TLEF Project – Final Report

Report Completion Date: (2020/04/30)

1. PROJECT OVERVIEW

1.1. General Information

Project Title:	**Phase I**: Teaching Laboratory Data Management (TLDM) System (2015/2016) **Phase II**: Development of an Automated Grading and Data Manipulation Program for the Teaching Laboratory Data Management (TLDM) System (2017/2018)		
Principal Investigator:	Peter Englezos		
Report Submitted By:	Dhaneshwarie Kannangara, Jim Sibley and Derek Choy		
Project Initiation Date:	May 1st 2015	**Project Completion Date:**	March 31st 2019
Project Type:	☐ Large Transformation ☒ Small Innovation ☐ Flexible Learning ☐ 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

The Teaching Laboratory Data Management (TLDM) system is an online Excel-based coaching tool that provides guidance, feedback, and instructional scaffolding for students as they grapple with long complex laboratory analysis and calculations. The TLDM system also provides, grading assistance to TAs and student performance statistics to instructors.
The first phase of this project focused on development of TLDM modules for the second, third and fourth year undergraduate laboratory courses offered to CHBE students as well as the third year undergraduate laboratory course offered to UNBC/UBC Environmental Engineering students (CHBE 364). The progression of modules is designed such that instructional scaffolding is reduced for each successive undergraduate year.

The second phase of the project focused on streamlining the TLDM data files that contain students' raw data and answers by the creating a custom computer program that automates the operation of TLDM files within the various experimental modules. This saves many hours of TA and instructor grading time. This created program is used to process, automatically grade, and provide specific feedback based on each student's experimental data. This will also aid in accreditation reporting and future course improvements.

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
Phase I: Teaching Laboratory Data Management (TLDM) System (2015/2016)		
Sopida Chotwanwirach*	CHBE fresh graduate	• Generate 27 TLDM files for each experiment in six courses (CHBE 262/362/364/365/366/464)
Norman Siu*	CHBE fresh graduate	
Juana Gonzales*	CHBE fresh graduate	• Test and debug TLDM files
Phase II: Development of an Automated Grading and Data Manipulation Program for the Teaching Laboratory Data Management (TLDM) System (2017/2018)		
Meghana Venkataswamy	CS graduate student	• Initial planer
Brandon Lau	ECE graduate	• Develop automated python program
Nathan Chan*	CHBE fresh graduate	• Develop Excel-macros automated program • Modify Excel-macros automated program due to the decommissioning of the online Connect platform on Aug. 30th, 2018 and transition to the Canvas platform • Modify all TLDM files to improve performance of the TLDM system • Prepare CHBE TLDM guide
Shirley Zhang*	CHBE fresh graduate	• Test and debug, modified TLDM template and answer key files
Jamie Samuel*	CHBE fresh graduate/CS undergraduate student	• Introduce problem sets with historical data • Generate TLDM files for new experiments

*Six CHBE fresh graduates instead of GTAs, were hired to work on the TLDM modules and automated system. These students were selected because they had taken all CHBE laboratory courses and were therefore familiar with all experiments for which this TLDM system was prepared.

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)
CHBE 262	001- 002	2015 - 2019	Fall & Winter
CHBE 263	101 - 104	2019 - present	Fall
CHBE 264	201 - 202	2019 - present	Winter
CHBE 362	101	2015 - present	Fall
CHBE 364	101	2015 - present	Fall
CHBE 365	201	2015 - present	Winter
CHBE 366	201	2015 - present	Winter
CHBE 464	001	2015 - 2016	Fall & 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:
Teaching Laboratory Data Management (TLDM) Files	
Developed 27 TLDM modules and successfully implemented them in Chemical Engineering Laboratory courses (n = 400) for the 2015/2016 academic year. Each CHBE experiment has a unique TLDM module comprised of 5 linked Microsoft Excel™ files: 1) raw data, 2) calculations template containing sample raw data, 3) answers for sample raw data, 4) final answers and 5) master grading sheet. Completed TLDM modules are: • CHBE 262: Revised and debugged two workshops and six experiments • CHBE 364: Revised and debugged four experiments • CHBE 362: Developed two workshops and three experiments • CHBE 365: Developed two workshops and three experiments • CHBE 366: Developed two experiments • CHBE 464: Developed three experiments Updated all TLDM templates and master grading sheets in 2017 summer so that answer keys contain copies of students' data and answer keys. The answer key file would only require to link within itself rather than following specific pathnames, which previously resulted in broken links.	• CHBE teaching laboratory website • Lab instructors' computers • Canvas websites
Computer Automated Programs and CHBE TLDM Guide	

Two programs were created (Python and Excel-Macro) instead of one program as proposed to process, automatically grade, and provide specific feedback based on each student's experimental data. Openpyxl Python library was selected to develop the Python automated system because of the compatibility of this library with Excel files. However, it was found later that scatterplots in certain experiments are too complex for the library to process. To provide a solution for the above problem, a macro program in Microsoft Excel was developed with the capability of preserving charts/graphs generated within the master grading file. Both of these programs have bulk and single upload options. Instructors mainly use the bulk upload system to grade students' lab reports. However, the single upload tool is useful when the instructors grade TLDM files that are either submitted late or required re-grading. The macro automated system (Excel-Macros) has been used in CHBE lab courses (2017-present) for grading students' work. The necessary modifications to the automated macro system program were completed enable it to handle students' data, template and answer files downloaded from the new online learning platform, Canvas.	• CHBE teaching laboratory website • Lab instructors' computers • CHBE teaching laboratory website

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 TLDM project was intended to enhance learning for a significant number of students both directly and indirectly: the system was designed to provide guidance and feedback to students directly while also empowering teachers to teach more effectively. Instructors and TAs were also expected to have an enhanced teaching experience, as the amount of time spent on grading was likely to decrease significantly, allowing for instructional efforts to be refocused on directly working with students.

Enhancement of teaching and learning

Students would benefit by having a better and more successful learning experience through the ability to access timely feedback and support while working on their calculations and data analysis. The TLDM system would flexibly incorporate aspects of the flipped classroom experience with mastery learning. The system would provide a learning experience that students could access anywhere and at any time (flexible learning). Students would be able to teach themselves and their peers, and be better prepared for help interactions with TAs and instructors (flipped classroom learning). Finally, students would be coached toward mastery using guided pathways, scaffolding and fading, clear milestones, specific objectives, and clear goals (mastery learning).

TAs and instructors would benefit from a more efficient and accurate marking process that would free up valuable time that could be better spent interacting with students; this would allow students to receive more focused and constructive feedback from TAs. Very often, the students that are struggling the most have difficulties articulating where and why they are struggling. Since students and TAs would be working from the same guided pathway, TAs would be able to more quickly pinpoint student difficulties and coach them through the next steps. The guided analysis pathways provided by the calculations templates would also help facilitate focused discussion among students.

Optional and scalable scaffolds to support diverse learners

The calculations template containing sample raw data together with associated sample answers serves as an instructional scaffold. To accommodate students with various backgrounds and in different years of the program, the scaffolding offered by the TLDM system is intended to be adaptable, progressive and, more importantly, optional. Components of the calculations template could be adapted and progressively removed for higher-level courses in order to offer an appropriate level of scaffolding. The scaffolds are optional such that they would not interfere with the learning of more expert learners (which is always a concern when using scaffolds). When students are ultimately evaluated based on the quality of their lab reports, and not for the completion of the calculations template, it would mean that students are free to use their own calculation methods as long as they reach the correct results. For students that do take advantage of the provided instructional scaffold, the TLDM modules with sample raw data and sample results should serve as instant feedback during their calculations attempts, allowing them to periodically check their answers and progress, and change learning strategy until they have mastered the calculation process.

Clear expectations and traceability

Students would be encouraged prior to the laboratory session to review the empty raw data file in order to obtain a clear understanding of what data is expected to be gathered during the experiment; this would prevent the situation where students leave the laboratory with an incomplete set of raw data, only to find that they cannot complete their calculations later. The availability of complete raw data and a clear list of expected results (outlined by the answers file) would also help prevent students from unintentionally submitting incomplete lab reports.

Since all numerical results would be graded based on the answer key file generated from the unique raw data set belonging to each student/group, TAs could more quickly and efficiently identify errors and provide necessary feedback on the reports; TAs could also easily include the correct calculation methods and answers (generated by the master grading file) as part of their feedback. Since the raw data file must be submitted at the end of each experiment, and is then used to generate the unique answer key, any “fudging” of data or results would be quickly and simply identified by the TA.

An additional benefit could be the ability for an instructor to provide students with an archived set of raw data for their reports in the event that they were unable to generate usable data themselves during their experiment. In the long term, performance statistics could be extracted from archived data to identify calculation steps and

concepts that students are having most trouble with, and focused improvements could be made to address those areas.

Developing Microsoft Excel™ skills

The calculations template Excel™ file would demonstrate proper use of Excel. Students would be able to explore various Excel™ features, such as statistical functions and data analysis tools; these advanced features are also useful in subsequent CHBE courses. Students would also be able to learn by example strategies for spreadsheet layout, labeling and cell referencing.

Focus on concept mastery rather than task mastery

Students should be focused on understanding scientific concepts, and not with formatting Excel spreadsheets and mindlessly grinding through calculations. By providing the calculations template containing pre-built and pre-labeled data tables, we hoped that students would have time to focus more on understanding the science and mathematics associated with the experiments. By providing sample raw data to demonstrate expected results of the experimental analysis, students would be able to make comparisons to their own results and hypothesize reasons for deviations. Armed with confidence in the accuracy of their calculations, they could focus on scientific analysis and discussion of their results.

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 TLDM system has been very well received by students, TA, and instructors. We have been in conversation with the students (e.g., through the CHBE Undergraduate Society, UNBC/UBC Environmental Engineering Student Association), and TAs throughout the development stages of this project. The CHBE Undergraduate Society conducted an online survey about the TLDM system (during the pilot stage) in 2014. 88% of students completed the survey and indicated that the system was extremely effective, while 94% would like to see the system extended to senior year laboratories. The same survey was conducted for the CHBE 362 laboratory class (n=136) in 2018 Fall term and overall approval of this system remained very high (84% of the class participated in the survey). For more details on these survey, survey results and individual feedback, please refer to articles - *Teaching Laboratory Data Management (TLDM) System [1] and Transforming Undergraduate Chemical Engineering Laboratories [2].*

Past TLEF funding has supported many innovations and improvements in Chemical and Biological Engineering (CHBE) laboratory courses. The value of these innovations was brought to the forefront during the COVID-19 outbreak. CHBE second-year lab course was able to leverage the online resources developed in the past 17 years to navigate these challenging times for teaching. All CHBE teaching laboratories were moved away from in-person learning activities effective Monday March 16th, 2020 with a very little prior notice. 50% of CHBE 264 (n=104) lab class had to complete their last lab (Fluids and Thermo labs) using the available online lab write-ups, videos and the TLDM system. The report was completed using an archived set of raw data provided from the TLDM databank by the lab instructor. The transition was very smooth because of the available online tools built, including the Video PODcasts created with the support of TLEF grant “Using Video PODcasts to integrate conceptual knowledge and laboratory practice (2013)” and the TLDM system (2015 – 2019). These tools will be used in Fall 2020, if we have to continue to offer these teaching labs online.

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.*

1. D. Y. C. Choy, J. Sibley, and D. Kannangara, "Teaching Laboratory Data Management (TLDM) System", *Proc. 2019 Canadian Engineering Education Association; Paper 045, 2019*. [Online]: https://doi.org/10.24908/pceea.vi0.13732 [Apr. 29th, 2020]

2. D. Kannangara and J. Sibley, "Transforming Undergraduate Chemical Engineering Laboratories," *Proc. 2019 Canadian Engineering Education Association; Paper 046, 2019*. [Online]: https://doi.org/10.24908/pceea.vi0.13733 [Apr. 29th, 2020]

3. D. Kannangara, J. Sibley, and D. Choy, "Teaching Laboratory Data Management (TLDM) System", UBC Centre for Teaching Learning and Technology Teaching and Learning Enhancement Fund (TLEF) Showcase, 2016, Vancouver, Canada

4. N. Chan, D. Choy, L. Creagh, D. Kannangara, B. Lau, and J. Sibley, "Development of an Automated Grading and Data Manipulation Program for the Teaching Laboratory Data Management (TLDM) System", UBC Centre for Teaching Learning and Technology Teaching and Learning Enhancement Fund (TLEF) Showcase, 2018, Vancouver, Canada

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 no*

The introduction of the TLDM system has drastically improved the CHBE second and third-year teaching laboratory data collection and analysis practices by:

- enforcing traceability and accuracy of raw data
- reinforcing understanding of course material
- providing effective, accurate and timely feedback for students
- facilitating discussion of calculated results by students that is focused on the methodology
- Creating a unified platform for discussion between students and teachers, and among students
- exposing students to deeper statistical techniques using larger datasets (i.e., "big data") stored in the TLDM database, and advanced features in Microsoft Excel

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?*

In the long-term, the sustainable benefits will include better student learning/mastery, higher quality interactions (e.g., among students, between instructor and students, among TAs and between TAs and students), and more efficient use of TA and instructor time. Instructors will also benefit from the comprehensive archive of student-generated raw data and results, which will be invaluable for future course development and unexpected situations (such as COVID-19)

Some foreseeable challenges include complications that may arise while updating the TLDM files following modifications to existing experiments, as well as generating TLDM modules for new experiments. Difficulties may also be experienced while updating the automated program for use on future online learning platforms.