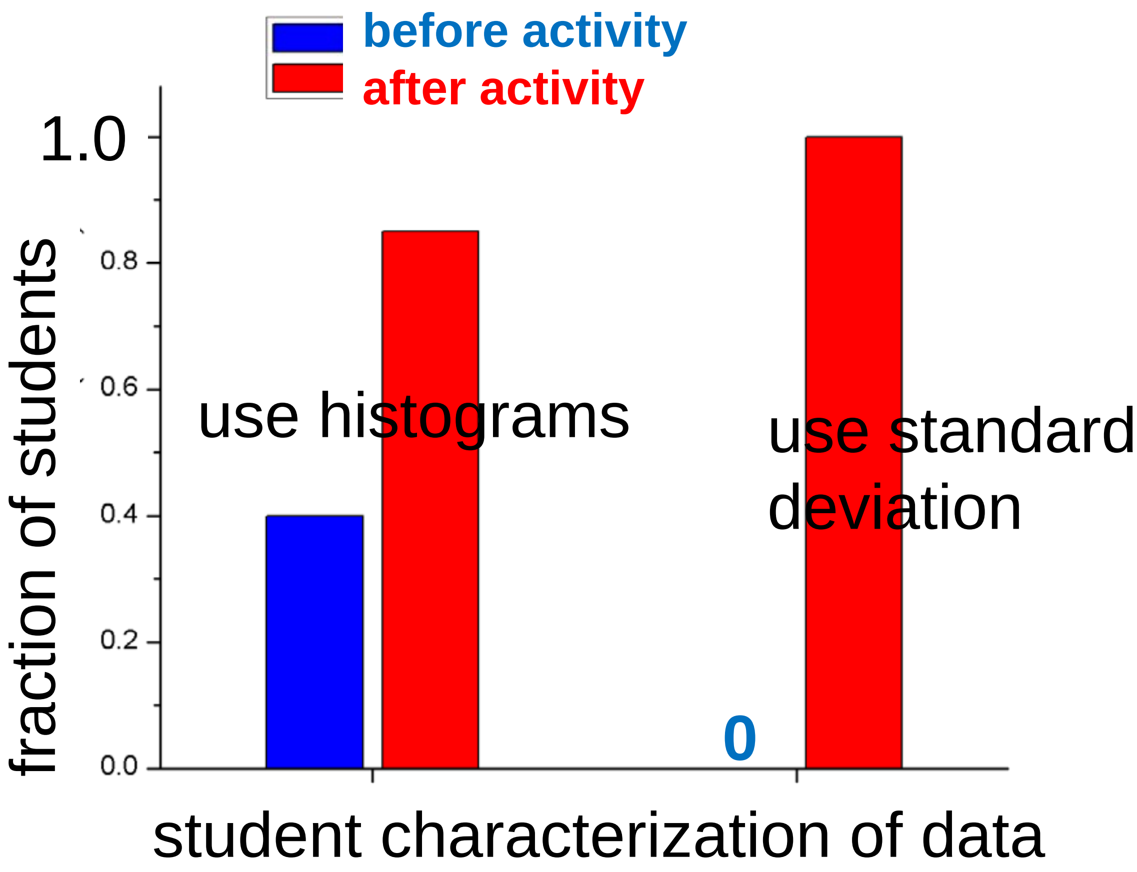


EOS collecting data on time students studying in courses.

Relative amount of time for different courses across sci.

Phys 109 & Sci 1 Intro physics lab

“invention” activity to develop scientific reasoning



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.

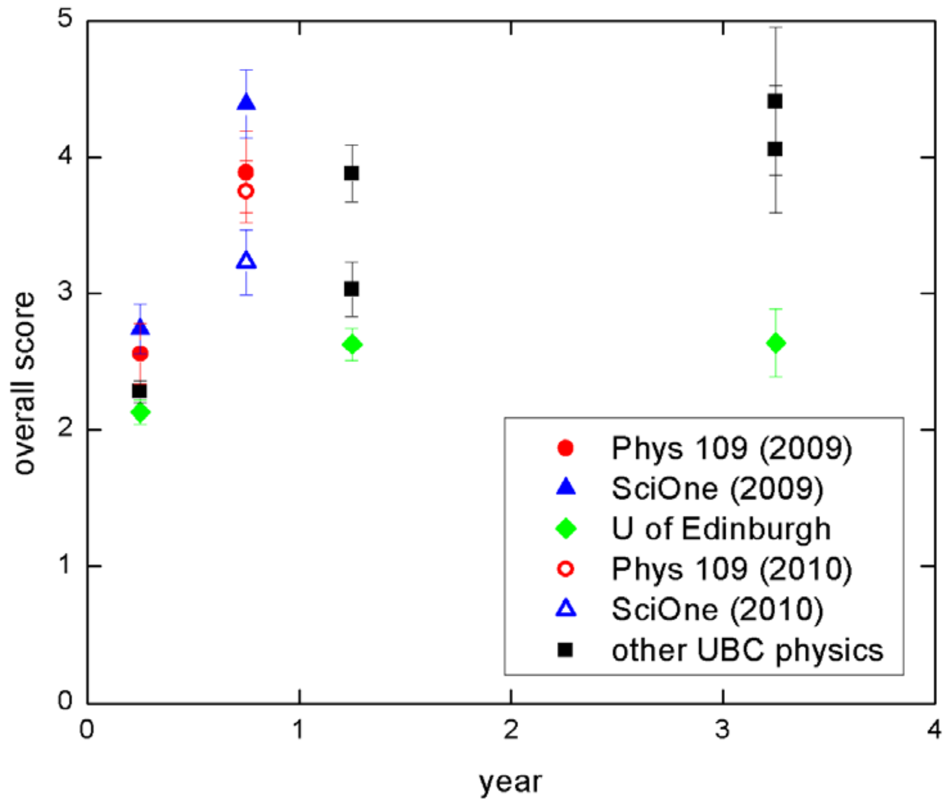
Looking forward to great progress in coming year third year quantum mechanics course--

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