Physics and Astronomy

CWSEI Department Summary

This document summarizes the Department of Physics and Astronomy's activities as part of the Carl Wieman Science Education Initiative over the years 2007-2019. In this initial version, it replaces a series of web pages that were updated over the lifetime of the CWSEI. It may be updated in future with more detail on impact.

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Overview

Physics & Astronomy received seed funding in 2007 and began their SEI efforts in the Fall of that year. The department moved to full funding starting in 2008.

A new phase began in 2014 – the Harris Project – an extension of CWSEI that runs from 2014 to 2017. In addition to continuing course transformations and faculty support, this phase includes deliberate effort toward effective transfer of pedagogies to new instructors using a co-teaching (paired teaching) model. This project is funded by John and Deb Harris, the UBC Faculty of Science, and the Physics & Astronomy Department.

More details on the different aspects of the program are given in the Activities section and sub-sections.

People

CWSEI Dept. Director: Joss Ives, Georg Rieger (emeritus), Doug Bonn (emeritus), Georg Rieger (emeritus), Mona Berciu (emeritus)
STLFs: Electra Eleftheriadou, Linda Strubbe, Jared Stang, James Day, Jim Carolan, Louis Deslauriers, Ido Roll, Peter Newbury, Cynthia Heiner
Faculty: D. Bonn, J. Folk, B. Gladman, J. Iqbal, D. Jones, J. Ives, A. Kotlicki, K. Madison, J. Matthews, M. Pavan, H. Richer, I. Stairs, M. Van Raamsdonk, S. Reinsberg, G. Rieger, L. Van Waerbeke, C. Waltham, C. Wieman, J. Zibin, S. Burke, D. Witt, V. Sossi, J. Roettler, J. Charbonneau, S. Bates, J.Young, D. Bryman, I. Affleck, V. Hinkov
Students: J. Bale, D. Fujimoto, F. Moosvi, E. Altiere, S. Berkman, N. Holmes, S. Martinuk, D. Mazur, B. Ramshaw, E. Schelew, M. Sitwell, J. Stang (later an STLF), S. Vafaei, C. Veenstra, T. Vernstrom, M. Warren, R. Wong

Activities

Overview of the items detailed in this document (some further resources are on the website https://cwsei.ubc.ca/outcomes/departments/physicsastronomy):

Curriculum: Extensive diagnostic testing of conceptual understanding is starting to uncover information that will inform upcoming curriculum decisions.

Course Redesign: 22 courses are undergoing or have completed transformation.

Course Resources: Materials for some of the transformed courses (learning goals, in-class activities, homework,...).

Teaching Assistants Development: We have created a teaching assistants workshop which now runs during the first week of classes every September, and a new graduate course in pedagogy in Physics & Astronomy.

Research: Numerous Physics & Astronomy education research studies have sprung out of the course redesign efforts.

Newsletters: 2010-2012, we published a newsletter focusing on various teaching activities taking place in conjunction with the CWSEI STLFs.

Curriculum

The large first-year physics courses (PHYS 101 & PHYS 102) include 6 3-hour lab experiments. Because it is so difficult to sync the concepts presented in multiple lecture sections with the experiments, we are trying to convert the lab experiments to self-contained "learning units." These would include pre-lab exercises and lab activities that contain all the necessary information. Wherever they are in the sequence of lectures, instructors could use these experiments to preview what's coming next, to reinforce what they're currently covering, or to wrap up already-covered topics. The development and testing of several activities and pre-lab exercises started in the Summer 2010 PHYS 102 section.

Extensive diagnostic testing by Jim Carolan and Louis Deslauriers uncovered information that will inform curriculum decisions. Extensive testing of first and upper year students using an electricity and magnetism concept survey (BEMA) is providing information on learning gains and retention. The results from the survey are being used in decisions about merging the Eng. Phys and Honours Phys. streams of E&M. These results also feed into decisions about the freshman treatment of E&M concepts. There are also efforts to optimize the way E&M topics are covered in various courses, at all levels, to formulate a set of coherent learning goals for these courses and to insure that faculty will strive to achieve these learning goals in the future.

Poster (CWSEI EOY 2011): Tracking Students' Knowledge of Electricity and Magnetism from 1st to 3rd Year

Widespread deployment of CLASS student attitudes about science surveys in all first year courses, with testing done in September, at the end of the first term, and again at the end of the second term.

Jim Carolan looked at 2008-2014 survey data with a special focus on gender differences. He also looked at FCI, MBT, CLASS, and BEMA results in several courses as a function of time.

Louis Deslauriers has developed a math diagnostic to assess upper-level physics students' grasp of the math skills needed to succeed in the senior courses. This tool will be used to make judgments about curriculum and will feed discussions with the math department about their curriculum. This complements the math department's own efforts on entrance-level testing of math skills. A math diagnostic for first-year math has also been automated. The two diagnostics are available online at:
First Year Diagnostic: http://cwsei-diagnostics.sites.olt.ubc.ca/first-year-math-diagnostic/
Upper Year Diagnostic: http://cwsei-diagnostics.sites.olt.ubc.ca/upper-level-math-diagnostic-exam/

Courses

Status as of May 2016:

Course	Learning goals	New Assessments	Improved Methods
ASTR 310: Exploring the Universe I: The Solar System (Summer '08 – 2012) Faculty: Brett Gladman, Harvey Richer STLF: Peter Newbury Grad Student: M. Milkeratis, S. Lawler, M. Gendre, S. Vafaei Poster (CWSEI EOY 2011): Shifting to a Copernican Model of the Solar System by Shifting Away from a Copernican Model of Teaching Poster (CWSEI EOY 2009): Exploring the Solar System with a Human Orrery Poster (CWSEI EOY 2009): Interactive Tutorial Activities in ASTR 310	Course-level goals: complete Topic-level goals: complete	Improved midterm and final exam questions based on assessing learning goals	Created 6 activities for tutorials including guidelines for TAs for facilitating the activities Using MasteringAstronomy for Just-in-time teaching (Gladman) Aligning lecture material with learning goals Peer instruction using clickers (Richer) Using Lecture-Tutorial workbooks (Richer)

ASTR 311: Exploring the Universe II: Stars and Galaxies (Summer '09 – 2012) Faculty: Ingrid Stairs, Jeremy Heyl, Ludovic Van Waerbeke, Jim Zibin STLF: Peter Newbury Grad Student: M. Gendre, T. Vernstrom Poster (CWSEI EOY 2010): Transforming Introductory Astronomy: from Learning Goals to Instruction & Assessment	Course-level goals: complete Topic-level goals: complete	Developed pre/post concept test for tutorial activities Improved final exam based on learning goals Light and Spectroscopy Concept Inventory (LSCI) pre- and post-test (Stairs) Pre-, Post-testing with the Test of Astronomy Standard	Developed 7 50-minute activities for tutorial sessions including guidelines for TAs for facilitating the activities Intense focus on learner-centered instruction: peer-instruction with clickers, lecture-tutorial workbook, in-class worksheets (Stairs)
PHYS 100: Introductory Physics (Sept '07 – ongoing) Faculty: Georg Rieger, Andrzej Kotlicki, Stefan Reinsberg STLF: Ido Roll, Jim Carolan Grad Student: F. Moosvi, M. Sitwell, S. Berkman	Course-level goals: complete Topic-level goals: complete Lab goals revised towards skills development: complete	Conducted study on impact of learning goals on student self assessment of understanding Lab diagnostic developed and interviews conducted Improved the lab skills assessment - given to students on the first and last weeks of the term	Provided feedback for clicker question improvement and more student engagement in lectures Revised the labs - they now include a homework component in which students do the actual experiments prior to coming to the lab for data analysis. The labs and homework build on each other so that each component is required for the subsequent task; so they create a sequence in which students use new tools to analyze old data, or collect more data to improve conclusions from data collected earlier, etc. Added clickers to the lab – a couple of clickers at the beginning of class are used to

Video Paper (Physics in Canada, 2014): A "flipped" approach to large-scale first-year labs Poster (CWSEI EOY 2013): Interactions between teaching assistants and students boost engagement in physics labs Poster (CWSEI EOY 2012): Transforming and Evaluating the Physics 100 Labs		Conducted study comparing different forms of invention activities an support for group work Use of the CLASS survey to monitor students' attitudes over several years during course transformation Used two-stage midterm exams Evaluated all labs using surveys and interviews Use of a frequent-testing approach	recap previous labs. Several clickers at the end of the lab are used to summarize the lab and frame the discussion about what was done during that specific lab. Description of the reformed lab and lab worksheets are now available at http://www.phas.ubc.ca/teaching-support Use of Learning Catalytics and bi-weekly quizzes. (2014) Development of an online lab section with experiments at home and online support Developed a blended resource for use in face-to-face and online sections based on an edX platform. Integrated open-stax textbook and labs at home.
PHYS 101: Energy and Waves (2007–2015 for transformation; paired teaching ongoing) Faculty: Fran Bates, Georg Rieger, Cynthia Heiner, Javed Iqbal, Alex Mackay STLF: Jared Stang (2015-) Cynthia Heiner, Peter Newbury Poster (CWSEI EOY 2013): Productive	Course-level goals: complete Topic-level goals: complete	Conducted survey targeting students approach to and learning from pre-readings, clickers, and in-class worksheets Used two-stage exams (summer) Conducted survey targeting attitudes towards two-stage exams Joss Ives is currently developing a diagnostic test	Developed new lab experiments on measurement/uncertainty and interference Complete set of in-class activities and worksheets developed Complete set of pre-reading assignments developed Use of PeerWise in spring and summer. A similar tool that expands the capability of PeerWise to different learning objects is currently under development for Blackboard/Connect, with the goal of supporting pre-class reading. Paired teaching in one section: pairing of a research scientist with a PER specialist Using two-stage exams consistently in

Engagement with PhET Simulations click here to view course materials		specifically for PHYS 101 content.	midterms and finals from Fall 2014 onwards Learning object assessments deployed in W2 sections (2013 and 2014). Initially through Connect, now entirely within UBC Blogs (including assessment). Paired teaching (Spring 2016): pairing two STLFs (Stang & Strubbe)
PHYS 102 (now PHYS 118): Electricity, Light and Radiation (Sept '09 – 2015) Faculty: Georg Rieger, Fran Bates, Vesna Sossi, Joerg Roettler, James Charbonneau STLF: Jared Stang (2015-) Peter Newbury, Louis Deslaurier	Course-level goals: complete Topic-level goals: complete	Creating pre-lab exercises using PhET simulations. Used two-stage exams (summer) Used the BEMA diagnostic	Fully interactive environment Developing complete set of reading assignments, clicker questions, and worksheets Revising lab experiments Use of the Washington Tutorials Paired teaching in one section: pairing of a research scientist with a PER specialist
PHYS 107 & 109: Enriched Physics 1 lab and Intro to Experimental Physics (Sept '07 – ongoing) Faculty: Doug Bonn STLF: J. Day, I. Roll, L. Strubbe Grad Student: N. Holmes Poster (PERC 2013): Doing science or doing a lab? Engaging students with	Course-level goals: complete Topic-level goals: complete	Developed & validated physics lab pre-post diagnostic Conducted study on the impact of invention activities completed preceding versus following a lesson End-of-term survey Conducted studies on the impact of structure in invention activities	Developed 15 invention activities on data interpretation and analysis Developed marking rubrics for all labs and improved them to reward for quality of measurements and experimental and reflection procedures Introduced Learning Catalytics to support peer instruction during lab discussions and instruction Introduced scientific reasoning scaffolding in early experiments to encourage reflection and evaluation in order to improve the quality of measurements Introduced (weekly) reflection questions for

scientific reasoning during physics lab experiments Poster (CWSEI EOY 2011): On Guided Invention Activities that Support Scientific Reasoning and Domain Learning Poster (CWSEI EOY 2010): Preparing students for learning through invention activities Poster (CWSEI EOY 2010): Using Invention Tasks to Help Students Become Better Scientists Poster (CWSEI EOY 2009): Physics Lab Diagnostic & Teaching by Building from Student Invention		on learning and on scientific reasoning skills Several additional surveys being used to measure student attitudes and motivation across the year including the E-CLASS (C-LASS for Experimental Physics) and Achievement Goal Questionnaire Conducting study on gender biases of mix-gender groups during experiments Conducting study on students' use of evaluation and reflection during experiments and their understanding of measurement and uncertainties	students, to help them recognize their development as scientists and connect their in-class learning to other science courses and everyday life
PHYS 107: Enriched Physics I (Sept '10 – Fall '14) Faculty: Ian Affleck STLF: Jim Carolan	Course-level goals: complete Topic-level goals: under development	Pre & post concept surveys completed ('10 & '11) Lecture observations Student post course interviews completed for '10	Clicker use – developed Online pre reading quizzes – developed In-class activities - worksheets developed

		and '11 Pre and post problem solving skills surveys completed for '11 Used the Mechanics Baseline Test and the CLASS survey	
PHYS 117: Dynamics and Waves & **PHYS 118: Electricity, Light and Radiation** (Sept '14 - ongoing) Faculty: Joss Ives and Georg Rieger	Course-level goals and topic –level goals: complete	Used the FCI in English and Chinese Use of bi-weekly tests Use of two-stage tests and exams Conducted BEMA survey	Development of two sections for an international cohort of students ("Vantage College") Fully interactive environment (fully developed 'flipped' approach) Complete set of reading assignments, clicker questions, and worksheets Paired teaching in one section: pairing of a research scientist with a PER specialist
PHYS 119: Experimental Physics Lab (Jan '16 – ongoing) Faculty: D. Bonn, J. Ives, R. Kiefl STLF: L. Strubbe Poster (Science Education Open House 2016): Developing Student Attitudes in the First-Year Physics Lab at UBC AAPT/PERC presentations	New course (mostly) using first half of curriculum from PHYS 107/PHYS 109	Conducted CDPA at beginning of course Conducted ECLASS at beginning and end of course	Revised first three labs to introduce confidence intervals and probability distributions more clearly As above in Phys 107, introduced (weekly) reflection questions for students, to help them recognize their development as scientists and connect their in-class learning to other science courses and everyday life

forthcoming (summer 2016)			
PHYS 157 & 158: Introductory Physics for Engineers I & II [formerly PHYS 153] (Sept '10 – ongoing) Faculty: Sarah Burke, Don Witt, Andrzej Kotlicki, Kristin Schleich, Michael Hasinoff STLF: Cynthia Heiner, Louis Deslauriers Poster (CWSEI EOY 2012): Transforming traditional large lectures into active learning environments	Course-level goals: complete Topic-level goals: complete	Compared student performance on exams in transformed course vs. earlier traditional version Conducted BEMA survey Conducted student survey rating course elements	Bank of clicker questions In-class activities for entire term Peer instruction Learning goals were referred to throughout the course for aligning material and for creating exams Paired teaching in one section: pairing of a research scientist with a PER specialist Use of PhET simulations in conjunction with pre-reading assignments
PHYS 159: Introductory Physics Laboratory for Engineers [formerly part of PHYS 153] (Nov '11 – ongoing) Faculty: Doug Bonn, Jeff Young, Michael Hasinoff, Bill McCutcheon, Don Witt, Evert Koster STLF: James Day	Course-level goals: complete	Two final lab exams created, closely aligned with course-level learning goals Peer assessment between TAs, to promote and support deliberate practice	Three “tutorial weeks” modified (based on last year's TA and student feedback) to provide students with basic skills needed for the rest of course (i.e. use of basic stats, uncertainty analysis, and experimental design) Rubrics created for individual labs Brief pre-lab readings created 2-day TA and instructor training sessions added

PHYS 200: Relativity and Quanta (Sept '08 – 2015) Faculty: Mark Van Raamsdonk, J. Karczmarek STLF: Louis Deslauriers	Course-level goals: complete Topic-level goals: complete	Lecture & HW session observations Analyzed Mid-term Midterm & end-of-term survey	Weekly interactive tutorials developed. Improved clicker questions Use of pencasts (J. Karczmarek)
PHYS 250: Introduction to Modern Physics (2009 -2015) Faculty: Carl Wieman, Louis Deslauriers STLF: Louis Deslauriers  click here to view course materials	Course-level goals: complete Topic-level goals: complete	Development of an extended Quantum Mechanical Conceptual Survey Lecture & HW session observations Two-stage exams Analyzed Mid-term Midterm & end-of-term surveys Measured long term retention of quantum concepts	Weekly tutorials developed Bank of clicker questions In-class activities for entire term Measurement of long term retention for the quantum part of course Demonstrated a successful intervention with lower performing students
PHYS 301: Electricity and Magnetism (2009, 2014) Faculty: Doug Bryman		Administered the CUE (Colorado Upper Division Electrostatics Assessment, 2009 & 2014)	Clicker questions incorporated into lecture (2014)
PHYS 304: Introduction to Quantum Mechanics (2010–2014)	Course-level goals: complete Topic-level	Lecture & HW session observations Measured effect of	Creating a bank of clicker questions Designing in- class activities for every lecture

Faculty: Kirk Madison, Ariel Zhitnitsky STLF: Louis Deslauriers	goals: 80% complete	BONUS clicker questions on student engagement during voting period. Compared student performance to previous terms – transformed course scores are consistently higher Measured student engagement in general - compared it to other course the Eng Phys cohorts were taking at the same time	Improved engagement during clicker questions by adding BONUS questions Clicker questions and weekly quizzes (2014)
PHYS 315: Physics of Materials (Sept '11 – 2014) Faculty: Vladimir Hinkov STLF: James Day Poster (CWSEI EOY '12): The transformation of Physics 315 click here to view course materials	Course-level goals: complete Topic-level goals: complete	Homework assignments closely aligned to learning goals	New clicker questions drafted and older clicker questions improved Training on delivery of clicker questions and subsequent results In-class group activities Implementation of pre-reading Lecture video recorded to help instructor associate feedback on style with actual footage Formative midterm and year-end feedback form created
PHYS 333: Energy and Climate (online) (2014 – ongoing)	Detailed set of learning goals created	Piloted the "Adaptive comparative judgment" online peer review system	Problem sets linked to learning objectives Targeted quiz questions in online materials

Faculty: James Charbonneau		(students compare assignments based on a supplied rubric) Created rubrics for all assessments	Authentic take-home experiments with PowerPoint-based lab reports
PHYS 401: Electromagnetic Theory (Sept '11 – 2012) Faculty: Doug Bryman STLF: Peter Newbury	Course-level goals: draft Topic-level goals: complete set		Creating in-class worksheets and clicker questions aligned with learning goals Focus on moving from instructor-centred to student-centred instruction Development of pre-reading assignments
PHYS 403: Statistical Mechanics (2014) Faculty: Mayra Tovar			Use of clicker questions (coloured cards) and worksheet activities (2014)
PHYS 408: Optics (Sept '09 – 2013) Faculty: David Jones STLF: Louis Deslauriers Course successfully transferred to Kirk Madison  click here to view course materials	Course-level goals: complete Topic-level goals: complete	Developd Optics Conceptual Survey Lecture observations; observed HW sessions Analyzed Mid-term Compared student performance to previous terms – transformed course scores are consistently higher Measured student	Created a bank of clicker questions In-class activities for entire term Developed a remedial tutorial for students lacking pre-requisite in signal processing (Fourier Transforms) Development of active learning materials for two new topics: Quantum optics and non-linear optics

		engagement and compared it to other course the students were taking at the same time	
PHYS 450: Quantum Mechanics (Jan '09 – 2013) Faculty: Joshua Folk STLF: Louis Deslauriers	Course and Topic level learning goals: 95% complete	Lecture & HW session observations Analyzed Mid-term Conducted study on impact of student peer discussions vs. classic instruction on students' knowledge retention	Created a bank of clicker questions (including isomorphic questions to test longer-term retention)
PHYS 170 & 270– Mechanics diagnostic surveys are being administered annually to monitor conceptual learning gains and aid future course development. Clicker usage is being encouraged in the large multi-section engineering course, PHYS 170, with lecture observation and advice from STLF Jim Carolan. Paired teaching in one section of PHYS 170. **PHYS 101 & 108** - clicker usage was developed & improved in these large freshman courses with extensive observation and advice from Jim Carolan			

Course Resources

Physics 408: Optics

Prof. David Jones Winter 2011 course website with materials

Prof. Prof. Kirk Madison Winter 2015 course website with materials

Courses archived in the SEI course materials system at https://sei.ubc.ca/ are

PHYS 101: Energy and Waves

PHYS 250: Introduction to Modern Physics

PHYS 315: Physics of Materials

Teaching Assistant Development

In the Physics and Astronomy department, we recognize that teaching assistants are front-line educators in our program and if we are to improve the learning experience for our undergraduates we must better prepare our graduate student TAs.

Poster (UBC 2015 Science Ed Open House): Physics & Astronomy TA Professional Development Program

Paper (The Physics Teacher, 2013): Teaching Assistant Professional Development by and for TAs

Course-specific TA development:

[2015-2016] Linda Strubbe, Dhaneesh Kumar, Derek Fujimoto and Doug Bonn have been developing a TA training program for TAs who are teaching in the first-year physics labs (PHYS 107, 109, 119). We hold a weekly meeting for TAs with the instructor or head TA to discuss pedagogy, practice and discuss facilitating (e.g., invention activities), discuss likely student issues and how to address, and give TAs practice with the experiment. This is being evaluated using a TA confidence survey and TA weekly reflection surveys, along with observations (protocol being developed by Damien Quentin).

TA workshop and mentoring:

A coordinating team of graduate students in the department developed and regularly run a very successful, one-day interactive workshop, which started in the beginning of the 2007 fall term by former graduate students Mya Warren, Joss Ives, and Sandy Martinuk. The workshop is required for incoming graduate students and available to veterans as well. A system of mentor TAs provides a structure in which senior graduate TAs oversee other graduate students in the first year undergraduate courses and help to develop their teaching skills through a peer-mentorship framework. 'Head TAs' are also deployed in each of the large multi-section courses to develop and deliver course-specific training as follow-up throughout the term.

Many excellent resources from the training program can be found at http://www.phas.ubc.ca/~phas_ta/, including a TA Handbook developed by current and past TA training coordinators.

Graduate course in teaching and learning physics & astronomy:

This program is enhanced by a graduate course in pedagogy in Physics & Astronomy: PHYS 520, Teaching Techniques in Physics and Astronomy. This course exposes students to current Physics education research literature and allows them to apply the research to their own teaching by developing activities such as clicker questions or invention activities. In addition, many students complement this course with a directed studies project that allows them to get involved in physics education research in the department.

Research

Paired Teaching

Electra Eleftheradou, Jared Stang, and Linda Strubbe studied the effectiveness of paired teaching as a method of faculty development in teaching. Poster (UBC 2015 Science Ed Open House): Two models of paired teaching in first year physics lectures, and Poster (UBC 2016 Science Ed Open House): Paired teaching for faculty professional development. They also presented the work at conferences: collection of conference presentations for this project

Two-Stage Exam Studies

Joss Ives studied two-stage exams over multiple projects. With Simmer Mand, he modelled student success on related clicker questions a few days after the two-stage exam (undergraduate honours thesis). With Nutifafa Kwaku Sumah, he is analyzed video of students partaking in the group stage of the exam to understand how students participate (undergraduate honours thesis). Analysis is ongoing with Jared Stang, Nutifafa Kwaku Sumah, and Matias de Jong van Lier. UBC 2016 Science Ed Open House posters

Sims to Enhance Pre-reading

Jared Stang, Megan Barker, Sarah Perez, Joss Ives, and Ido Roll conducted a study in PHYS 157 on using PhET sims (online interactive physics simulations) to enhance pre-reading assignments. UBC 2016 Science Ed Open House poster

Student Attitudes about Experimental Science

Linda Strubbe is conducted a study (with Doug Bonn and Joss Ives) in PHYS 119 on student attitudes about experimental science during the first-year physics lab. She developed pre-lab questions where students reflect on their learning and development as a scientist, and is analyzed results from pre- and post-semester ECLASS surveys. UBC 2016 Science Ed Open House poster

Student Attitudes on Learning Astronomy

Linda Strubbe worked with Anabele Pardi (graduate student at the Max Planck Institute for Astrophysics in Germany) to study student attitudes during a summer school on astronomy held in Nigeria in July 2015.

Scientific Reasoning During Lab Experiments

Natasha Holmes and Doug Bonn conducted ground-breaking research focused on improving students' scientific reasoning and critical thinking in an introductory physics laboratory course. They developed a simple learning framework that employs cycles of decisions about making and acting on quantitative comparisons between datasets or data and models. This led to significant and sustained improvement in students' critical thinking behaviors. The work was published in the Proceedings of the National Academy: N. Holmes, C. Wieman, and D. Bonn (2015) Teaching critical thinking, Proceedings of the National Academy of Sciences, 112(36), pp. 11199–11204. Also see Doug Bonn's talk slides from the UBC 2016 Science Ed Open House: Making Comparisons: A Strategy for Teaching Scientific Reasoning.

PER PhD Thesis

We graduated our second PhD student in physics education research. Natasha Holmes' thesis work about the intervention in the Phys 107/109 labs can be found online at: http://circle.ubc.ca/handle/2429/51363

Gender Issues During Lab Experiments

Natasha Holmes, Ido Roll, and Doug Bonn published a paper on issues of gender during experiments. (Physics in Canada 2014): Participating in the physics lab: does gender matter?. James Day, Jared Stang, Natasha Holmes, Dhaneesh Kumar, and Doug Bonn have a follow-up paper on the gender gap on the CDPA and behavior differences in the lab that could contribute to such a gap [link/citation to Physical Review Physics Education Research].

TA-Student Interactions

Jared Stang and Ido Roll published a paper on TA interactions and student engagement in the first-year physics lab: Interactions between teaching assistants and students boost engagement in physics labs, Phys. Rev. ST Phys. Educ. Res. (2014)

Invention Activities and Lab Diagnostic

Natasha Holmes, James Day, Idol Roll & Doug Bonn, with further assistance from students Hiroko Nakahara, and Brad Ramshaw, studied the effectiveness of invention activities to improve students' data interpretation and analysis skills and understanding. This included classroom observation, pre/post testing with a lab diagnostic, and data-mining of student work on an online system used to deliver invention activities. The latter was used to understand how invention activities can help students develop high level scientific reasoning skills.

Paper (2013 PER Conference Proceedings): Finding Evidence of Transfer with Invention Activities: Teaching the Concept of Weighted Average

Paper (Instructional Science 2013): Making the failure more productive: scaffolding the invention process to improve inquiry behaviors and outcomes in invention activities

Paper (Instructional Science 2012): Evaluating metacognitive scaffolding in guided invention activities

Paper (Physical Review ST-PER 2011): Development of the Concise Data Processing Assessment

Paper (The Physics Teacher, 2010): Teaching Standard Deviation by Building from Student Invention

Poster (CWSEI EOY 2012): The Invention Support Environment: Where Do We Go From Here?

Two-Stage Exams

Cynthia Heiner, Georg Rieger, and Carl Wieman published two papers on two-stage exams:

Paper (The Physics Teacher, 2014): Physics Exams that Promote Collaborative Learning

Paper (J. College Science Teaching, 2014): Examinations That Support Collaborative Learning: The Students' Perspective

Reformed Phys 100 labs

Georg Rieger, Michael Sitwell, Jim Carolan, and Ido Roll published a paper on the reformed Phys 100 labs. (Physics in Canada 2014): A "flipped" approach to large-scale first-year labs

Pre-Reading Study

Cynthia Heiner and Mandy Banet (Biology) published a paper on pre-reading assignments:

Paper (American J. Physics 2014): Preparing students for class: How to get 80% of students reading the textbook before class

Effectiveness of Astronomy Tutorial Exercises

Peter Newbury completed pre- and post-testing of ASTR 310 and ASTR 311 tutorial exercises, such as the Human Orrery. The results were presented at AAS 216, May 23-27, 2010 in Miami, FLA. In Stair's ASTR 311 (Fall 2010) students wrote the Light and Spectroscopy Concept Inventory pre- and post-test. The results were used to compare the impact of interactive, learner-centered instruction to similar introductory astronomy courses across the U.S.

Paper (The Physics Teacher 2010): Exploring the Solar System with a Human Orrery

Poster (April 2009): Exploring the Solar System with a Human Orrery

Impact of Pre-Reading on student questions

Louis Deslauriers, Georg Rieger, and Bing Dai studied the impact of pre-reading on the sophistication of student questions during lectures. The study took place in Physics 101, 102 and 250. Results consistently show that pre-reading along with proper incentive leads to an increase in the sophistication of student questions.

Impact of Learning Goals

Louis Deslauriers, Joshua Folk, and Georg Rieger studied the impact of learning goals on student self assessment of their understanding in Physics 100 and Physics 101.

Peer Discussion Effect on Knowledge Retention

Louis Deslauriers and Joshua Folk conducted a study in PHYS 450 aimed at comparing the effect of peer discussions and classic instruction on students' knowledge retention.

Conceptual Inventories

CWSEI efforts in PHAS involved widespread deployment of conceptual inventories to assess student understanding of mechanics and electricity & magnetism concepts. These included an extensive vertical survey from first to fourth year using the new lab diagnostic, a similar vertical survey using the BEMA diagnostic, and use of the FCI in first-year classes and second-year mechanics.

CLASS surveys

Widespread deployment of CLASS (Colorado Learning Attitudes About Science Survey) in all first year courses, with testing done in September, December, and April of several academic years.

Newsletters

2010-2012, we published a newsletter focusing on various teaching activities taking place in conjunction with the CWSEI STLFs. Instructors involved in a transformation, or TAs involved with or students taking such transformed courses express their views about what works and what doesn't, and how things can be further improved. These 1-to-2 pages newsletters were distributed to the entire faculty in order to

keep them informed about these various efforts and give them a contact person to talk to if they become interested in any particular aspect.

An zip archive of the newsletters is available here: https://cwsei.ubc.ca/sites/default/files/cwsei/outcomes/departments/PHAS_SEI_newsletters_2010-2012.zip

2012 Newsletters

Summer 2012 - Two-stage exams (individual followed by group exam)

March 2012 - Active learning in lecture courses

2011 Newsletters

December 2011 - Pre-Reading Assignments – Why they may be the most important homework for your students

August/September 2011 - New and on-going CWSEI activities in the department

July 2011 - Effectiveness of teaching problem solving strategies

May-June 2011 - Changes in PHYS153: *Elements of Physics*

April 2011 - Handling student evaluations

March 2011 - Invention as Preparation for Learning study

February 2011 - Math diagnostics development

January 2011 - Changes in PHYS107: *Enriched Physics I*

2010 Newsletters

December 2010 - Group photo

November 2010 - Changes in ASTR 311: *Exploring the Universe II: Stars and Galaxies*

October 2010 - TA training and mentorship program

September 2010 - Summary of new and on-going CWSEI activities

August 2010 - Changes in PHYS101: *Energy and Waves*

July 2010 - Changes in PHYS200: *Relativity and Quanta* - introduction to special relativity and quantum mechanics

June 2010 - Changes in ASTR310: *Exploring the Universe I: The Solar System*

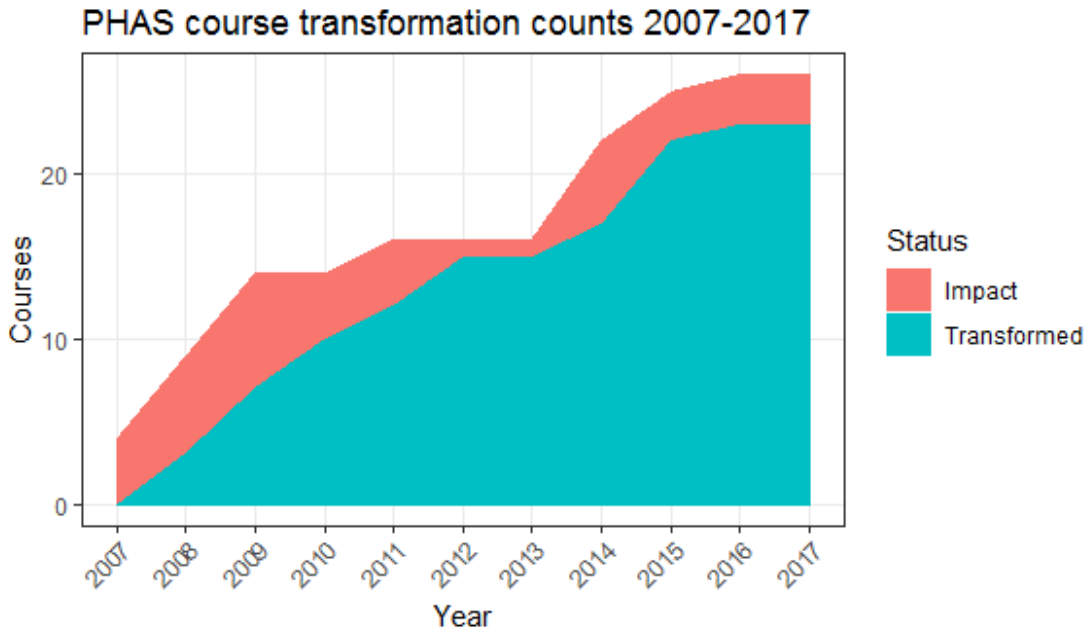
May 2010 - Student impressions of transformed lab course

April 2010 - Upper-level Quantum Mechanics and Optics Course transformations

Impact

Transformed course counts

As of Spring 2018, we had 26 PHAS courses with CWSEI and/or Skylight influence:



Impact in terms of seats/registrations

We can look at this in terms of the **66 undergraduate courses offered by PHAS in 2017** with LEC, LAB or DST as primary activity and excluding distance ed. sections. In terms of **seats/registrations** (with LEC, LAB or DST as primary activity; excludes distance ed. sections):

EFFECT	Seats. 2012	Seats.2013	Seats.2014	Seats.2015	Seats.2016	Seats.2017
Transformed	4183	4121	6667	7094	6952	7001
Impact	883	1084	1155	1180	1108	1158
Other/None	2825	2559	1868	2068	2084	2115

EFFECT	Prop. Seats. 2012	Prop.Seats. 2013	Prop.Seats. 2014	Prop.Seats. 2015	Prop.Seats. 2016	Prop.Seats. 2017
Transformed	53.0%	53.1%	68.8%	68.6%	68.5%	68.1%

Impact	11.2%	14.0%	11.9%	11.4%	10.9%	11.3%
Other/None	35.8%	33.0%	19.3%	20.0%	20.5%	20.6%

Publications and Presentations

Paper	**Comment on "Benefits of completing homework for students with different aptitudes in an introductory electricity and magnetism course"** Georg Rieger, Stefan Reinsberg (Physics & Astronomy, UBC), and Carl Wieman (Stanford Univ.) Physical Review Physics Education Research, 12, 028001 (2016)	
Paper	**Gender gaps and gendered action in a first-year physics laboratory** James Day, Jared Stang, Natasha Holmes, Dhaneesh Kumar, and Doug Bonn (Physics & Astronomy, UBC) Physical Review Physics Education Research, 12, 020104 (2016)	
Paper	**Transforming a fourth year modern optics course using a deliberate practice framework** David Jones & Kirk Madison (Physics & Astronomy, UBC) and Carl Wieman (Stanford Univ.) Physical Review Special Topics - Physics Education Research, 11, 020108 (2015)	
Paper	**Teaching critical thinking** Natasha Holmes, Carl Wieman, and Doug Bonn (Physics & Astronomy, UBC, and Stanford Univ.) Proceedings of the National Academy of Sciences, 112(36), pp. 11199–11204 (2015)	paper sup material
Paper	**Quantitative Comparisons to Promote Inquiry in the Introductory Physics Lab** Natasha Holmes and Doug Bonn (Physics & Astronomy, UBC) The Physics Teacher, Vol. 53, pp 352-355, Sept. 2015, DOI: 10.1119/1.4928350	preprint

Paper	**Invention Activities: A Path to Expertise** James Day & Doug Bonn (Physics & Astronomy, UBC), Wendy Adams (U. Northern Colorado), Carl Wieman & Daniel Schwartz (Stanford) Physics in Canada, Special Issue on Physics Education Research, 70(2), pp. 81-83 (2014)	
Paper	**Participating in the Physics Lab: Does Gender Matter?** Natasha Holmes, Ido Roll, and Doug Bonn (Physics & Astronomy, UBC) Physics in Canada, Special Issue on Physics Education Research, 70(2), pp. 84-86 (2014)	
Paper	**A "flipped" approach to large-scale first-year labs** Georg Rieger, M. Sitwell, Jim Carolan, & Ido Roll (Physics & Astronomy, UBC) Physics in Canada, Special Issue on Physics Education Research, 70(2), pp. 126-128 (2014)	
Paper	**Preparing students for class: How to get 80% of students reading the textbook before class** Cynthia Heiner (Physics, UBC), Amanda Banet (Zoology & Botany, UBC), & Carl Wieman American J. Physics, Vol. 82(10), pp. 989-996 (2014)	
Paper	**Interactions between teaching assistants and students boost engagement in physics labs** Jared Stang & Ido Roll (Physics & Astronomy, UBC) Physical Review Special Topics - Physics Education Research, 10, 020117 (2014)	To view full text
Paper	**Not a magic bullet: the effect of scaffolding on knowledge and attitudes in online simulations** Ido Roll, Adriana Briseno, Nikki Yee, & Ashley Welsh (UBC) Proceedings of the International Conference of the Learning Sciences, *in press* (2014)	preprint
Paper	**The usefulness of log based clustering in a complex simulation environment** Samad Kardan, Ido Roll, & Cristina Conati (UBC)	preprint

	Proceedings of the International Conference on Intelligent Tutoring Systems, *in press* (2014)	
Paper	**Examinations That Support Collaborative Learning: The Students' Perspective** Georg Rieger and Cynthia Heiner (Physics & Astronomy, UBC) Journal of College Science Teaching, Vol. 43, No. 4, pp. 41-47 (2014)	
Paper	**Physics Exams that Promote Collaborative Learning** Carl Wieman, Georg Rieger, and Cynthia Heiner (Physics & Astronomy, UBC) The Physics Teacher, 52, pp. 51-53 (January 2014)	
Paper Poster	**Finding Evidence of Transfer with Invention Activities: Teaching the Concept of Weighted Average** James Day, Natasha Holmes, Ido Roll, and Doug Bonn (Physics & Astronomy, UBC) 2013 PERC Proceedings, pp. 117-120 (2014) Physics Education Research Conference (PERC), Portland, OR, July 2013	
Paper Poster	**Doing Science Or Doing A Lab? Engaging Students With Scientific Reasoning During Physics Lab Experiments** Natasha Holmes and Doug Bonn (Physics & Astronomy, UBC) 2013 PERC Proceedings, pp. 185-188 (2014) Physics Education Research Conference (PERC), Portland, OR, July 2013	
Paper	**Development of a General Undergraduate Estimation Skills Survey (GUESS)** Andrew Macdonald, Sarah Burke, and Cynthia Heiner (Physics & Astronomy, UBC) 2013 PERC Proceedings, pp. 237-240 (2014) Physics Education Research Conference (PERC), Portland, OR, July 2013	
Paper	**Multiple-choice Assessment for Upper-division Electricity and Magnetism** Bethany Wilcox & Steven Pollock (Physics, CU) 2013 PERC Proceedings, pp. 365-368 (2014)	To view full text
Paper	**Making the failure more productive: scaffolding the invention process to improve inquiry behaviors and outcomes in invention activities** Natasha Holmes, James Day, Anthony Park, Doug Bonn, and Ido Roll (Physics & Astronomy, UBC)	

	Instructional Science, Vol. 42, No. 4, pp. 523-538 (2014; pub online Nov 2013)	
Paper	**Teaching Assistant Professional Development by and for TAs** Natasha Holmes, Matthew Martinuk, Joss Ives, and Mya Warren (Physics & Astronomy, UBC) The Physics Teacher, 51, pp. 218-219 (2013)	
Paper	**Evaluating metacognitive scaffolding in guided invention activities** Ido Roll, Natasha Holmes, James Day, & Doug Bonn (Physics & Astronomy, UBC) Instructional Science, Vol. 40, pp. 691-710 (2012)	
Paper	**Development of the Concise Data Processing Assessment** James Day and Doug Bonn (Physics & Astronomy, UBC) Physical Review Special Topics - Physics Education Research, Vol. 7, 010114 (2011)	
Paper	**Improved Learning in a Large Enrollment Physics Class** Louis Deslauriers, Ellen Schelew, and Carl Wieman (Physics & Astronomy and CWSEI, UBC) Science, Vol. 332, no. 6031 pp. 862-864 (May 2011)	To view full text
Paper	**Learning And Retention of Quantum Concepts with Different Teaching Methods** Louis Deslauriers and Carl Wieman (Physics & Astronomy, UBC) Physical Review Special Topics - Physics Education Research, Vol. 7, 010101 (2011)	
Paper	**Exploring the Solar System with a Human Orrery** Peter Newbury (Physics & Astronomy, UBC) The Physics Teacher (December 2010) To view a video of this activity, click HERE.	
Paper	**Teaching Standard Deviation by Building from Student Invention** James Day, Hiroko Nakahara, and Doug Bonn (Physics & Astronomy, UBC)	

	The Physics Teacher, 48 (November 2010)	
Poster	**The Impact of Targeted Learning Goals on Student Attitudes about Experimental Physics** Natasha Holmes, Joss Ives, and Doug Bonn (Physics & Astronomy, UBC) Physics Education Research Conference (PERC), Minneapolis, MN, July 2014	
Poster	**Students' perspectives on pre-class reading assignments** Cynthia Heiner (Physics and Astronomy, UBC) and Amanda Banet (Zoology, UBC) Foundations and Frontiers of Physics Education Research: Puget Sound (June 2012)	
Poster	**Exploring the Solar System with a Human Orrery** Peter Newbury, Melanie Gendre, Brett Gladman, Laura Kasian, Nicole Meger,and Harvey Richer (Physics & Astronomy, UBC) 214th Meeting of the American Astronomical Society, Pasadena, CA (June 2009)	

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