



TLEF Project – Final Report

Report Completion Date: (2018/10/23)

1. PROJECT OVERVIEW

1.1. General Information

Project Title:	Structured Quantitative Inquiry Labs: Developing Critical Thinking in First Year Physics Labs		
Principal Investigator:	Doug Bonn		
Report Submitted By:	Doug Bonn		
Project Initiation Date:	2015/04/05	Project Completion Date:	2017/08/30
Project Type:	<input type="checkbox"/> Large Transformation <input checked="" type="checkbox"/> Small Innovation <input type="checkbox"/> Flexible Learning <input type="checkbox"/> Other: [please specify]		

1.2. Project Focus Areas – Please select all the areas that describe your project.

- Resource development (e.g. learning materials, media)
- Infrastructure development (e.g. management tools, repositories, learning spaces)
- Pedagogies for student learning and/or engagement (e.g. active learning)
- Innovative assessments (e.g. two-stage exams, student peer-assessment)
- Teaching roles and training (e.g. teaching practice development, TA roles)
- Curriculum (e.g. program development/implementation, learning communities)
- Student experience outside the classroom (e.g. wellbeing, social inclusion)
- Experiential and work-integrated learning (e.g. co-op, community service learning)
- Indigenous-focused curricula and ways of knowing
- Diversity and inclusion in teaching and learning contexts
- Open educational resources
- Other: [please specify]



1.3. Project Summary

1.4. Team Members – Please fill in the following table and include **students**, undergraduate and/or graduate, who participated in your project.

Name	Title/Affiliation	Responsibilities/Roles
Doug Bonn	Professor (PHAS)	Project lead
Joss Ives	Senior Instructor (PHAS)	Project co-lead and Lead Instructor for PHYS 119
Linda Strubbe	Teaching and Learning Fellow (PHAS)	PHYS 119 Instructor and lead on student attitudes and diversity
Jeff Bale	Graduate student (PHAS)	Development and assessment of PHYS 119 labs
Derek Fujimoto	Graduate student (PHAS)	Head TA during PHYS 119 implementation
Dhaneesh Kumar	Undergraduate student (PHAS)	Development of PHYS 119 labs

1.5. Courses Reached – Please fill in the following table with **past**, **current**, and **future** courses and sections (e.g. HIST 101, 002, 2017/2018, Sep) that have been/will be reached by your project, including courses not included in your original proposal (you may adapt this section to the context of your project as necessary).

Course	Section	Academic Year	Term (Summer/Fall/Winter)
PHYS 119	All	2015/16	Winter
PHYS 107 + SCIE 001	All	2016/17	Fall
PHYS 119	All	2016/17	Fall
PHYS 109 + SCIE 001	All	2016/17	Winter
PHYS 119	All	2016/17	Winter
PHYS 107 + SCIE 001	All	2017/18	Fall
PHYS 119	All	2017/18	Fall
PHYS 109 + SCIE 001	All	2017/18	Winter
PHYS 119	All	2017/18	Winter



2. OUTPUTS AND/OR PRODUCTS

2.1. Please list project outputs and/or products (e.g. resources, infrastructure, new courses/programs). Indicate the current location of such products and provide a URL if applicable.

Product(s)/Achievement(s):	Location:
New Course - PHYS 119 labs	UBC Life Building
Refined course – PHYS 107/109/SCIENCE 1 labs	UBC Life Building
SQLabs documentation including training program documents	https://sqlabs.phas.ubc.ca/

2.2. Item(s) Not Met – Please list intended project outputs and/or products that were not attained and the reason(s) for this.

Item(s) Not Met:	Reason:

3. PROJECT IMPACT

3.1. Project Impact Areas – Please select all the areas where your project made an impact.

- Student learning and knowledge
- Student engagement and attitudes
- Instructional team teaching practice and satisfaction
- Student wellbeing, social inclusion
- Awareness and capacity around strategic areas (indigenous, equity and diversity)
- Unit operations and processes
- Other: [please specify]

3.2. What were you hoping to change or where were you hoping to see an impact with this project? – Please describe the intended benefits of the project for students, TAs, instructors and/or community members.

The project had two principal aims, and a further goal developed as the project evolved.

First, the project supported the introduction of a new first year physics lab course, aimed at students with an interest in the physical sciences, and replacing the laboratory component of PHYS 102. The new course, PHYS 119, was based closely on the highly successful laboratory sequence developed over several years in PHYS 107/109/SCIENCE 1, with modest compression to fit into a single term. The goal here was to increase the number of students benefitting from our successful transformation to a course that develops

quantitative scientific reasoning. It also better prepares them for upper year physics labs. This course also provided us with an opportunity to explore ways to further improve and enhance the student experience, with some extra focus on student attitudes and affect.

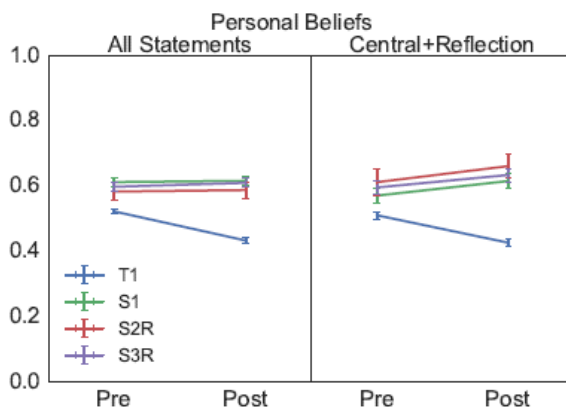
The second aim was to build a sustainable program for the delivery this entire collection of first year labs, with a focus on TA training, and development of targeted documentation that separately supports students, instructors, and graduate TAs.

The third aim, which emerged as PHYS 119 was being developed, was to introduce a small number of virtual labs, experiments that could be conducted using a simulation, rather than actual physical apparatus. The motivation is related to our second aim – to come up with means to make the first-year lab program sustainable and even transferrable to other institutions.

3.3. Were these changes/impacts achieved? How do you know they occurred? – What evaluation strategies were used? How was data collected and analyzed? You are encouraged to include copies of data collection tools (e.g. surveys and interview protocols) as well as graphical representations of data and/or scenarios or quotes to represent and illustrate key themes.

The main aim, to establish a new first-year physics lab that expands the reach of our Structured Quantitative Inquiry labs (SQILabs) was achieved with the sustained delivery of PHYS 119 for the past 3 years. These labs were already extensively validated in terms of effectiveness in the PHYS 107/109 version. In addition to simply implementing an already-tested teaching method, the new course offered an opportunity to enhance certain aspects, particularly in the context of a significantly different, and more diverse, student population that included students in the new UBC Vantage College. In particular, this implementation in PHYS 119 involved iterative assessment of the introduction of some flipped class elements, and work on student attitudes and beliefs, using activities that asked students to reflect on their learning.

As an example of some of the new data and insight that was obtained, we used the Colorado Learning Attitudes about Science Survey – Experimental Physics (E-CLASS) survey as a pre/post-test of student attitudes. Our initial first-year labs actually showed a decline in student attitudes towards experimental physics, as illustrated by the blue plotted trends shown in the figure below (Strubbe et al., 2017), taken prior to the introduction of reflection questions. This downward trend was neutralized with the next iteration that included reflection, with slight improvement for questions central to the course targets.



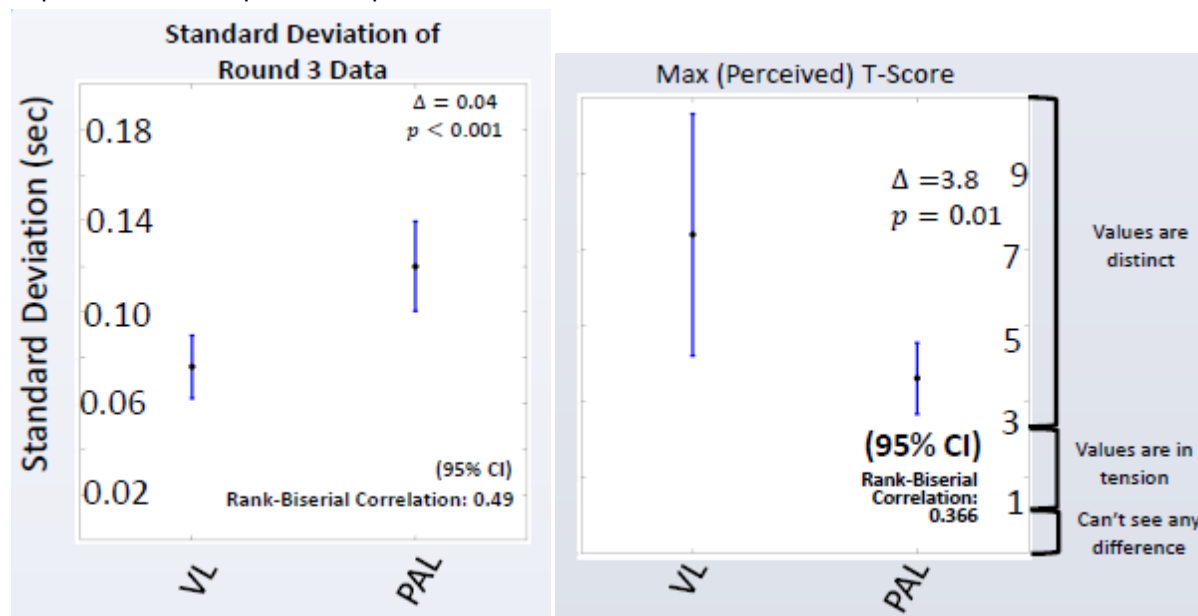
The key focus on TA training for the first-year labs was mainly evaluated through formative feedback surveys during the training program. Examples of the feedback and response in one instance were

- 1 - TA meetings are too long
- 2 - Myself and the course instructors need to be more in sync with what is being taught in each lab
- 3 - Overall the meetings seem to be effective at preparing the TAs for the labs.
- 4 - The PD part did not seem to go over well with some of the TAs. The consensus seems to be that more time allocated to the lab materials would be better.

The proposed solutions following TA suggestions were:

- 1 - Reduce meetings to 1h 45 mins.
- 2 - We will be better at this next year as the course instructional materials get generated and saved in the SQLabs folder. For 109, the instructor directions will be helpful to have ahead of time.
- 3 - Cheer.
- 4 - Re-allocate time: 30 mins for PD not related to the lab (1h 15 mins lab specifics), 45 mins for PD related to the lab (1h lab specifics). By "PD related to the lab" I mean "teaching tactics within the context of an activity in the lab".
- 4 alt - We reserve more of the teaching techniques portion for the returning TAs, so split the meeting in two at some point. I think our first year TAs would have appreciated more time playing with the equipment.

A further area in which we made noteworthy progress, and have considerable assessment data, is in the introduction of some “Virtual Labs” to the first-year labs. Data is still being analyzed and included student surveys, computer screen captures, COPUS-like student classroom observations, and mining of student lab data. As shown in the figures below, the students in the “Virtual Lab” (VL) condition produced timing data with lower standard deviation than those using physical apparatus, and produced higher t-values indicating that they were better able to discern the main effect that we wanted them to notice – a small amplitude dependence of the pendulum period.





3.4. Dissemination – Please provide a list of **past** and **upcoming** scholarly activities (e.g. publications, presentations, invited talks, etc.) in which you or anyone from your team have shared information regarding this project.

Publications:

“Developing student attitudes in the first-year physics laboratory”

Linda E. Strubbe, J. Ives, N. G. Holmes, D. A. Bonn, and N. K. Sumah, 2016 Proceedings of the Physics Education Research Conference, edited by D. L. Jones, L. Ding, and A. Traxler (2017).

Presentations:

Doug Bonn: ‘Teaching Critical reasoning in a First-Year laboratory’: Canadian Association of Physicists Congress (2017); American Physical Society North West Meeting (2016); Univ. de Montreal seminar (2017); McGill University colloquium (2017); Guelph Physics colloquium (2016).

Joss Ives: ‘Authentic experimentation in labs using Structured Quantitative Inquiry’: Langara Department of Physics and Astronomy (2018).

Linda Strubbe: “Developing Student Attitudes About Experimental Science and Being a Scientist,” Physics Education Research Conference (2016).

“Teaching scientific thinking in Canada, West Africa and Central Asia” San Francisco State University (2018); University of California, Merced (2018); University of California, Santa Cruz (March 2018)

“Developing scientific reasoning: at UBC and in West Africa” NRC Herzberg Institute for Astrophysics (2016); University of Texas at Austin (May 2016)

“Developing student attitudes in the first-year physics lab at UBC”, AAPT (2016)

“Teaching inquiry in Nigeria and Canada” International Astronomical Union General Assembly (2017)

“Developing student attitudes in the first-year physics lab”, Foundations and Frontiers in Physics Education Research Puget Sound (2016); American Association of Physics Teachers Physics Education Research Conference [PERC] (2016)

Jeff Bale: SKYLIGHT Supper Series, 2016

Foundations and Frontiers of Physics Education Research: Puget Sound, 2018

Workshops:

Doug Bonn led ‘Workshop on Introduction to SQLabs’: Waterloo University faculty retreat (2018); Penticton High School Teachers’ workshop (2016)

J. Ives, N.G. Holmes, L. Strubbe, led “Authentic Experimentation in Labs Using Structured Quantitative Inquiry,” American Association of Physicists Summer Meeting Workshop, July 17, 2016.

4. TEACHING PRACTICES – Please indicate if **your** teaching practices or those of **others** have changed as a result of your project. If so, in what ways? Do you see these changes as sustainable over time? Why or why not?

The instructors directly involved in both the project and the delivery of the first-year labs are most directly affected in their teaching practices. This results directly from the experience of developing and delivering these



labs, reflecting on a range of assessments, and various formal and informal co-teaching and class-observation arrangements. Those most affected in this way include the PI (Bonn) and collaborators (Ives, Strubbe). These three have all refined their already-transformed lab teaching methods. The refinements have included approaches aimed at improving student attitudes and affect, and have entailed an increased flipping of materials that allows students to develop some skills at home, prior to the challenge of coming into the relatively stressful environment of a time-limited lab period. Two others have had their approach to lab teaching strongly influenced through teaching these first year labs for the first time, and participating in the training programs: Rob Kiefl (Professor) and Electra Eleftheriadou (Sessional Instructor). In addition, through a formal co-teaching arrangement, Sarah Burke (Assoc. Professor) exchanged lab teaching ideas that influenced both parties. The course she was in charge of at the time, PHYS 159, is the very large first-year lab course for engineers. Both Bonn and Burke are now fluent with the differing aims and format of these two reformed lab courses.

The largest result in terms of teaching practices is a sustainable change to the role played by Teaching Assistants, with many graduate and undergraduate TAs involved in weekly training, and the more experienced TAs being brought up to the experience of acting as the lead instructor for a laboratory section. Further details are noted below in relation to project sustainment.

5. PROJECT SUSTAINMENT – *Please describe the sustainment strategy for the project components. How will this be sustained and potentially expanded (e.g. over the next five years). What challenges do you foresee for achieving the expected long-term impacts listed above?*

Along with introducing a new first-year laboratory course as part of the Physics&Astronomy's reorganization of first-year teaching, the central goal of this TLEF has been to build a sustainable delivery model for the first-year labs. There are four components to this now firmly established. First, the TLEF project has enabled a thorough development of documentation, with parallel streams tailored to instructors, teaching assistants, and students. These are presently maintained by the course instructors, but work is also under way to make them broadly available to instructors at any institution, via the archive used for Physics education materials, Physport. Second, the number of faculty and sessional instructors in the department that are experienced in the delivery of this material, and in leading entire multi-section courses, has been increased. With continued attention to overlapping experienced and inexperienced instructors, the long-term sustainment of the first-year lab courses is assured and a pool of people will grow to tackle the remainder of the department's laboratory teaching.

The TA training program is perhaps the most vital piece for the long-term health of this teaching program. The original vision was to develop a one-stage training program that would take novices through their first year of training. This is well-established now and operates on a model that is driven to a significant extent by a Head TA in the course, freeing up Instructor time and effort, which further enhances the viability of the courses. The head TA position is a competitively allocated TA job, one amongst several that have strong appeal to graduate students that are ambitious about their teaching profiles. A new feature that developed through the course of this TLEF project was to take the more experienced, and top-performing TAs, and give them the opportunity to be in charge of a lab section, a role historically reserved for Instructors in the Physics&Astronomy department. It has been a challenge for the department to sustain that large a commitment of Instructors, so a fraction of the work-load being taken on by our top graduate students has been a positive development in this regard. In turn, this development has opened up somewhat more room for top undergraduate students to take TA positions in the course, enhancing their own educational experience.