THE UNIVERSITY OF BRITSH COLUMBIA

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Carl Wieman Science Education Initiative

at the University of British Columbia

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Departments Involved:
Chemistry
Computer Science
Earth & Ocean Sciences
Life Sciences
Mathematics
Physics & Astronomy
Statistics

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CWSEI Annual End-of-Year Event

The Carl Wieman Science Education Initiative has had its third annual "End-of-Year" Event on April 27. This was a campus-wide event that not only gave science departments opportunities to share their accomplishments and plans for the future across disciplines but also allowed the rest of the university to learn about their progress to date on improving undergraduate science education.

Three years into the initiative, there are now widespread changes and improvements across all science departments at various scales and levels of maturity. This was showcased through a poster session displaying nearly 40 posters presented by Science Teaching and Learning Fellows (STLF), faculty members, and undergraduate/graduate students involved in the CWSEI efforts. This session was an integral part of the event that provided opportunities for people to share the details of the work they have done and learned, exchange ideas across disciplines, and have conversations about their efforts.

Joshua Caulkins, EOS Science Teaching & Learning Fellow with Ashley Welsh, CWSEI Grad Research Assistant during the End-of-Year Poster Session.

What is an STLF?
An expert in a discipline who works collaboratively with faculty members to implement changes in teaching & assessment for a course.

A Little Help on How to Learn Goes a Long Way

Transforming the lowest performing students

Typically, an intervention to help low performing students would involve providing resources such as extra review sessions, office hours, and distributing additional practice problems. However, studies have shown that most of the students that avail themselves to these resources are in fact the high performing students rather than the lower performing students. So, what happens to the weakest students? Is there something an instructor can do to make a difference?

In an attempt to make a difference, an intervention study was conducted in two courses (Physics 250 and Earth & Ocean Sciences 112).

<u>How it was done</u>

After the first midterm exam, the lowest performing students in each course were sent a personalized email by the instructor expressing concern for their performance and asking them to come meet to discuss how they might improve. In Physics 250, the email was sent to those who scored at the bottom 25% of the class. In EOSC 112, a very similar email was sent to those who failed the exam and reported studying more time than the class median (6 hours). A different email was sent out to another group of students in EOSC 112 who failed the exam and reported study-

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Traditional Lecturing vs. Active Learning—

Demonstration of a dramatic difference in student learning

It has been observed that students in physics struggle with the basic concept of electromagnetic waves. In response to these findings, Louis Deslauriers (Physics STLF) and Ellen Schelew (Physics graduate student) decided to conduct a study comparing student learning in two different sections of the same 1st year physics course with one section using the traditional lecturing method and the other using a research-based style of teaching involving highly interactive learning.

How the study was done

These two sections were taught by two different highly-rated instructors. During the first 11 weeks of the course, it was found that these two sections were essentially the same as measured by student attendance, engagement, and performance on the 1st and 2nd midterm exams, and a test of knowledge of electricity and magnetism concepts.

Then starting week 12, while the instructor of Section 1 maintained his traditional lecture style of teaching, the instructor of Section 2 decided to take a radically new approach and allowed Louis Deslauriers and Ellen Schelew to lead the class on electromagnetic (EM) waves using research-based active learning techniques. This transformed section included pre-reading assignments with quizzes, in-class small group activities, clicker questions with student discussion, targeted instructor feedback guided by observations of student thinking, and very little lecturing.

Study Results

Attendance: The attendance in both sections before EM waves module (Week 12) was quite similar at about 58%. However, during the EM waves module, the attendance for the transformed section increased to 81% while it remained unchanged for the traditionally taught section.

Student Engagement: The engagement of students before and during the EM waves module was measured for both sections by several trained experts seated at various locations in the classroom. The research based protocol involved the periodic monitoring of a group of students (between 10 and 15 students).

Based on this assessment, student engagement for both of these sections prior to transformation measured at about 50%. During transformation, this number escalated to 85% in the transformed section while it remained constant in the traditionally taught section.

Learning: A post test of 12 questions was administered at the end of the module in both sections to measure student learning. The format and content of the test were agreed upon by the instructors. The post test result was 41% for traditional section and 74% for the transformed section—a huge difference!

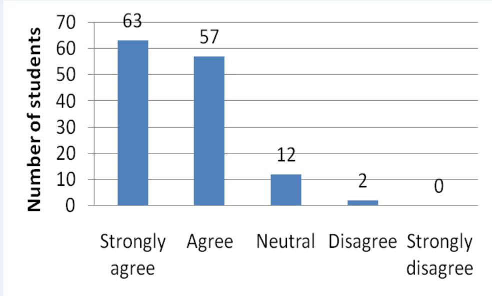
	Traditional	Transformed
Attendance	58%	81%
Engagement	50%	85%
Learning	41%	74%

Note: Guessing would have resulted in a score of 23% on the learning test

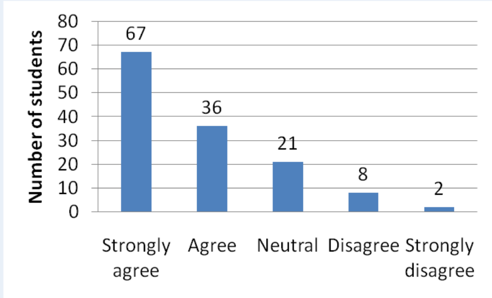
How did students feel about this transformation?

An online survey was given to the students in the transformed section to find out how satisfied they were with their experience. A total of 150 surveys were completed.

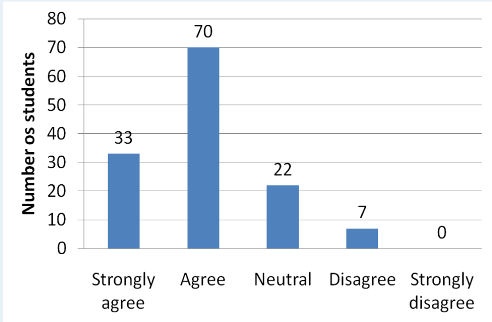
Here are some sample questions and class responses.



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



Q2. I feel I would have learned more if the whole PHYS 153 course would have been taught in this highly interactive style.



Q8. In class, the group discussions with my neighbors were very helpful to my learning.

>A Little Help on How to Learn Goes a Long Way

(Continued from page 1)

ing less than the class median. This group, however, was just provided with study guidelines via email rather than a face-to-face meeting.

In response to the email, 12 students in Physics 250 and 7 students in EOSC 112 came to meet one-on-one with one of the instructors for 15-25 minutes each. After some brief introductory discussion about the course and their study habits, each student was asked to carry out a specific set of activities in studying for future exams as follows:

- Attempt to "do" each learning goal by generating your own explanations.
- Consult course resources (notes, reading, homework, sample problems and solutions) in a targeted manner, to improve your ability with a specific learning goal. Do not simply re-read.
- Match assessments (e.g. clicker questions, practice questions, homework problems) to specific learning goals, and test yourself on all of those items, creating your own responses before looking at answers. Imagine alternate ways to test the goal, and test yourself with your own questions.
- Attend the weekly (optional) problem solving sessions (Physics course only).

Results after intervention

Students who met face-to-face with the instructor increased their scores on midterm 2 over midterm 1 by averaged 20% in Physics 250 and 30% in EOSC 112, moving the bottom quartile of students to near or slightly above the class median. The group who received email but no face-to-face meeting in EOSC 112 also increased significantly but less than the active intervention group.

These results demonstrate that student performance should not be considered something outside of the instructor's control and that they can make a dramatic difference with minor but appropriately targeted intervention to improve study habits.

Transformation of First Year Biology Course—

Learning to think more innovatively

Problem solving is arguably one of the most important skills for science students to develop. In an effort to promote problem solving and creative thinking, invention activities were designed and used in a large first year biology course.

What are invention activities (IA)?

Invention activities are designed to allow students to solve problems that are analogous to the class material, and that are based on concepts that have not yet been covered. These activities have multiple possible solutions and are therefore intended to stimulate creative thinking.

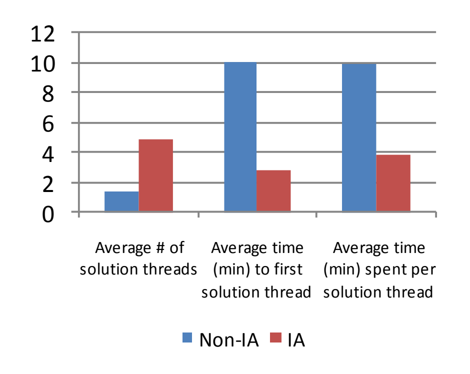
How the study was conducted

The IA study was conducted in a large first year biology course. A total of 170 students volunteered to participate in the IA over 8 weeks, meeting once a week. During each of the 50-minute activity sessions, students spent the first 30 minutes working together in groups of 3 or 4 to solve problems and write out their solutions on large pieces of flip-chart paper. The next 10 minutes were spent on group presentations of their solutions, and the final 10 minutes were dedicated to a wrap up which involved a mini-lesson introducing the related material the students would see in lecture and explaining how their inventions were analogous to the material.

Study results

Ten students who participated in the IA and 7 students who didn't participate were interviewed to test their problems solving skills. During the interview, students were asked to suggest a solution to a biological problem based on a system they had not seen in class and which they had no way of knowing what the "correct" solution would be.

As shown in the results below, when faced with developing a solution to a challenging and unfamiliar biology problem, IA students were much quicker to engage with the problem, and routinely provided multiple feasible solutions.



This study provided evidence that early phase problem solving skills can be taught through the use of invention activities, and when properly designed, these activities show a high level of student engagement and provide them with an opportunity to practice innovative thinking.

Implementation of Active Learning in an Introductory Computer Science Course

APSC 160 is an introductory computing course required by all engineering programs at UBC. As a way to transform this traditional lecture style course into one that involves active learning, the instructor developed a series of 29 short screencasts (voice-over-PowerPoint) and accompanying in-class problem sets to introduce basic concepts.

<u>How it was done</u>

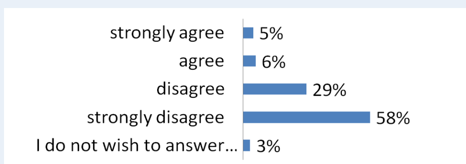
Prior to each class, students were asked to watch one or more screencasts which covered introductory concept materials. At the start of each class, a series of clicker questions was used to assess students' comprehension of the concepts presented in the screencasts and to address any misunderstandings.

Students then worked in small groups on worksheets that gradually exposed them to more difficult problems. This new approach to teaching and learning was applied in all four sections of the course offered in the past winter session which included over 800 students, of which 70% downloaded at least 80% of the screencasts.

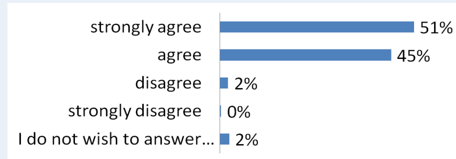
<u>How students felt about this</u>

Survey was conducted after the midterm to find out what students had to say about this transformation.

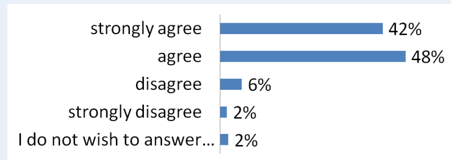
I would prefer that this course be taught using a traditional lecture format rather than having online screencasts and in-class problem sets.



The online screencasts help me learn basic concepts on my own.



The in-class problems sets help me gain a deeper understanding of the concepts presented in the screencasts.



"Most classes teach the basics in class and make you figure out advanced problems on your own. This method lets you figure out the easy stuff and then helps you with the harder problems."

"I find watching the screencasts before the lectures and applying the information during lecture time helps me to pinpoint what information I understand and what I do not more effectively than a usual lecture format."

"I didn't have to study for the midterm because I ended up already knowing how to do things."

Development in the First Year Calculus Workshops

The CWSEI-Math program has been ramping up quickly, doubling its number of Science Teaching and Learning Fellows to four in the past six months. One of the most notable developments in its program is the transformation in the First-Year Calculus Workshops under the two year study that started last year.

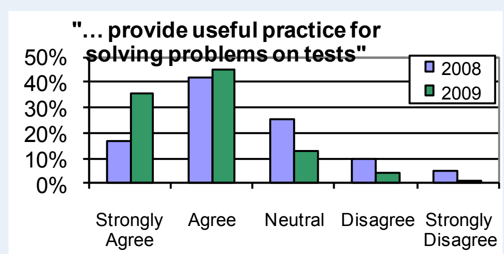
The first-year Calculus Workshops are mandatory weekly problem-solving sessions in which students work on selected problems in groups of 3-4, applying concepts introduced in lectures. The program involves more than 900 students and 25 Teaching Assistants (TAs) each year. Each workshop consists of about 25 students with one graduate TA and one undergraduate TA.

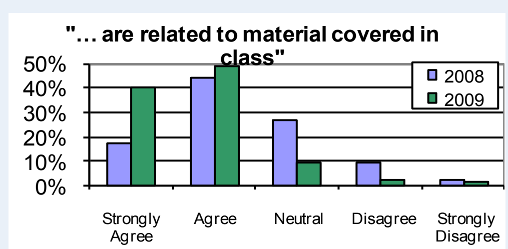
Through various surveys and observations, it was found that the workshop content in the previous years was lacking alignment with lectures, causing students to lose interest and become disengaged. In addition, no individual assessment was provided to students, contributing to further time off-task for some students.

In 2009, many changes were implemented to address the issues, transforming the program into a team effort. Meetings with workshop coordinator, instructors, and TAs were scheduled on a regular basis and students received individual feedback in the form of weekly quizzes. In addition, clear learning goals were stated on weekly problem sheets and the implementation of a week-long production cycle of problem sets allowed for content revisions and pedagogical improvements.

An end-of-term survey was administered in both 2008 and 2009 to find out what students had to say.

"The workshop problems....





As these sample survey results show, the changes made in 2009 resulted in improved student attitudes toward the workshop program.