



# Scientia Education Investment Fund Grants Final Report

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**Improved Learning Through Digital Resources and Hands-on  
Labs in Large Faculty-Level Undergraduate Courses**

**Faculty of Engineering**

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## 1. Executive Summary

### Project

This project aimed to improve the resource sharing and use of technology in hands-on laboratory classes in the new Faculty level course in undergraduate fluid mechanics (ENGG2500) in the transition to UNSW 3+. The project aimed to maximise resources within the university by optimizing the use of existing teaching infrastructure between schools and across multiple teaching terms. This was achieved by sharing the state-of-the-art fluid mechanics laboratory facilities of the School of Mechanical and Manufacturing Engineering across the two participating Schools (School of Civil & Environmental Engineering and School of Mechanical & Manufacturing Engineering). The project also aimed to increase the efficiency of the fluid mechanics courses by using technology to replace many laboratory demonstrators and providing an efficient solution for teaching at scale. This was achieved by developing new pre-/post-lab online assessments and pre-recorded laboratory instruction videos of high quality.

The objective of this project was to improve the overall student learning experience and learning outcomes by giving students continuous opportunity to put theory to practice. This was achieved by running laboratory classes in parallel to the lectures to allow students to experience fundamental fluid mechanics concepts in reality. The laboratory classes were run as small group projects fostering social competencies and a sense of community. Laboratory classes are always a highlight in the course evaluations and providing more access to labs efficiently (using online assessments and teaching videos) provided an alternative and complementary teaching tools to traditional lectures. The laboratory class features were created during 2018 and successfully launched in T1 2019 with a class of more than 600 students.

### Context

The use of automated online assessments at scale has been tested by the Project Leaders in 2017 for their respective 2nd year Fluid Mechanics courses. This included the use of weekly or block quizzes which provided an efficiency gain in automatic marking of close to 1000 online questions allowing students to receive marks/feedback almost instantaneously. Following this successful project, the project leaders planned to introduce new digital laboratory content and wider access to existing teaching laboratory facilities as part of a faculty-wide resource sharing and consolidation initiative for the large scale undergraduate fluid mechanics classes (> 1000 students).

The project timing was favourable due to the consolidation of the 2nd year fluid mechanics courses into the Faculty of Engineering course ENGG2500 “Fluid Mechanics for Engineers” in 2019. The course consolidation was based on the identified common themes across the fluid mechanics courses fostering the development and transition to UNSW3+. Two engineering schools were part of the project: Civil and Environmental Engineering (represented by Drs Stefan Felder and Kristen Splinter) and Mechanical Engineering (represented by Dr Shaun Chan).

While the laboratory classes were already part of the teaching curriculum in both participating schools, each school previously offered a different set of experiments for the students and sharing the existing laboratory teaching equipment between the Schools across multiple trimesters is optimising its use, and enables a more efficient use of the laboratory space and lab demonstrators in UNSW3+.

### Priorities addressed

The project addressed the 2025 Strategy priority A, Theme A2: Part 4: *“To establish UNSW as a global leader in technology-enhanced learning, positioning us as a preferred partner for others at the leading edge of innovation in higher education and digital service delivery. We will develop the organisational culture, infrastructure and capabilities necessary to identify, test and implement the best technology-enhanced learning solutions while at the same time discontinuing those that are less effective”*

The project targeted the SEIF Priority 1: *“Expand and develop new offerings for UNSW students”* and SEIF Priority 3. *“Significantly enhance the student experience or student outcomes via any other original approach not covered above or in other funded schemes like the Inspired Learning Initiative or UNSW 3+ calendar.”*

## Outputs

The project delivered new and improved teaching features for ENGG2500 including:

- Efficient sharing of the fluid mechanics experimental setups across the Engineering Faculty.
- New high-quality laboratory instruction videos for the three laboratory setups in ENGG2500.
- New Moodle lessons which include relevant theoretical background, simple questionnaires to support students' understanding and the lab instruction videos.
- New pre-laboratory assessments (Online Moodle Quizzes), which become available on the Moodle course page following the successful completion of the Moodle lessons.
- Improved laboratory experience through better integrating the laboratory classes with the lecture content.
- Individual post-laboratory assessments in which students use the collected laboratory data in an adaptive assessment in MapleTA. The post-lab assessment automatically compares the student data inputs against the calculated solution allowing efficient and consistent marking.
- Use of student ID scanners at the beginning of the laboratory classes which automatically record student attendance in Moodle as well as automatically close the pre-lab assessment and open the post-lab assessment.
- Use of a smiley app on an iPad to observe the student satisfaction at the end of the laboratory classes.

All these features could be adapted at scale in any undergraduate or postgraduate course across UNSW to make better use of the available learning resources and to improve student learning experiences in laboratory classes using technological solutions.

The project has already been presented at the Engineering Education showcase 2018 and is scheduled to be presented in 2019. The project team will continue to monitor the learning improvement over coming terms and plans to publish the project outcomes once additional data are available over coming terms.

## Key findings

Overall the new features of the laboratory classes were well received by students. This observation is based upon student responses using the smiley app indicating high student satisfaction ratings of ~95% for lab settings 1 and 2 and a lower rating for lab setting 3 due to technical difficulties with this lab setting as well as time limitations with this laboratory class (the lab setting will be adapted for future courses).

The project has achieved its purpose by improving the laboratory classes in ENGG2500 by blending of digital content, instruction videos and new pre- and postlab assessment with the hands-on laboratory classes.

While the overall integration of the laboratory classes with the Moodle course page worked well, the new features also exposed some software limitations. Two problems with the software MapleTA, which was used for the post-laboratory assessment, were found including the missing integration with Moodle and problems with accepted number formatting and not adapting the solutions after students made changes and did not submit from the final page of the assessments. These problems required extensive manual checking and adaptation of the results of the post-laboratory assessment. It is encouraged that UNSW better integrates MapleTA with Moodle or alternatively a different adaptive software solution should be found/developed.

The integration of the attendance taking with the iPads and ID scanners with the Moodle course page should be improved in future. While the current software allowed the recording of student attendances in Moodle, the automatic opening and closing of student activities (i.e. the pre- and post-lab assessments) did not work well and was only possible via the Moodle gradebook and manual saving of student attendances. In particular the use of Moodle gradebook is not preferable due to potential ASTRA interference in future courses (ASTRA was not in operation in this course in T1). A new function in Moodle should be developed to allow better integration of ID scanning with Moodle applications. This would benefit not just ENGG2500, but other courses which may consider use of ID scanners in their courses.

## Recommendations

As outlined in the previous section, the improved lab features and the novel integration of the laboratory classes with the Moodle course page was overall successful and well received by students. In future ENGG2500 classes, several teething problems linked with laboratory setting 3, the limitations of MapleTA and the better integration of the ID scanning with Moodle applications should further improve the new laboratory features. While Moodle can handle basic question types including STACK questions, MapleTA is able to allow the required basic programming to carry previous answers through the entire assignment. However, the missing integration of MapleTA within Moodle, and the teacher and user unfriendliness of MapleTA more generally highlight the need for a better software which allows an efficient marking process in more complicated assessments with data input. It appears that there is currently a gap/room for improvement in the tools for online assessments more complicated than Moodle can handle.

## **2. Outcomes and impact**

### Major achievements

This project had the aim to establish formal resource sharing of laboratory setups in the undergraduate fluid mechanics course (ENGG2500) across the Faculty of Engineering as well as the enhancement of the learning experience in the laboratory classes through digital enhancements. All objectives of the project have been achieved including:

- Resource sharing of the fluid mechanics laboratory setups between the two participating Schools (School of Mechanical & Mining Engineering and School of Civil & Environmental Engineering) has been achieved providing all students equal access to the best possible teaching equipment while using resources across the faculty efficiently and cost-effective.
- The laboratory classes have become a main feature of the ENGG2500 course providing students hands-on-experiences of fundamental fluid mechanics theory. The content of lectures and laboratory classes have been integrated and streamlined.
- New high-quality instruction videos have been created for each laboratory class allowing students to familiarize themselves with the content and tasks prior to their laboratory classes and at their own pace. The videos have been integrated into new Moodle laboratory lessons on the course page.
- New pre-and post-lab assessments have been created. The pre-lab assessments have an Online Quiz format on the Moodle course page and become available once students have completed the laboratory lessons. The post-lab assessment was setup in MapleTA to allow an adaptive assessment, i.e. students insert their collected results in MapleTA at the beginning of the assessment and correct answers are subsequently adapted based upon each student's data set. This adaptive assessment methodology allows a fair marking process irrespective of the quality of the collected data during the laboratory class. Also, students who are unable to attend laboratory classes (e.g. due to disability or in special consideration cases) can be provided with an exemplary data set to complete the post-lab assessment. All assessments are marked automatically providing cost-efficient and fair marking process for this large undergraduate course.
- Use of iPads during the laboratory class to take student attendance at the beginning of the laboratory class and to assess student satisfaction at the end of the class via a smiley app. In particular the attendance taking with an ID scanner at the beginning of the lab classes was a great success. The ID scanning of student cards was time-efficient and provided an exact time stamp of the time a student attended the lab. Via an attendance app (designed by the Faculty of Engineering education support team), the attendance data were directly transferred to the Moodle course page. The attendance data were not only recorded in Moodle but were also used to close the pre-lab assessment and open the post-lab assessment for each student individually.
- The new features in the laboratory classes have been well received by students as evidenced by the new satisfaction surveys via a "smiley app" at the end of the laboratory classes. Constructive feedback provided by students in the myExperience surveys will be used to further improve the course and the laboratory integration in future terms

## Project impact

The impact of this project depends on how the digital uplift of the lab classes and resource sharing meet the pedagogical, technical and business challenges in engineering education. The online material (videos, pre- and post-lab assessments) are assumed to be available for use in years to come, making this project sustainable at scale as well as into the future. On-going upkeep by Project Leaders and/or teaching assistants (lab demonstrators, tutors, etc.) will allow for the resources to be maintained and/or tweaked for improvement in the future. The Fluid Mechanics courses are core undergraduate courses in Engineering and the project leaders are very likely to teach ENGG2500 well into the future. Whenever a change in course personnel (lecturers, tutors, demonstrators) occurs, both Schools have a tradition and planning for a smooth transition and passing on the knowledge and resources to the succession personnel.

A large student cohort with wide ranging academic demographics requires an adaptive and flexible learning system. The language barriers faced by our diverse and international student cohort must also be acknowledged. The sharing of course resources and the development of the new laboratory learning features enables the adaptation to individual student's knowledge levels and educational requirements. Data from Moodle logs in the fluid mechanics courses have indicated that online activities such as adaptive quiz and micro-lectures improve course efficiency and student satisfaction, as well as help Fluid Mechanics students keep up with and review the course work. The new laboratory online features in ENGG2500 were also well received, enabled students to learn more flexible and provided out-of-class support to students, particularly those whose participation in traditional learning activities is restricted (e.g. student with disability or language difficulties). This ensures equality of access for all students in line with the mission, direction and priorities outlined in UNSW's 2025 Strategy. Moreover, as students become more confident and competent with fundamental concepts through the hands-on learning in labs, valuable face-to-face contact time in the classroom can be used for in-depth learning (e.g. more complex and open-ended problem solving).

The consolidation of the two main fluid mechanics courses across the faculty has been successful allowing a more streamlined and flexible learning experience for students. A core component of the new ENGG2500 course was to provide all students with the same opportunity of state-of-the-art laboratory classes, which was achieved through the sharing of the laboratory setups and the wider course resources. Herein the present project has provided a way forward for sharing of educational resources across UNSW which would have wide impacts in terms of more efficient use of resources and providing more students access to state-of-the-art teaching resources.

## Strategic priorities

In line with the 2025 strategy to deliver exemplary education, through innovative digital and hands on learning, the project proposes to share and consolidate the resources across large scale undergraduate Fluid Mechanics courses across the Faculty of Engineering. In particular the project addressed the 2025 Strategy priority A, Theme A2: Part 4: *"To establish UNSW as a global leader in technology-enhanced learning, positioning us as a preferred partner for others at the leading edge of innovation in higher education and digital service delivery. We will develop the organisational culture, infrastructure and capabilities necessary to identify, test and implement the best technology-enhanced learning solutions while at the same time discontinuing those that are less effective"*

The project also targeted the SEIF Priority 1: *"Expand and develop new offerings for UNSW students"* and SEIF Priority 3. *"Significantly enhance the student experience or student outcomes via any other original approach not covered above or in other funded schemes like the Inspired Learning Initiative or UNSW 3+ calendar."*

## Number of students likely to benefit from this project

This project provides direct benefits to 1000+ students annually in ENGG2500.

The project explored and provided many new features to improve laboratory classes and to better integrate the laboratory classes with the overall course content and the Moodle course page as well as resource sharing across the faculty. Herein any of these new features could be adapted in other courses across the university and could be applied at scale, including:

- Sharing of resources providing all students access to world class teaching facilities.

- Integration of laboratory classes with digital learning features including lessons, instruction videos, pre- and post-lab assessments, allowing students to work at their own pace through the course assessments, as well as prepare for and familiarize themselves with the lab ahead of time.
- Adaptive assessments using the laboratory data that students collected during the laboratory class.
- Use of ID scanners to automate the recording of student attendance in Moodle and potential integration with further digital resources.

## 2. Dissemination strategies and outputs

### Dissemination activities

The new laboratory features have been consistently communicated to the ENGG2500 students to provide as much clarity as possible for the course deliverables and the laboratory-based assessments. This has been achieved through the course profile, distinctive Moodle laboratory modules and through regular communication via email, in the Moodle Discussion Forum and in lectures. The communication has been successful as evidenced by the participation of all 600 students in the lab classes and lab assessments. An important part of the communication strategy was based around the new instruction videos which allowed students to prepare for their laboratory classes at their own pace. These instruction videos have also been the feature of a news story on the Water Research Laboratory web page and associated social media channels.

The sharing of laboratory resources provides a more efficient use of university resources while allowing students equal access to state-of-the-art learning methodologies. The sharing of the laboratory setups in ENGG2500 has been enabled through the personal connections between academic members of CVEN and MMAN as well as through the support of the Heads of School in CVEN and MMAN. Both Schools are therefore aware of potential sharing opportunities in other courses. Due to the positioning of ENGG2500 within the Faculty, other Faculty based courses are likely to adopt the resource sharing approach.

An overview of the project and its implementation has been presented at the Engineering Education Showcase in 2018. At the upcoming Engineering Education Showcase 2019, the project will be presented in more detail including the lessons learned from the first successful implementation in T1 2019. This presentation will ensure that a wider audience will become aware of the project.

The project team will continue to monitor the student satisfaction and learning experiences along the project (an ethics approval is in place) and plans to publish the results once more data become available in subsequent years.

### Outputs

A significant output of this project is the improved learning experience for more than 1000 students in one of the core engineering courses across the Engineering Faculty. The improved laboratory classes and their integrated blended learning features will provide students important hands-on experiences to better understand the fundamental fluid mechanics concept in real applications. Better understanding of the engineering fundamentals will increase student performances not only in this course, but also in subsequent more applied engineering courses. Ultimately students that have received a better education and a more in-depth understanding will be able to be effective engineers in their future working life benefitting the wider society and improving the standing of the engineering education at UNSW.

An effective engineer must be able to work in a team to resolve engineering challenges. The laboratory classes are undertaken as a group project fostering communication between students and their social interaction and provide an important interactive experience of problem solving.

The laboratory classes and its blended learning features provide important Stage 1 Competencies for Professional Engineers as per guidelines of Engineers Australia (EA) including:

- PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals
- PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing
- PE2.1 Application of established engineering methods to complex problem solving
- PE2.2 Fluent application of engineering techniques, tools and resources
- PE3.2 Effective oral and written communication (professional and lay domains)
- PE3.6 Effective team membership and team leadership

### 3. Evaluation of project outcomes

#### Evaluation strategy

In 2018 prior to the implementation of the project, surveys on the Moodle course page were undertaken in the fluid mechanics courses to identify students' interest in laboratory classes more generally and in new laboratory features including the implementation of instruction videos and blended learning. The results indicated that students overall liked the laboratory classes due to their practical relevance and were keen on more integrated digital lab features.

To monitor the success of the new laboratory features during the first implementation in T1 2019, several evaluation options were implemented comprising the smiley app on an iPad which gathered the students lab experience at the end of each laboratory class (Qualtrics survey), dedicated via feedback questionnaires for each lab class on the Moodle course page and a particular question about the lab classes in the myExperience survey "Laboratory sessions were a valuable part of this course".

In addition to these surveys, an ethics approval is in place (HC16993: Understanding cross-faculty changes in student learning and engagement after a blended learning implementation in Fluid Mechanics courses) to monitor the student performances in ENGG2500 using data of the Moodle course page and of the course assessments. The idea is to link the students' performances in the coursework assessments and their regular participation in the various blended learning features on the Moodle course page with their overall course performances.

#### Evaluation of results

The lab classes were overall well received by students with a satisfaction rating of ca. 95% for lab classes 1 and 2 based upon the smiley app at the end of the laboratories. However, lab 3 had a much lower satisfaction rate of only 60% which appeared to be linked with student concerns about inadequate time and inaccuracies in their measurements (as expressed in the Moodle feedback surveys and the myExperience feedback).

The feedback in the online surveys on the Moodle course page indicated overall high satisfaction of more than 90% with the lab classes.

The myExperience score for the lab class was lower indicating only a satisfaction rate of ca. 85%. The student feedback in the myExperience survey indicated student concerns with lab class 3. Students' main concern was linked with time pressure during the lab class and their feeling that this resulted in measurement inaccuracies. The much higher satisfaction for lab classes 1 and 2 in their individual evaluations suggest that lab class 3 was responsible for the lower than expected overall evaluation of the lab classes in myExperience.

#### Evaluation report

As outlined above multiple evaluations were undertaken during the first implementation of the new lab features. While the overall outcome is that the lab classes were well received, further improvements must be made in future including:

- Review of timing (start times and penalties, duration for pre- and post-lab assessments).
- Review of lab assessment marks (likely reduction in marks).
- Major adjustment of required data collection in Lab 3 and better communication regarding expectations and measurement accuracies during the lab class.
- Monitoring of student feedback for further finetuning of the lab class features to optimize student satisfaction and learning experiences.
- Ongoing collection of data to evaluate the long-term success of the project.