TLEF Project – Final Report

Report Completion Date: (2019/03/31)

1. PROJECT OVERVIEW

1.1. General Information

Project Title:	Blended learning to enhance students' learning experience in a large undergraduate Biology laboratory course.		
Principal Investigator:	Pam Kalas and Kathy Nomme		
Report Submitted By:	Pam Kalas		
Project Initiation Date:	April 1, 2016[1]	**Project Completion Date:**	March 31, 2019
Project Type:	☒ Large Transformation ☐ Small Innovation ☐ Flexible Learning ☐ Other: [please specify]		

[1] Note that although the project officially started on April 1, 2016, some preliminary work (including the development of some 'prototype' resources) for the project took place as early as the Fall of 2015. This is relevant with respect to the evaluation data on students' writing in Appendix C.

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

The Biology 140 blended learning project was developed to enhance the learning experience of a large number of students in first year biology, many of whom are taking a biology lab course for the first time. Students struggle with essential transferrable skills such as a sound understanding of the fundamental elements of scientific enquiry, and the ability to communicate clearly and logically. Also, undergraduate students are unaware of world-leading research conducted on campus. To this end, the project set out to capitalize on blended learning to 1) develop and incorporate appropriate scaffolding resources and opportunities to practice and connect the fundamental elements of scientific inquiry/investigation and communication and 2) raise student motivation and perceptions of the relevance of their lab activities by making explicit connections to current research at UBC. The project resulted in broadly applicable instructional resources. We assessed the project's success by measuring student learning (pre- and post-test) and capturing their perceptions and attitudes at the end of the course.

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
Kathy Nomme	Professor of Teaching/Zoology	Co-PI
Pam Kalas	Senior Instructor/Zoology	Co-PI
Natalie Schimpf	Postdoctoral Teaching and Learning Fellow/Zoology	Development and production of videos and other instructional resources, development and deployment of evaluation tools (SCENDI pre/post-test, student survey, TA workload sheets), data collection, analysis of pre/post-test data
Chin Sun	Lecturer/Zoology	Support with implementation
Lynn Norman	Lecturer/Zoology	Support with implementation
Bernardita Germano	Sessional lecturer/Zoology	Revision and editing of instructional materials
Eric Jandciu	Science Centre for Learning and Teaching (Skylight)	Project management and consultation
Beth Volpov	Postdoctoral fellow/Zoology	Project evaluation; analysis of student survey and TA workload data, data organization and archiving, development of R script to analyze survey data in years to come
Gayathri Athavan	Undergraduate Academic Assistant/Chemistry	Producing illustrations/animations for the "Biology Frog" video series
Brian Tung	Undergraduate Academic Assistant/Biology	Closed captioning, assisting with editing instructional materials
Rachel Petrynko	Educational Technologist/Biology (currently Faculty of Science)	IT support, production of Interactive tutorial, assistance in production and deployment of quizzes

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)
Biology 140	All sections (~1,400 students/year)	2015W1 onwards	Fall, Winter and Summer

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:
Instructional video: Intertidal environments	All resources are currently being archived in organized folders on a dedicated BIOL 140 –resources Canvas site as well as on a USB drive and on the internal Zoology Cloud.
Instructional video: Intertidal inhabitants	
Instructional video: Forest ecosystem	
Instructional video: Scientific questions and investigative approaches	
Instructional videos: Experimental designs for BIOL140 I and II	
Animated video (Biology Frog): What is the literature	
Animated video (Biology Frog): How to find relevant literature	
Animated video (Biology Frog): How to use the literature	
Animated video (Biology Frog): Error bars	
UBC Researcher video – Dr. Chris Harley	
UBC Researcher video – Dr. Amy Angert	
UBC Researcher video – Dr. Allen Carrol	
UBC Researcher video – Dr. Michelle Tseng	
Interactive tutorial: Experimental design	
Illustrated summary documents on statistics and data analysis for BIOL 140	
Eight online formative quizzes covering the material presented in the various instructional resources	
Diagnostic quiz (to administer as pre/post)	
Student experience survey	
R script for effective analysis of quantitative and qualitative student survey data	

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:
Instructional video: Data analysis and statistics	The person intended to provide content for these videos is no longer available for the project. ***To partly substitute the planned instructional videos we developed a short, focused video animation targeting issues around error bars and an illustrated summary on the two statistical methods used in the course.***
Interactive tutorial: Research teams	After deploying the first interactive tutorial (Experimental design), the feedback from the students was that they not find this kind of resource useful and would prefer some instructional material (documents to read or video to watch) followed by a quiz. ***We therefore developed a written and illustrated document about effective research teams instead of the tutorial***.
Interactive electronic workbook	Student feedback told us that students would prefer sticking with a paper-based lab workbook and having access to a simple electronic copy (PDF) where they can locate relevant sections/terms using the "search" function.

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.*

Through the development and integration of a variety of (mostly video) resources into BIOL140, the project aimed at accomplishing the following:

- Improve students' learning experience, motivation and satisfaction with the course;
- Improve student perceptions of biology research through connections to UBC research by featuring current UBC research in videos.

- Maintain or improve the level of conceptual learning that already existed in BIOL 140;
- Improve student learning in the area of scientific writing and reporting results (by providing targeted resources and activities that specifically support students in their writing assignments);
- Reduce TA workload so as to keep it within the approved 192 hours per term per TA.

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 project objectives were achieved.

a. Student learning experience, motivation, and satisfaction in the course; perceptions of biology research

Student self-reported satisfaction with the course has improved compared to the past; students still enjoy the "hands on" aspects of the course, see the relevance of the course activities, appreciate opportunities to improve on their writing, generally like working in groups, and find that the assessment criteria and expectations are clearly outlined (a stark contrast with historical data from pre-renewal). Moreover, many students made comments suggesting that the new structure of the course is supportive of wellbeing. Relevant data are included in Appendix B.

b. Student conceptual learning

We developed a short, multiple choice quiz targeting some of the major concepts addressed in BIOL 140 and used it as a pre/post-test for several terms after the start of this project. While the level of conceptual understanding varied among students both at the start and at the end of term, we observed a meaningful improvement between the pre- and the post-test performance (large effect size and considerable mean normalized change[1]; Appendix C).

c. Scientific writing and reporting skills

BIOL 140 includes a scientific writing component; among other things, students prepare a publication-style lab report for their hypothesis-testing experiment. The major sections are the Introduction and the Discussion, and the class-wide mean grade on these writing assignments increased by over 5 percentage points (about two letter-grades) since the advent of the TLEF-funded resources (Appendix C). While these resources were not the only change in the course, the improvement in student performance on the two writing assignments indicates that the support provided is now better aligned with what they are expected to produce.

d. TA workload

During several terms throughout the project, Graduate Teaching Assistants employed in the course tracked and reported their hours of work. In all cases the mean and median number of hours worked per term were within the stipulated 184 hours/term (Appendix D).

[1] Marx, J.D., and Cummings, K. (2007). Normalized change. *Am. J. Phys 75*(87)

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.*

- Presentation: "Biology 140 Renewal: Responding to student feedback" (N. Schimpf, P. Kalas, K. Nomme); Skylight Annual Science Education Open House, UBC; 2016, Apr 11th
- Presentation: "Developing Scientific Writing Skills" (K. Nomme, P. Kalas, N. Schimpf); Northwest Biology Instructors' Organization Annual Meeting, Eugene, OR; 2016, Apr
- Presentation: "Engaging and Learning in Authentic Environments – Does Scaffolding of the Inquiry Process Enhance Student Learning?" (K. Nomme, P. Kalas, N. Schimpf); UBC Okanagan Leanring Conference; 2016, May 4th
- Presentation: "Biology 140 Renewal Update" (N. Schimpf, K. Nomme, P. Kalas); Biology Program Annual Teaching Retreat, UBC; 2016, Aug
- Workshop: "Standardizing scientific conventions across the Biology Program" (P. Kalas, N. Schimpf, K. Nomme); Biology Program Annual Teaching Retreat, UBC; 2016, Aug
- Presentation: "Assessing student learning following course revision" (K. Nomme, N. Schimpf, P. Kalas); Western Conference on Science Education, London, ON; 2017, Jul 5th
- Poster: "The impetus for course renewal – responding to student feedback" (N. Schimpf, K. Nomme, P. Kalas); Western Conference on Science Education, London, ON; 2017, Jul 6th
- Presentation: "Using Concept Assessments to Evaluate Student Learning Gains and Course Curriculum Revision" (K. Nomme, P. Kalas, N. Schimpf); Assessment in Higher Education conference, Manchester, UK; 2017, Jun
- Poster: "Insights and contradictions from student surveys in a 1st year Biology course" (P. Kalas, K. Nomme, N. Schimpf, B, Volpov); Skylight Annual Science Education Open House, UBC; 2019, Apr 5th

Upcoming – We are planning two posters focused on students' perceptions/opinions about the course and about the various resources associated with it, respectively, at the following events:

- This year's TLEF showcase event during "Celebrating Learning" week here at UBC.
- The Western Conference on Science Education in London, Ontario, July 2nd – 5th

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?*

Since BIOL 140 is a laboratory-only course, there was previously a relatively large amount of lecturing that occurred in lab. The newly developed instructional videos replace most of this lecturing and lab time is now used for students to participate in hands-on activities and for lab instructors to provide specific feedback and support to students. The course includes a good deal of group-based work and in the past, students had to schedule time outside of class to meet and collaborate with their groups. With lecturing taking place through online video resources, most group work can now take place during lab time.

Because the new format of the course is implemented in all sections, the teaching practices in the course have changed for everyone involved. These changes should be sustainable over time given that they do not require any particular extra resources now that the materials and format are in place. In addition, enhanced teaching guides that include activity-specific teaching tips, lesson plans, *etc.* were developed in parallel with the

implementation of this project. These guides should ensure that successful teaching practices can be adopted by any instructor in BIOL 140.

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?*

Because the main goal of the project was to develop resources (mostly videos), the project requires minimal work to be sustained. The current course format and curriculum incorporate all these resources in such a way that no additional work is required from the instructional personnel other than deploying them each term on the course Canvas site (by making them visible to students at the appropriate time) and occasional minor updating to ensure the resources are aligned with the correct week of the course. Electronic quizzes associated with these resources are self-sustaining in that they are graded automatically.

Final as well as editable copies of all instructional resources are currently stored in a repository accessible to anyone teaching in BIOL 140; once BioSpace will be operational we plan to move them there so that they will be accessible also by colleagues teaching other courses. Copies of the evaluation tools (student survey, SCENDI pre/post –test) and the R script to consistently analyze open-ended student responses are also stored in the repository and can be deployed and used by anyone in BIOL 140. Multiple current members of the BIOL 140 teaching team are very familiar with the resources developed and how to deploy them; they are also used to "train" new members, which will ensure continuity as the team's composition changes slightly every year.

APPENDIX B: EVIDENCE OF PROJECT SUCCESS – STUDENT SATISFACTION AND EXPERIENCE IN THE COURSE[2]

Student (and alumni) satisfaction with multiple elements of the course had historically been low, thus prompting the renewal project. For example, students used to find criteria and expectations for assessment to be unclear – something that has drastically changed with the renewal (Figure 1).

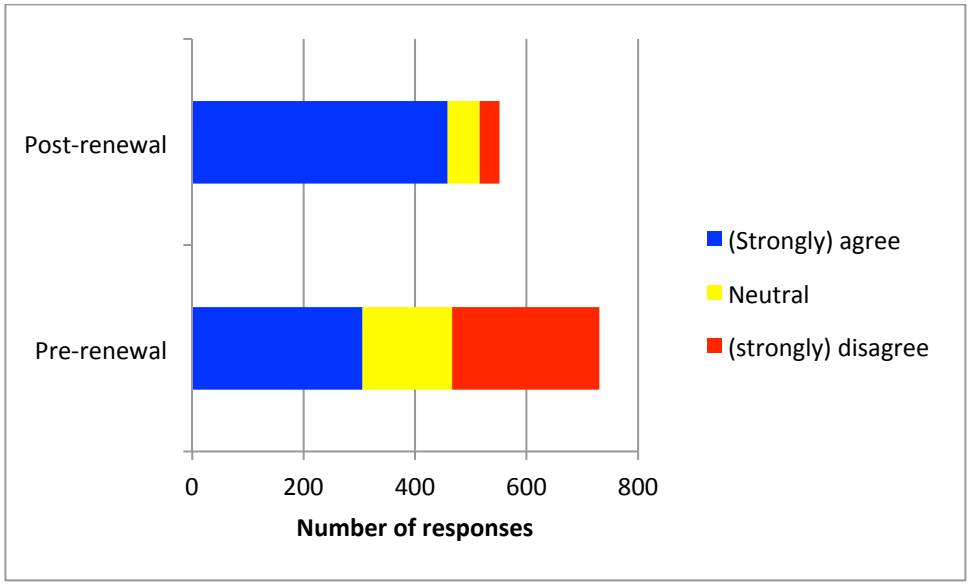

Figure 1. Number of responses to the statement "Assessment criteria and expectations for assignments were clearly outlined" provided by BIOL 140 students surveyed during the renewal project (post-renewal, n=551) and BIOL140 alumni surveyed pre-renewal (n=730).

Student workload was another point of dissatisfaction: 73% of pre-renewal BIOL 140 alumni surveyed had indicated that the BIOL140 workload was greater than other lab courses they had taken at UBC (Figure 2). Post-renewal BIOL140 students still perceived the workload as "high" (although not higher than for other courses), their self-reported weekly workload was average (about 3-4 hours a week outside of class time; Figure 3).

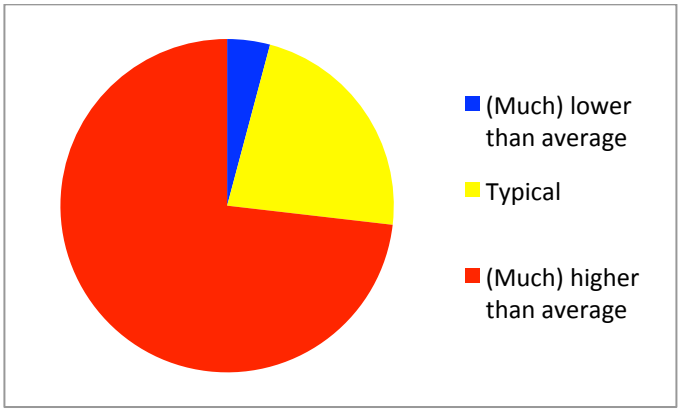

Figure 3. Relative frequencies of **pre-renewal** BIOL 140 alumni's responses when asked to compare the BIOL140 workload to that of other courses and lab courses that they had taken (n=723).

[2] Data collected through online end-of-term surveys

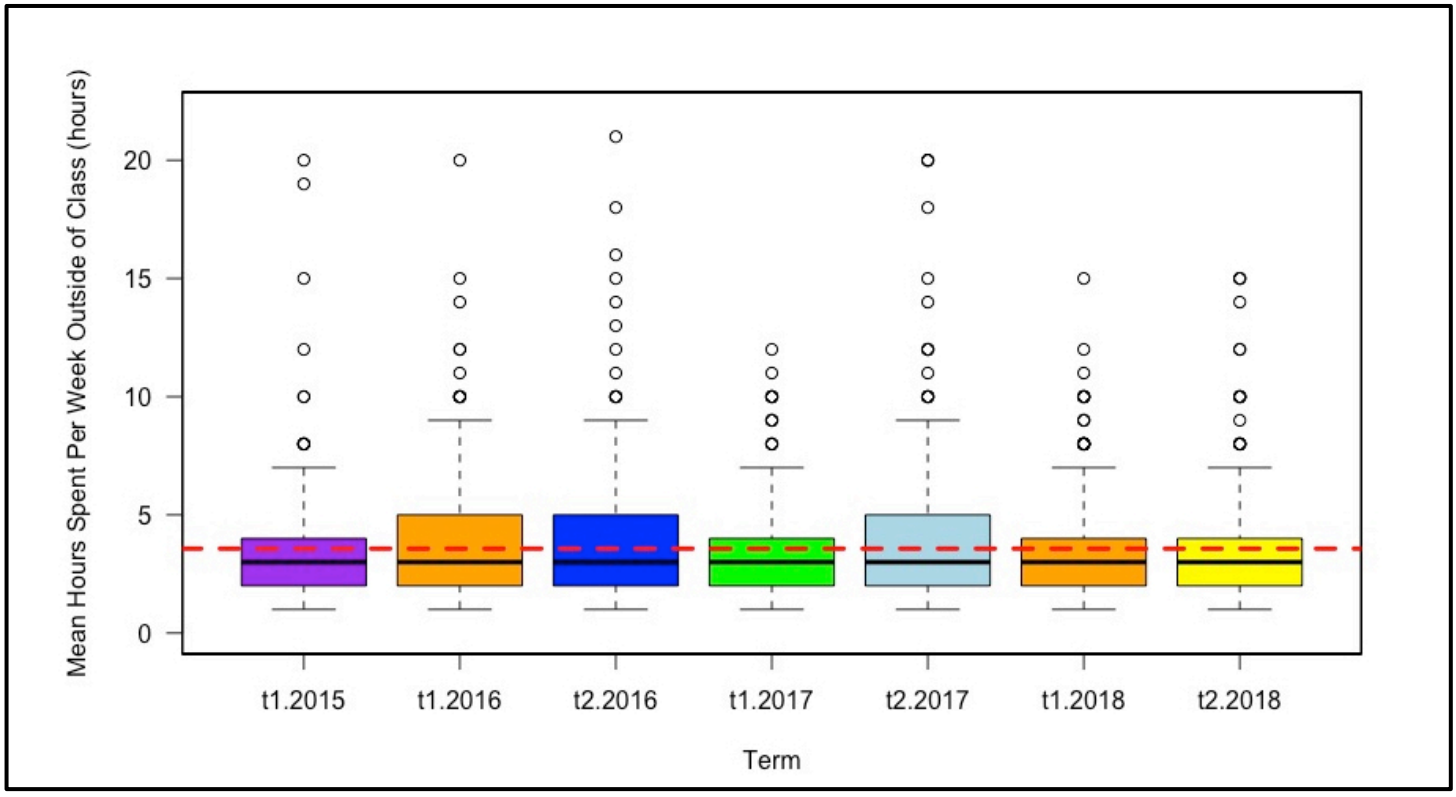

Figure 4. End-of-course survey results for student-reported average weekly workload outside of class across 7 terms 2015-2018 (**post-renewal**) in BIOL 140. The dashed red line indicates the mean hours worked per week across all students and all term combined (3.5 hours).

Authenticity of the inquiry-based activities conducted by the students was another point of dissatisfaction pre-renewal, as exemplified by the following comments reported by pre-renewal alumni:

"We all know the research we are doing is unimportant."

"I felt a very large disconnect with the material"

"Contrived"

Alumni had also reported that the research in BIOL140 was tedious and boring, and did reflected real research as they had subsequently experienced in other courses. To address this situation, this TLEF project introduced several researcher profile videos featuring UBC professors and their research (Chris Harley, Allan Carroll, Amy Angert, Michelle Tseng). Where possible, we had these researchers illustrate some tedious yet important aspects of their research, and we also illustrated links to the research experience of the BIOL 140 students (*e.g.* using transect lines [Amy Angert], measuring body size of many organisms [Chris Harley]). These videos were used in conjunction with activities and questions in class, and we also tried to feature UBC research in certain scenarios and activities throughout the course. This resonated with (at least some) students, as demonstrated by the following comments on the end-of-term course survey:

"I actually do [feel like I conducted real biology research], yeah!"

"In a way, yes [I feel like I conducted real biology research]"

In terms of **overall experience**, within the "Additional Comments", students often expressed positive comments about the course overall such as:

"I really enjoyed this class. Very comfortable learning environment where I didn't feel afraid to ask questions or request clarification."

"I really enjoyed that the students were given enough freedom to conduct an experiment they actually wanted to do, however were also supported and we're directed in the right direction and corrected if necessary."

While not directly related to the new resources developed as part of this project, these comments suggest that the renewal effort (which entirely connected to, and enabled by, the TLEF project) resulted in a course where students have a positive experience.

APPENDIX C: EVIDENCE OF PROJECT SUCCESS – STUDENT LEARNING/PERFORMANCE

1. Conceptual learning

One of our initial concerns was that using short videos that students had to watch on their own time to convey important course material may not be effective, and students might not necessarily learn the fundamental concepts that the course is meant to teach. Through three consecutive iterations we developed a diagnostic conceptual test (SCENDI, for SCENario-based Diagnostic Inventory) assessing students' understanding of such concepts. While not rigorously validated, the SCENDI was satisfactory for our purposes in terms of item difficulty and discrimination; we also did not detect gender bias in pre- or post-test scores, or in the normalized change[2]. Moreover, the fact that students performed significantly better on the post-test suggests that the concepts assessed on the SCENDI are aligned with what is taught in the course.

The SCENDI was administered in its final version a total of four times during the 2016 and 2017 academic years. The mean normalized change[3] between pre- and post-test increased slightly every term, from 0.21 (2015W1, when the first new resources were introduced) to 0.34 (2017W2, when all resources were being deployed in their "final" format for the second time). Another measure commonly used to quantify the difference between sets of scores, the effect size (Cohen's *d*), went from medium in 2015W1 to large (>1) the following three terms. Together, these results indicate that students' understanding of the course fundamental concepts increases noticeably between the start and the end of term – they are learning a good deal.

Table 1. SCENDI summary statistics and differences between pre- and post-test for the 2016 and 2017 academic years. Only data from students who participated in both the pre- and the post-test are reported.

	N	Min, Max	Mean	Median	SD
2016W1					
SCENDI pre	553	2.00, 13.00	6.99	7.00	2.03
SCENDI post	553	0.00, 14.00	8.55	9.00	2.39
Normalized change (c)	553	-1.00, 0.88	**0.21**	**0.25**	0.32
Effect size (d; pre vs. post) 2016W1: ***0.70*** *(medium)*					
2016W2					
SCENDI pre	825	1.00, 12.00	6.93	7.00	1.81
SCENDI post	825	1.00, 14.00	9.04	9.00	1.91
Normalized change (c)	825	-0.75, 1.00	**0.29**	**0.33**	0.26
Effect size (d; pre vs. post) 2016W2: ***1.13*** *(large)*					
2017W1					
SCENDI pre	514	2.00, 12.00	7.26	7.00	1.97
SCENDI post	514	3.00, 14.00	9.45	9.00	2.02
Normalized change (c)	514	-0.56, 1.00	**0.31**	**0.33**	0.30
Effect size (d; pre vs. post) 2017W1: ***1.05*** *(large)*					

[3] Marx, J.D., and Cummings, K. (2007). Normalized change. *Am. J. Phys 75*(87)

*2017W2**					
SCENDI pre	701	1.00, 13.00	7.59	8.00	2.04
SCENDI post	701	2.00, 14.00	9.84	10.00	2.01
Normalized change (c)	701	-0.80, 1.00	**0.34**	**0.33**	0.29

Effect size (d; pre vs. post) 2017W1: ***1.11*** *(large)*

2. Writing and reporting skills

2.1. The mean grade on the Introduction and Discussion assignments (which make up the respective sections of students' experimental reports) have improved after the deployment of the newly developed instructional resources (Figure 1). Two sets of resources targeting these assignments were provided to students **starting in Fall 2015 (2015W1**): the first version of the TLEF-funded "Biology Frog" animated series, and grading rubrics (not part of this TLEF project, but developed in conjunction with it). While it is impossible to discern the respective effects of each set of resources, the data suggest that, together, they resulted in higher quality student work compared to previous terms. Additional "Biology Frog" videos were **deployed in 2015W2**, and all of those resources have been used since.

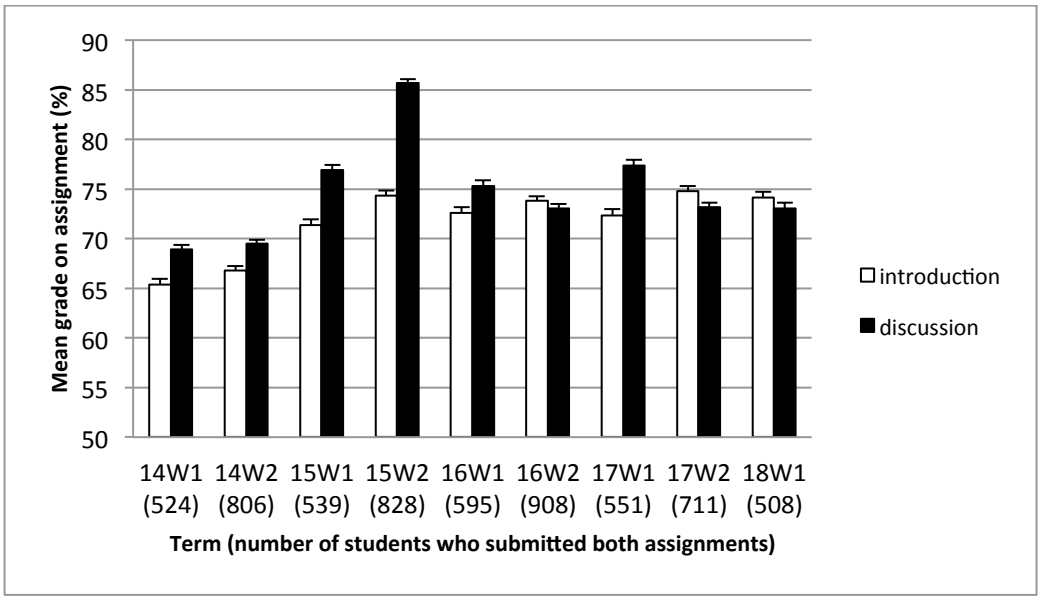

Figure 1. Mean grade (%) on the Introduction and Discussion written assignments, respectively, from 2014 Winter Term 1 (prior to the deployment of any new resources) to 2018 Winter Term 1. The error bars represent the S.E.M.; in brackets below the term designation is the number of students represented in the data. Only data for students who submitted both assignments are included.

APPENDIX D: EVIDENCE OF PROJECT SUCCESS – TA WORKLOAD

One of the challenges of course revision is to ensure that the changes do not result in unsustainable practices, such as an increased workload for Teaching Assistants (TAs). In fact, Biology 140 in its pre-TLEF project version was well-known for often resulting in TA being overworked, so it was critical for our project to achieve improved student satisfaction without overworking the TAs.

The BIOL 140 renewal has shown that TA workload has dramatically improved. The majority of TAs (79%) work less than the average of 12 hours per week and (93%) under the 192 hours per term (Figure 1, Table 1). Furthermore, TAs are requesting specifically to be re-assigned to BIOL 140 for consecutive semesters indicating positive TA perception of BIOL 140 overall.

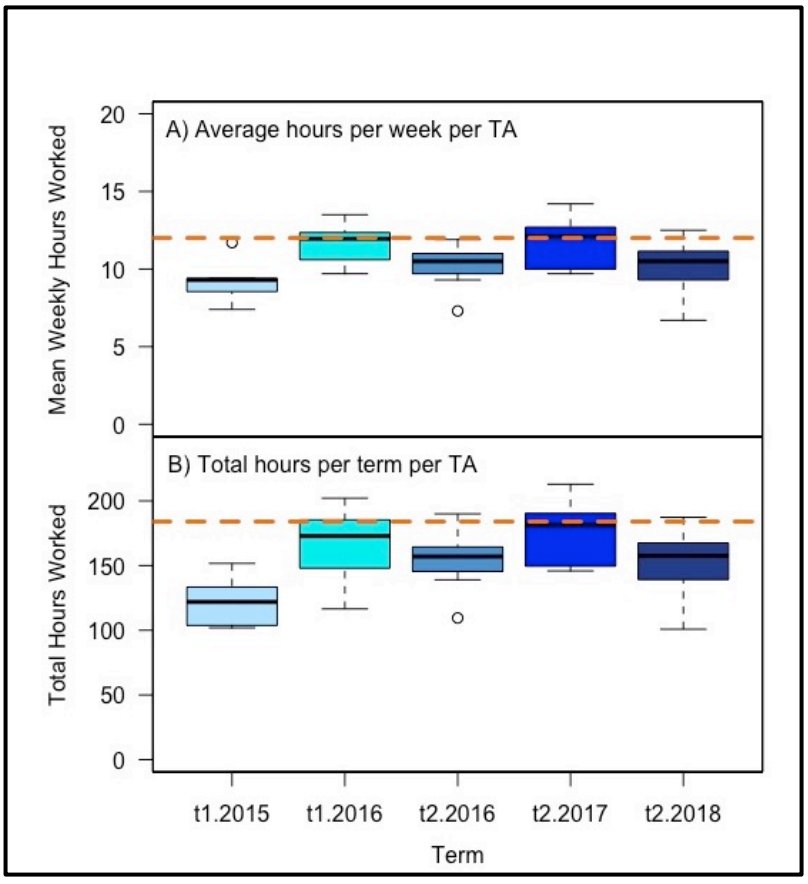

Figure 1. TA hours worked. Box-and-whiskers plot illustrating the average number of hours worked per week (A) and total hours worked per term (B) self-reported by TAs. The instructors suggested maximum average hours per week (12 hours) and maximum hours per term set by the collective agreement are indicated by orange dashed lines (184 hours=organge, 192 hours=red). Outliers are indicated by open circle data points. Data was available for 5 terms total including T1.2015 (n=8 TAs), T1.2016 (n=8 TAs), T2.2016 (n=9 TAs), T2.2017 (n=9 TAs), T2.2018 (n=8 TAs).

Table 1. TA Average Weekly and Total Hours Worked per term. Summary statistics of the average number of hours worked per week and total hours per term by TAs. Only complete or nearly complete timesheets were used in this analysis, others were discarded. All values in the Table were rounded to the nearest integer. Data was available for 5 terms total including 2015W1 (n=8 TAs), 2016W1 (n=8 TAs), 2016W2 (n=9 TAs), 2017W2 (n=9 TAs), 2018W2 (n=8 TAs).

	Average per week	Total per term
Mean (hrs)	11	155
Mean ± 1 s.d. (hrs)	9-12	125-185
Range (hrs)	7-14	101-213
Percent < 12 hr/week (%)	79%	NA
Percent < 184 hours/term (%)	NA	83%
Percent < 192 hours/term (%)	NA	93%
Sample size	42 (8-9 per term)	42 (8-9 per term)