Transformation in Engineering Education – A Case Study of Remote Learning Experiences in China

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SESSION C1: Integration of theory and practice in the learning and teaching process.

CONTEXT A collaborative teaching program between Deakin University and Wuhan University of Science and Technology (WUST) is a particular realization of a learning and teaching transformation. The collaborative program aims to bring high-quality Australian curriculum standards to mechanical engineering students in Wuhan, China. To maintain collaborative teaching quality, the entire Deakin mechanical engineering program is transformed to the WUST collaborative program.

PURPOSE This study focuses on the quality assurance of teaching in the collaborative program when the learning and teaching process happens outside Australia. When a Mechanical engineering program is offered at a different institution at a different time-span, it requires different learning and teaching support as well as educational settings.

APPROACH To address the first problem of insufficient equipment, we developed experimental equipment that is portable to WUST. To tackle the problem of teaching approaches, we implemented flipped-classroom teaching where equipping students with self-learning skills is emphasised. Quantitative and qualitative questions were given to the students at the end of the trimester teaching to analyse students' experiences and expectations on the implementation of new teaching styles. The outcome of this survey is then fed back to the improvement process of such new teaching styles for the future academic years of the collaborative program.

RESULTS The analysed survey results give an insight into students' perception of the new learning and teaching approaches. The initial results show the overwhelmingly positive reception of the project/design based approach. Obvious quantitative improvements that have been measured are as follows: Students' involvement in classroom/lab activities is improved when compared to that of a previous year cohort with the same activity. The WUST students showed improvement in terms of following along the intensive teaching/learning schedule.

CONCLUSIONS From the survey results, more than 90% of students agreed that the group-based practical activities were most helpful towards achieving the learning goals. The project/design-based learning activities have enhanced students learning capability of understanding practical/theoretical prospects in this course.

KEYWORDS Learning and teaching, collaborative teaching, students' experiences.

Introduction

The field of engineering, like many technical fields, is increasingly working in an international environment. In the Australian context, Australian engineers are increasingly practicing in an international environment. On the other hand, recent years have seen an increase in the number of engineers trained overseas working in Australia. This trend is also seen in higher education, where in recent years, there has been an increasing number of teaching partnerships between Australian and various universities in Asia.

Deakin University in Victoria has engaged in a few international education partnerships for training undergraduate engineers. The first was a partnership between the School of Engineering and IMC Technologies in Singapore to deliver Deakin's undergraduate engineering programme to students in Singapore by means of distance education and intensive on-campus classes in Singapore delivered both by local academics and visiting Deakin academics (Briggs & Chng Han Ming, 1998). Running over several years was a second partnership between Deakin and Kolej Damansara Utama (KDU) College in Malaysia (Selvalingam, Billings, & Booth, 2007).

In 2012 Deakin University and the Wuhan University of Science and Technology (WUST) established a partnership to offer a cooperative BE Mechanical programme in China (Chandrasekaran et al., 2016). The program aims to complement similar programmes operating at WUST, and to give local Chinese students an international engineering education. In this agreement, Chinese students in the programme complete 2.5 years of the course locally in Wuhan. Then they can complete the remaining two years of the course in Australia. Graduates of the program receive a Bachelor of Engineering from Deakin and from WUST. Students are exposed to modern methods of instruction such as cooperative learning and design-based learning. The initial results of the programme indicate that the participating students have an enhanced and satisfactory learning experience (Jiang, 2017). This paper examines the experience of teaching one unit in the programme, SEEW321, Electro-mechanical Systems. It discusses some of the challenges we found in delivering the unit in China and how these challenges were overcome.

Unit Outline of SEEW321 and problem statements

Unit outline of SEEW321

The course is a third-year engineering electro-mechanical unit. This unit is aimed at introducing the underlying concepts combining mechanics, electronics and computing in producing realistic modern day engineering systems. It comprises several main modules including Introduction to Electro-Mechanical Systems and Programming the Programmable Logic Controllers (PLCs).

Topics covered in this unit include: circuit theory, operational amplifiers for analogue signal processing; programmable logic controllers (PLCs) and ladder logic; sensors-position, velocity, encoders, optical pneumatic and hydraulic systems, mechanical actuation; motors-DC, stepper, motor control and computer interface.

Students used these experiences as the starting point for the design and research-based activities, working towards the following Unit Learning Outcomes:

- Gain a basic understanding of PLC programming.
- Use concepts and techniques in electronics to control and design various mechanical systems.
- Obtain an insight into signal conditioning and sensing.
- Provide an understanding into the working of electro-mechanical systems.

The unit has been delivered in both academic years 2016 and 2017. The assessment in the academic year 2016, when the unit is first delivered in China, was designed with most of the focus on assignments and final exam. Particularly in the 2016 curriculum, up to 40% of the final weight was dedicated to written assignments (15% for assignment 1, 10% for assignment 2, and 15% for assignment 3) and 60% of examination.

Problem statements

The unit has been delivered in the collaborative program since early 2016 for a cohort of 40 students. At the end of the teaching 2016 period, a simple evaluation survey was conducted (anonymously) so as to seek students feedback on the unit. The students were primarily asked three questions,

- "What I liked about the lessons (teaching materials and teaching)".
- "What I did not like about the lessons".
- And "what I would suggest to improve the lessons".

A total of 23 students provided feedback out of 40. A variety of remarks were received such as "too many lessons in one week", "give more examples", "provide more realistic examples", "the lesson maybe need some experiments", "the lesson have (no) interaction", etc.

The comments which were mentioned repetitively by students were observed as those might indicate common concerns within the student cohort. Typically, there are a total of seven comments (30%) suggesting to have more practicals and five remarks (21.7%) indicating difficulty to absorb the knowledge in a short period of time.

An investigation into the causes of those concerns of the 2016 cohort was carried out. In fact, even though an engineering unit, there was little experimentation demonstrated to the students. This was due to unavailability of WUST equipment that fits into this Deakin engineering curriculum. Another reason was that there was no existing Deakin equipment which could be used for both teaching at Deakin University and WUST (remote institution). Consequently, this posed a problem of constructing a new experimentation test bench that could be used at Deakin University and portably carried to WUST.

Via examination of the teaching method in 2016, it was obvious that the didactic pedagogy has created passive learning environment within the cohort. Together with a tight schedule – only two weeks of studying for the whole Deakin subject, it caused stress and strain among students who passively strived to follow the intensive schedule. Therefore, the other issue worth discussing is whether we can apply a teaching method that instils students to learn proactively in the intensive teaching mode.

Design-based Remote Learning and Teaching

To address the first problem of insufficient equipment, we developed experimental equipment that is portable to WUST. The equipment satisfies two primary objectives: 1) it is lightweight for the carrying purpose, and 2) it must fit nicely within the curriculum and unit outline of the existing Deakin University unit.

The respective unit earning outcomes require students to have practical capability in programmable logic controllers (PLC) and knowledge on various electro-mechanical signals and systems. An experiment platform training the students towards those outcomes was assembled by recycling existing LabVolt test panels (Festo Didactic Company, n.d.). The platform contains a real PLC and a small-scale wind turbine system as shown in Figure 1.

Not only suitable to training the students to achieve the learning outcomes, the experiment platform is also constructed in a way that is portable. All equipment can be stored in a 57-cm long x 35-cm width x 32-cm height box (Figure 2). As such, the equipment can conveniently be transported between Deakin University and WUST.

In the curriculum, the students work in groups to solve design-based problems constructed around the PLC-wind turbine platform. The basic knowledge of the equipment which is about programmable logic controller (PLC) was presented first. Then students were given design problems, starting from basics, then gradually progressing towards more advanced levels.

(a) The complete platform (b) Students are practicing with the platform

Figure 1: The experiment platform used to train practical capability in SEEW321.

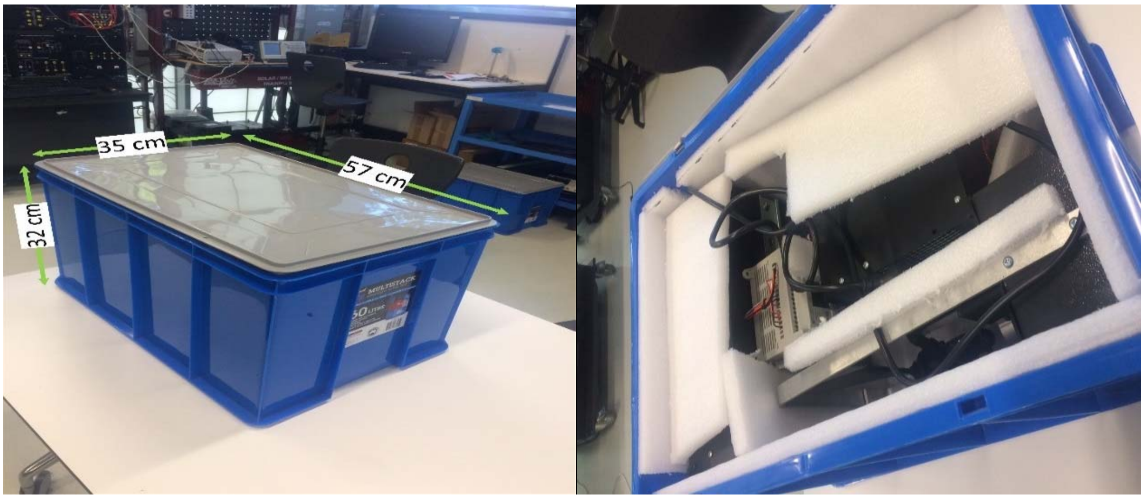

Figure 2: The platform is fit into a portable box (left: the dimension of the box, right: devices arranged in the box).

To address the second problem of teaching approaches, instead of conventional didactic teaching, we carried out flipped-classroom teaching (Velegol, Zappe, & Mahoney, 2015), where equipping students with self-learning skills is emphasised. Students spent their class time engaging in active activities rather than listening to two weeks' worth of intensive lectures. Now students can invest more learning hours into researching directed resources, and then comprehend the new knowledge in a manner consistent with active learning. The steps to carry out flipped classrooms are presented in Figure 3.

Some of the steps in Figure 3 are important. Particularly, the preparation and introductory lectures are vital since students in China are not familiar with flipped classroom teaching. Such beginning lectures prepare the students with this kind of learning and teaching approach which is considered unconventional in China and get the students ready to work in groups. Also, the introductory lecture gives the students an overview of the whole unit contents, the learning outcomes, and assessments so that the students can make plans for their study in this student-focused approach.

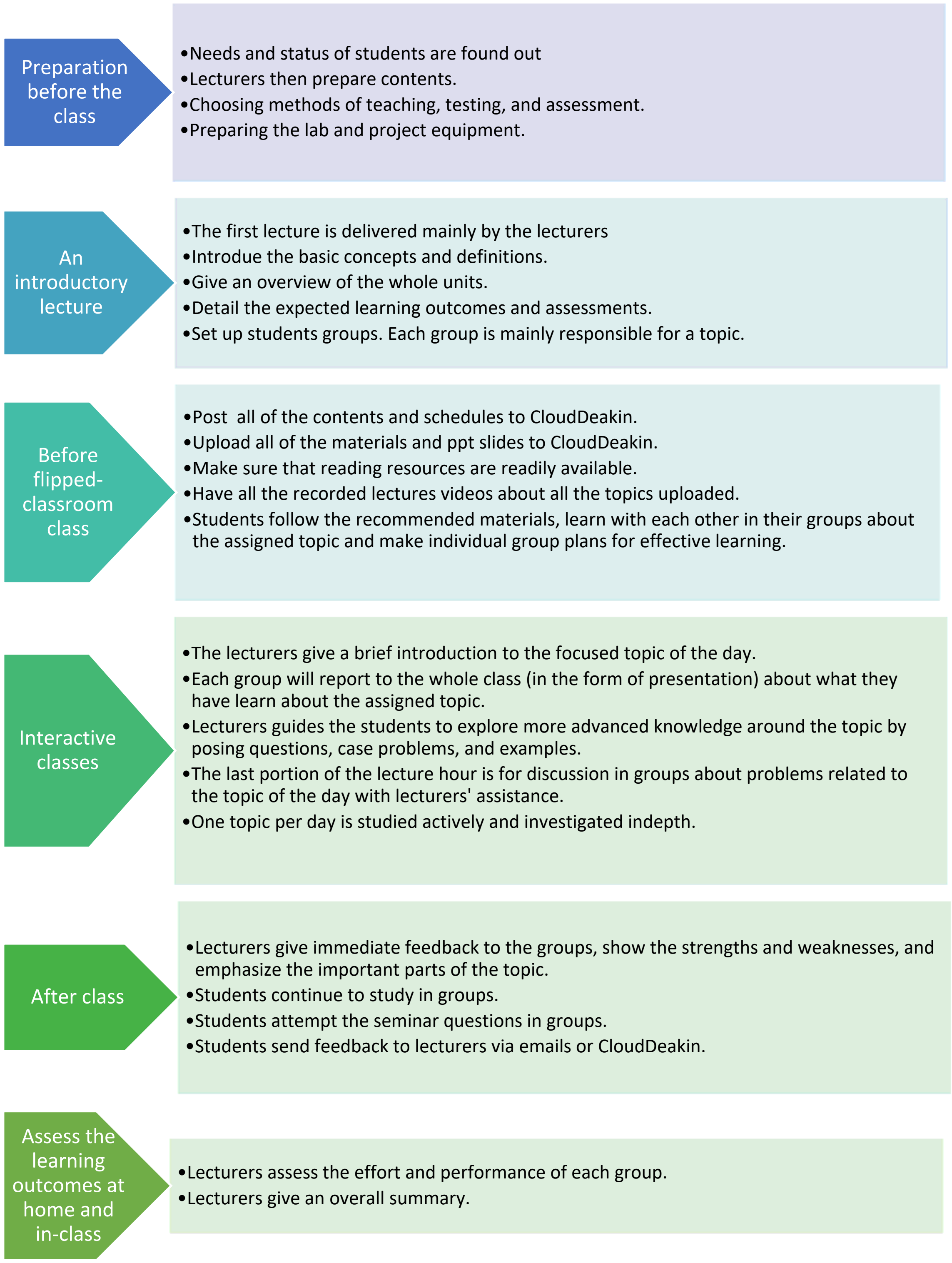

Figure 3: Detailed implementation of the flipped classroom for SEEW321 (after Biggs and Tang, 2011).

Another important step is the presentation (step 4 in Figure 3). Some studies recommend to have in-class discussion. However the students tend to be shy. As being their first time in this approach, they tend to passively listen rather than speaking out. The in-class, group presentation is an ice-breaking technique so as to guide the student to gradually express their opinion publicly and thus actively participate to the learning and study.

The flipped classroom in turn solves the problem of passive didactic learning and facilitates the students' active learning in a short period of time. Even though the whole process takes approximately the same amount of time face-to-face interaction with the students as the didactic, the whole lot of 4 topics of the unit are delivered to the students in an active way. This helps students to avoid the passive-follower phenomenon.

In 2017, in line with the new approach for the collaborative-teaching program, the unit curriculum, especially assessments, is also improved. Instead of focusing purely on the exam and written assignments, assessments on presentation and laboratory practicals are included in the improved curriculum. As such, up to 30% of the final weight is dedicated to assessment of oral presentation and lab work. Assessment also contains 30% of design and analysis assignments, and 40% of examination.

A final remark in this section is that the design of experimentation as well as the flipped classroom are in fact features of design-based learning (DBL) theory. The learning environment assists the curriculum to move into the twenty-first century with students being hands-on in their work. The students develop problem-solving skills, engage in collaborative teamwork, create innovative designs, learn actively, and work with real-world problems. In other words, the implementation of methods presented in this section is actually showcasing an application of DBL. The Table 1 below matches the features of DBL theory (Dopplet, Christian, Schunn, Silk, & Krysinski, 2008) and the teaching and learning methods presented here.

Table 1: DBL learning environment features.

DBL learning environment features	Methods in this section
- A design-based learning curriculum approach in teaching and learning. - Student projects around problem/design activities.	- The construction of the experiment platform and the design problems developed around this experiment platform.
- Team-based learning/collaborating learning in classroom seminars.	- The flipped classroom techniques in which students work, discuss, and present in groups. - The practice of lab practicals and cooperation in groups to solve design problems.
- Teaching and learning assessments/evaluation processes.	- Assessments for presentation, practicals, design assignments, and exam.

Methodology

To assess the efficacy of the proposed teaching and learning approach, perspectives of the students about the proposed approach are obtained. The students' perspectives are also important for staff to improve the teaching and learning approach for this international collaborative program. In this research, a paper-based survey with both quantitative and qualitative questions was utilized to capture the students' perspectives on the unit.

Table 2 shows the survey questions used in this research. The questions are constructed to determine the students' experience of their third-year undergraduate engineering within an international collaborative context. The questions are also designed to facilitate the quantitative and qualitative analyses of the students' perspectives about the design-based approach embraced in the delivery of SEEW321 Electro-mechanical Systems in 2017. Furthermore, challenges to the new teaching and learning approach was identified at the same time via the survey.

The entire cohort of 60 students in their third-year study was asked for their perspectives and level of experience. The survey was conducted anonymously and in a way that students' names are unidentifiable. Results of the survey would present students' own experiences as well as various views of the unit and the course. Such views and experiences also encapsulate knowledge and expectations of the students.

The survey also served the purpose of informing the collaborative teaching program any evolved issues and in turn enhancing the student experience of the program.

Abiding ethics process and procedure, the research survey was conducted only by a third party. Without the involvement of the unit chair and related academics, the students are surveyed with the following questions:

Table 2: Questions for the student survey.

1. Are you motivated to learn and achieve the learning goals in this design based learning unit?
2. Do you feel comfortable to participate and interact in the practical activities?
3. Are the individual/group based practical activities most helpful to achieve learning goals?
4. Do the practical activities help you to practice and obtain design (coding) skills?
5. Do the practical activities help you to practice and obtain problem-solving skills?
6. Do the practical activities help you to practice and obtain communication skills?
7. Do the practical activities help you to practice and obtain team-work skills?
8. Do you enhance your self-study skills by being involved in the flipped classroom teaching approach?
9. Overall are you satisfied with the new teaching approach (practical and flipped classroom)?
10. Does the practical activity task enhance your learning when compared to traditional lecture classes?

Survey Results

A total of 41 students participated in the survey. The students' perceptions on their learning experience are shown in Figure 4. For all the questions, the most common response was agreement. The most questions with which students agreed were questions 1 and 3. A total number of 96% of students agreed that the design-based learning unit had motivated them to achieve the learning goals. 98% of students agreed that the group-based practical activities were most helpful towards achieving the learning goals. These results reflect the fact that the students in China where the conventional theory-focused teaching is embraced have a strong desire towards practical and design-based curriculum.

Around 12% of students disagreed that their self-study skills are enhanced by participating in the flipped classroom teaching approach. The student responses to question 8 indicated that the students still find communication an issue for them in the learning environment. Moreover, since many students experience for the first time active learning, and since all the classes are conducted in English rather than in the native Mandarin, the benefits of flipped classroom are not yet fully comprehended. This area should be investigated further to better understand the underlying reasons for the high number of disagree responses.

The student responses to questions 2, 9 and 10 in the survey were similar. The combined number of agreed responses for these questions ranged between 93-98%. We can say that of the students surveyed, they felt similar about being satisfied with the teaching method and also that the practical activity task had increased their learning compared to traditional learning. Also, the students generally felt comfortable in participating and interacting in the practical activities. That being said, there remains 7% of students, especially in Q9, who were not challenges to the new teaching and learning approach was identified at the same time via the survey.

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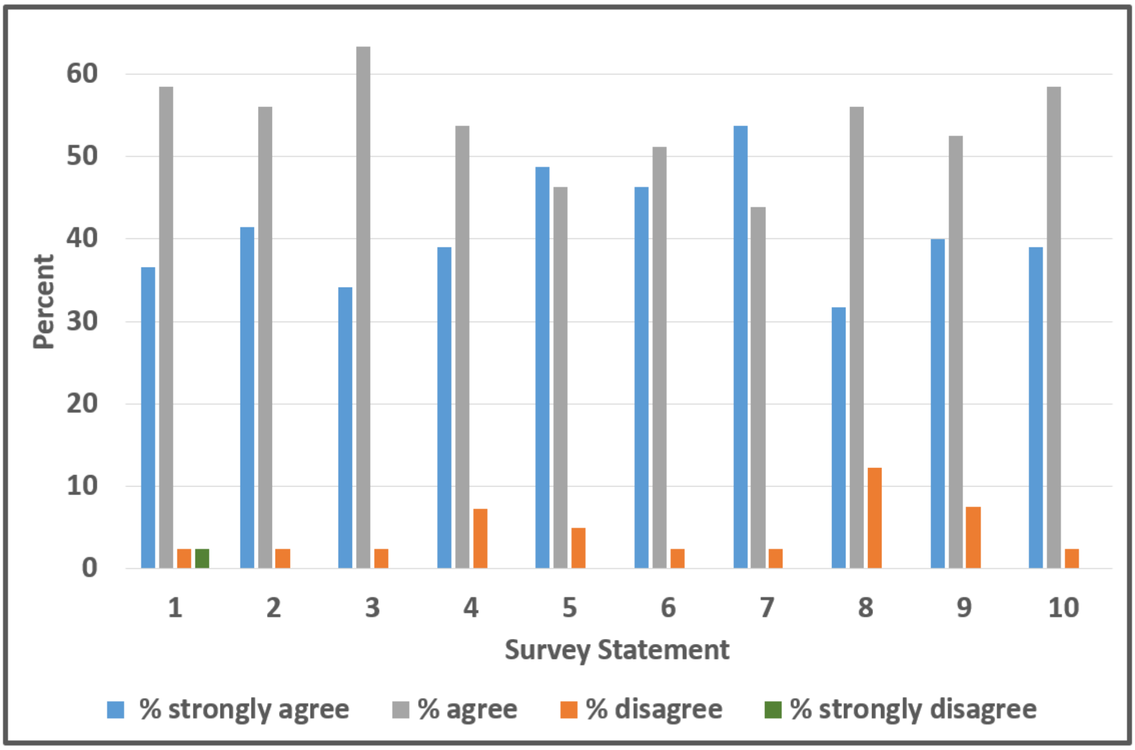

Figure 4: Results of the student survey.

Discussion

At WUST, students are exposed to an international experience of learning engineering professional knowledge and technical knowledge through this collaborative-teaching program. Changing the way of learning will change the students' behaviour in acquiring the values and culture for future career readiness. As an attempt of transformation, in this particular unit we have tried few processes of changing the classroom teaching towards a flipped classroom, along with a portable laboratory facility for students to work on design problems in teams.

It is not only bringing international values to the Chinese students. The motivation of collaborative teaching is bringing understanding and shared values between staff and students. The shared values will create a strong culture for a sustainable educational philosophy. In the process of transforming education, students should able to develop their own learning goals. To select their own learning goals, students should analyse problems and frame questions with respect to the information they lack to solve the problems. Gardner and Hatch (Gardner & Hatch, 1989) state that "intelligence is the capacity to solve problems". Therefore, "students should learn to integrate knowledge from different disciplines and learn to select methods, theories and tools to come up with a solution that is based on the chosen problem" (Jonassen, 2014).

The results show a clear set of positive student satisfaction for the Deakin University engineering design course they had recently completed at the remote institution (WUST). The results in this paper are in line with previous results reported in both Bishop & Verleger (2013) and Scott, Khoo, Peter, & Round (2016), in which significant student preference for the active learning mode is indicated. Furthermore, WUST students' positive response to the design-based and practical curriculum aligns with a recent engineering education research (Wordley, Jones, Taylor, & Pearson, 2016) where more than three quarter of the surveyed students said that they had improved understanding of concepts by spending more time on actively solving design problems. Therefore, the research in this paper implies that the active learning and design-based curriculum make students more satisfied with their learning outcomes irrespective of the geographical difference, i.e. the approach is applicable not only in Australian context but also at overseas institutions of collaborative teaching programs.

There are still some limitations. These limitations are worth being investigated further to make the remote DBL more complete. For example, 12% of students disagreed that their self-study skills are enhanced by taking part in the flipped classroom. Anecdotal evidence has suggested that students in China, besides being acquainted to and comfortable with passive learning, still find it difficult to communicate in English with Australian lecturers. The communication barrier has led to some of the students not to seek guidance from the Australian lecturers. Consequently, the benefits of active learning are not fully comprehended by the students. More surveys and quantitative analyses into this problem should be done in the future so as to resolve the issue. Further work will include a detailed survey of best practice in teaching to off-shore and international cohorts, and intensive training for the teaching staff who travel from Australia to China.

Another limitation is that there are budget constraints in the program that hinders development of portable lab equipment. Therefore, it is not easy to expand the approach proposed in this paper to other units of the WUST- Deakin program. Deakin University, is trialling remote laboratories in which the students via internet are able to remotely conduct experiments and answer design problems. However, this remote-lab solution is difficult to be applied in China due to the slow and unreliable internet connection between China and Australia.

In the future, the following work is proposed to find solutions for the issues:

- Carrying out more surveys to find a way to help students immerse themselves better into the active learning approach.
- Expand the flipped classroom and DBL approach to other units of the collaborative teaching program.
- Instead of making portable lab equipment which is more expensive, more mobile phones apps can be developed for the teaching at both Deakin University and the remote institution.

Conclusion

As part of a joint undergraduate mechanical engineering course offered by Deakin University and Wuhan University of Science and Technology, a third-year unit on electro-mechanical systems has been taught in 2016-2017. Problems with teaching practical skills and maintaining student engagement led to two significant pedagogical changes for 2017. Firstly, a flipped-classroom, design-based teaching approach was adopted, and second, portable lab equipment was brought from Australia to China to give the students some hands-on learning experiences. A survey of students given at the end of the 2017 delivery revealed that students overwhelmingly welcomed the changes to how the unit was delivered in the two-week period of instruction by the Deakin lecturer.

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