

Article

Sustainable Transformation of Undergraduate Engineering Education in China through Sino-Australian Cooperation: A Case Study on Electro-Mechanical System

Yufei Guo ¹, John M. Long ²  and Van Thanh Huynh ^{2,*} 

¹ School of Machinery and Automation, Wuhan University of Science and Technology, Wuhan 430081, China; guoyufei@wust.edu.cn

² School of Engineering, Deakin University, Geelong, VIC 3217, Australia; john.long@deakin.edu.au

* Correspondence: v.huynh@deakin.edu.au

Abstract: China's undergraduate engineering education is facing two significant challenges: passive learning and limited cross-cultural communication. In response, active learning methods such as project-based learning (PBL) and Sino-foreign cooperative education emerge as promising solutions. However, despite their potential, PBL's application remains constrained, and many Sino-foreign cooperative programs persist with traditional passive learning approaches. How to adeptly integrate the two, namely realizing active learning in Sino-foreign cooperative education, is the primary objective of this study. To this end, a sustainable strategy for cross-cultural transfer and the adaptation of active learning is proposed. Initially, a PBL-based active learning pedagogy is tailored for a course within a Sino-Australian cooperative undergraduate program. This approach integrates hands-on activities, teamwork, and the flipped classroom method. Moreover, to ensure implementation quality, an assessment method reliant on continuous student survey feedback is suggested. Subsequently, through the statistical analysis of students' survey data as well as final grades, both quantitative and qualitative results affirm the efficacy of the proposed strategy.

Keywords: undergraduate engineering education; transformation; Sino-foreign cooperation; active learning; PBL (project-based learning); cross-cultural communication; sustainable development



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1. Introduction

As the 'world's factory', China annually produces a substantial volume of industrial products while also educating a significant number of engineering students. According to the Chinese deputy minister of education, China has built the largest engineering education system in the world [1]. However, with the development of China's manufacturing industry toward high-technology innovation and internationalization, its traditional undergraduate engineering education is gradually struggling to meet contemporary demand [2]. This discrepancy has sparked a burgeoning call for the reform or transformation of undergraduate engineering education in China.

China's current undergraduate engineering education is fundamentally rooted in the '1952 reorganization of colleges and departments in higher education institutions', a huge systemic transformation which was primarily influenced by Soviet/Russian education—a lineage stemming from Prussian education [3,4]. Despite absorbing a substantial amount of European and American experiences since the 'reform and opening up' era, its foundational essence still retains traces of Prussian educational principles [4]. One reason for this lies in the historical and cultural similarities between the two. It has been reported that the late 18th-century Prussian reforms, which gave rise to Prussian education, drew certain inspiration from the ancient Chinese examination system (Keju) [5]. Hence, it is not surprising that the Prussian-style education has flourished in Confucian cultural environments, not only in China but also in Japan, Korea, and Singapore.

The primary issue plaguing current undergraduate engineering education in China, similar to all Prussian-style education, lies in passive learning, characterized by a teacher-centered classroom teaching approach [6–8]. This method demands that students predominantly receive information passively from teachers and subsequently resort to rote memorization during examinations or tests. Such a pedagogy yields numerous undesirable consequences, including insufficient practical experience, diminished motivation for learning, a lack of critical thinking skills, and, most critically, the stifling of innovative thinking [9]. However, innovation is widely recognized as essential for countries to develop advanced technology and sustain competitiveness in the 21st century [10].

The key solution to the above issue lies in the core principles of ‘engineering education’. In particular, engineering is about the application of natural sciences and mathematics to practical project solutions [11]. Hence, an engineering student should be educated not only to passively absorb knowledge but also to actively cultivate the skills necessary to address real-world project challenges. Furthermore, as De Graaff and Christensen stated, engineering education and active learning are inherently intertwined [12]. In addition, the National Science Foundation of the United States has emphasized that engineering education should encourage close interaction with industry and embrace project-based learning (PBL) pedagogy [13].

PBL, as its name implies, is a kind of teaching approach embedded within projects. Its core idea is that students acquire and apply new knowledge through tackling practical project-related problems [14–17]. These real-world problems can captivate students’ interest, foster critical thinking, and ignite their innovative potential. Consequently, PBL aligns with the principles of student-centered active learning pedagogy. As a result of these benefits, PBL has attracted considerable attention in global educational reform research and has spawned numerous derivatives, such as design-oriented PBL [18], online PBL [19], team PBL [20], etc. Additionally, considering the core idea of PBL outlined above, it is evident that another form of PBL, known as problem-based learning, is also encompassed within this category [21].

In engineering education, research on PBL has been more extensively developed than in other fields. This is because ‘engineering’ inherently embodies the characteristics of a ‘project’, meaning there is a natural closeness between the two. The outcomes of PBL studies in engineering are evident across various subjects, such as software engineering [22], computer engineering [23], mechanical engineering [17], and so on. However, the application of PBL in practice remains limited, even in developed countries and regions known for their innovation prowess. According to Graham, PBL implementation rates in educational institutions across Europe and the United States plateau at a mere 10% [24]. Furthermore, in developing countries and regions, the actual uptake of PBL is notably lower. For instance, in China, the adoption of PBL is predominantly led by a handful of international institutions, rather than the majority of state-run colleges [25].

Upon reexamining engineering education, it becomes evident that PBL within this field possesses its own distinct disciplinary characteristics, notably emphasizing hands-on activity. This characteristic stands as one of primary factors contributing to the limited spread of PBL implementation in China. Specifically, it necessitates more convenient and advanced hardware equipment, thus requiring greater financial investment. However, it is difficult for non-top-tier universities in China to meet this requirement due to a significant funding disparity compared to top-tier universities. According to reports, the Chinese government allocated more than twice as much funding to 113 key institutions (belonging to 211 and 985 projects) as to the remaining 670 ordinary undergraduate colleges [26].

The second issue troubling current undergraduate engineering education in China is the deficiency in cross-cultural communication. It encompasses not only ‘personal exchanges’, such as international interpersonal interactions among students and teachers, but also ‘non-personal exchanges’, such as intercultural knowledge transfer and remote learning [27]. This issue restricts students’ access to advanced high-tech knowledge and opportunities to engage with diverse perspectives, thoughts, and cultures, thereby hin-

dering the internationalization of undergraduate engineering education in China. As a consequence, this will lead to a decline in the competitiveness of both China's engineers and industrial products in the global market.

To address the above issue, the first type of approach involves adopting strategies related to 'personal exchanges'. Undoubtedly, there has been a significant increase in Chinese students studying abroad in recent years, as evidenced by a tripling enrollment of Chinese students in foreign universities from 229,300 in 2009 to 662,100 in 2021 [28]. However, this strategy primarily benefits students from affluent Chinese families. Similarly, due to financial constraints, the strategy of the widespread recruitment of foreign teachers is also not feasible for non-top-tier universities. Consequently, strategies relying on 'personal exchanges' often lack universal applicability, so it is crucial to prioritize approaches that emphasize 'non-personal exchanges'.

Regarding 'non-personal exchanges', the most notable type of approach nowadays is Sino-foreign cooperative education [29]. With this approach, Chinese students can gain international educational experience without needing to leave China, owing to its lower costs compared to self-funded study abroad. Furthermore, the program of Sino-foreign cooperative education can be categorized into three levels based on the scope of cooperation: university, institute, or degree levels [30]. The latter entails the least amount of expenditure, making it undeniably capable of benefiting a larger number of students.

However, in terms of implementation, the program of degree-level Sino-foreign cooperative education stands out as the most complex among the three tiers. It differs from a university-level program, which usually operates with its own physical campuses and facilities, and from an institute-level program, which has relatively independent administrations and staff. Instead, its facilities, campus, administration, staff, and even classes are fully integrated into the host Chinese university. Consequently, both administrative and teaching staff often lack the enthusiasm to promote these student-centered active teaching methods like PBL. The primary reason is that implementing PBL requires more time and effort from teachers compared to traditional methods [31]. Furthermore, the lack of adequate training in novel teaching methods for teachers further contributes to this issue [32]. In fact, numerous degree-level Sino-foreign cooperative education programs often devolve into mere formalities, relying solely on foreign teaching materials while still using traditional teacher-centered passive learning approaches. In addition, the lack of a sustainable evaluation system with in-depth student involvement is another reason why the quality of the degree-level Sino-foreign cooperative education program cannot be effectively guaranteed [33].

In summary, to produce engineers for high-tech industries and the international market, China needs to enhance the transformation of its undergraduate engineering education, prioritizing the resolution of passive learning and the lack of cross-cultural communication. While active learning approaches such as PBL have been extensively researched worldwide, their application in China is still in its early stages. Furthermore, degree-level Sino-foreign cooperative education programs, intended to be pivotal in fostering cross-cultural communication within China's engineering education, are generally suboptimally implemented due to the ineffective integration of active learning methods and the absence of an efficient evaluation system.

To further address the aforementioned issues, this study proposes a sustainable strategy for the cross-cultural transfer and adaptation of active learning teaching methods, within the context of a degree-level Sino-foreign cooperative education program. Specifically, based on the 'WUST-Deakin BE in Mechanical Engineering' program [34], and taking its 'Electro-Mechanical Systems' course as a case study, a PBL-centered active learning teaching methodology was introduced for the first time. It combines a variety of active learning teaching methods, including hands-on activities through portable lab equipment from Australia, as well as a flipped classroom [35–37] approach and teamwork activities, both of which are not necessary for PBL but are essential in cross-cultural communication. Furthermore, an evaluation method based on continuous student survey feedback was

incorporated to ensure the quality of implementation. Additionally, this study also presents various quantitative and qualitative research findings through the statistical analysis of students' final grades and survey data.

The main contributions and innovations of this study are two-fold. First, it proposes a student-centered active learning teaching methodology for the first time in a Sino-foreign cooperative engineering education program. This method, closely aligned with engineering practice, integrates hands-on and teamwork activities, as well as flipped classroom methods, in addition to PBL. Second, it proposes an evaluation method based on students' continuous survey feedback and final grades to sustainably improve the implementation effectiveness of the course. The surveys conducted included feedback not only from students during the semester but also from those entering the workforce after graduation.

2. Course Background and Information

2.1. WUST-Deakin BE in Mechanical Engineering

The 'WUST-Deakin BE in Mechanical Engineering' program is a degree-level Sino-Australian cooperative education program which aims at transferring the teaching materials of Australian BE (Bachelor Education) in mechanical engineering to China. This program is jointly developed by WUST (Wuhan University of Science and Technology, China) and Deakin (Deakin University, Australia). The two universities work together to design the curriculum and courses and arrange faculty to implement the teaching process.

Chinese students in this program can complete all their courses at WUST. Alternatively, they have the option to complete some courses locally at WUST and then travel to Deakin for the other courses. Graduates of the second kind receive a Bachelor's degree in Engineering from both WUST and Deakin.

Notably, according to the program's cooperative agreement, all courses are taught using traditional WUST teaching methods.

2.2. Electro-Mechanical Systems Course

The 'Electro-Mechanical Systems' course is a core component of the aforementioned program, encompassing nearly all aspects of an actual mechatronic system, including sensors, actuators, and controllers. In the traditional mechanical engineering program at WUST, there is no similar course, and the related content is independently contained in several different courses. In other words, the traditional courses at WUST are more specialized and theoretical, while the courses in this program tend to be more practical and emphasize the integration of different knowledge areas. Consequently, traditional teacher-centered classroom passive learning methods may not adequately meet the requirements of this course.

The 'Electro-Mechanical Systems' course is typically offered during the second semester of the third year. According to the original schedule, the teaching staff had to spend 72 h on classroom teaching activities, without any practical activities. In addition, student assessment in this course relied solely on regular assignments and a final exam.

The teaching staff consists of two members, one from WUST and the other from Deakin. The WUST staff is responsible for half of the classroom hours, as well as organizing assignments and exams, while the Deakin staff oversees the other half of the classroom hours and plays a more active role in training and mentoring the WUST staff.

3. Course Redesign and Research Methods

3.1. Original Course in First Year with Traditional Teaching Methods

The above program had a continuous enrollment plan spanning five years, which means that this course was delivered to five cohorts of students. For the first-year students of the course, who were also the first cohort admitted to this program (enrolled in 2016), we chose to use traditional teaching methods. This choice was made both as a conservative measure and to facilitate comparative research with new teaching methods in subsequent stages. Additionally,

we conducted a simple student questionnaire survey at the end of the first-year course to prepare for sustainable improvement and redesign for the following year's course.

3.2. Redesigned Course in Second Year Adopting New Teaching Methods

In the second year (2017), we redesigned the course primarily by introducing the PBL-based teaching method. The main project objective was to design a controller for an actual electromechanical system. However, due to the lack of suitable hardware at WUST, we developed a convenient lab platform at Deakin this year, which was then transported to WUST by the Deakin staff, as shown in Figure 1. Moreover, the lab platform is functionally compatible with the content of this course. It was created by reconstructing the LabVolt test panel (Festo Didactic Company, n.d.), specifically including a PLC control board and a compact wind turbine system. Obviously, based on this platform, hands-on activities were integrated into this year's course.

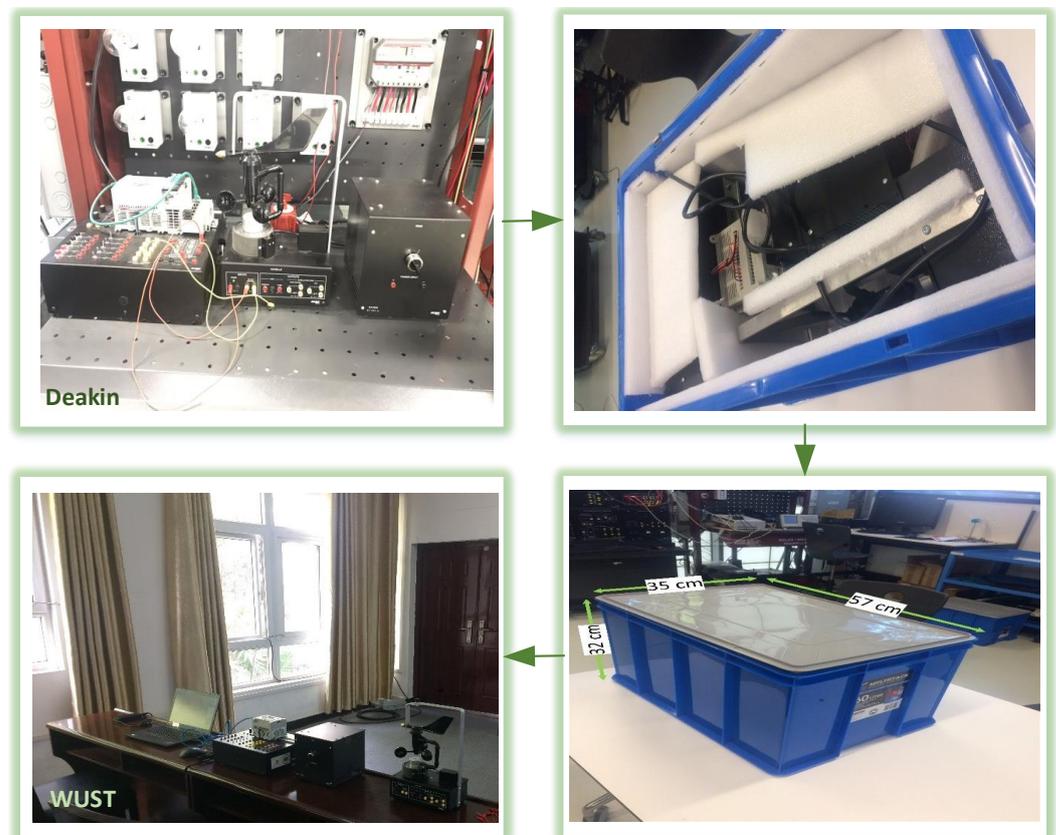


Figure 1. Portable lab platform transferred from Australia to China.

To foster teamwork skills, students were divided into groups to implement and complete the project on the lab platform. Specifically, in 2017, 54 students were evenly distributed into 7 groups, each consisting of 9 members. Moreover, each group elected a leader through democratic elections, and the task allocation within each group was also determined through democratic negotiation among the group members. Hence, teamwork activities have also been integrated into this year's teaching, as shown in Figure 2.

As mentioned earlier, a flipped classroom is not necessary for PBL teaching. However, in the context of cross-cultural communication, it becomes particularly important for students to express their ideas actively. This is because this course is delivered entirely in English, and most have limited English proficiency. Moreover, half of the content for Deakin staff teaching is strictly condensed into two weeks. This places significant pressure on the students. To address this issue, in 2017, we adopted the flipped classroom teaching

method. Specifically, during the project practice, students were provided with extra time to review, troubleshoot equipment, and report their final project results.



Figure 2. Teamwork activities based on lab platform.

The process of the flipped classroom is illustrated in Figure 3. The crucial step is the fourth step, involving group presentations. Given that many students are new to the flipped classroom and have limited English-speaking abilities, they often hesitate to engage in one-on-one discussions with the teacher. To address this, we introduced a group presentation format, serving as an ice-breaking technique to encourage students to share their perspectives and actively participate in learning and discussion. As shown in Figure 4, these in-class group presentations significantly enhance positive interactions and discussions between students and teachers.



Figure 3. Detailed implementation of the flipped classroom in 2017 [34].



Figure 4. One group of students engaging in discussion with the Deakin teacher.

In summary, the teaching methodology proposed in this study, which combines PBL with hands-on practice, teamwork, and flipped classroom, unfolds as follows. First, students are guided to familiarize themselves with the basic knowledge and operation of the project based on the lab platform. Second, different groups are assigned similar project problems, but each project has different parameters. Third, students delve into the fundamentals to solve their respective groups' problems. Fourth, students collectively present their project outcomes and engage in mutual evaluations within their groups. Finally, the teacher conducts the final assessment based on the students' presentations and peer evaluations.

3.3. Courses in Other Years Based on Sustainable Improvement

In the third- and fourth-year courses, we largely maintained the teaching methodology established in the second year, which emphasized an active learning approach centered around PBL. We continued to utilize hands-on activities, teamwork exercises, and flipped classroom methods. However, several adjustments were implemented, such as substituting hardware experiments with simulation experiments. Additionally, group sizes were reduced to three or four students per group, and students were given the autonomy to form their own groups rather than being assigned. Furthermore, the final-year course, conducted exclusively online due to the pandemic, was not included in this study.

4. Results and Analysis

To assess the effectiveness of the proposed teaching approaches, two kinds of evaluation were conducted in this study, including the following: (1) the evaluation of the students' total grades in the four years; (2) the evaluation of the students' assessment questionnaires for the course.

4.1. The Evaluation of the Total Grades

As mentioned above, the total grades of this course in all four years are composed of two parts: the assignment grade and the final examination grade. Specifically, in 2016, 2018, and 2019, the assignment and final examination were graded/weighted at 40% and 60%, respectively. However, in 2017, the grading/weighting of the assignment and final examination were changed to 60% and 40%, respectively. In addition, the final grade of this course uses the traditional 'Hundred Score' system, with 60 marks as the passing grade.

In each year, there were students who dropped this course and also students who moved to Australia for further studies. As a result, we ended up collecting 37, 57, 61, and 56 final grades in 2016, 2017, 2018, and 2019, respectively. In this study, the following three statistical techniques were used for the comparative analysis of the above collected final grades.

4.1.1. Comparison between 2016 and 2019 Using Normal Distribution

First, we performed a normal distribution analysis of the total grades for this course, as this kind of analysis is required for most traditional WUST courses. Here, the difference is that we used the 'normplot' (MATLAB) statistical technique instead of traditional histograms. The 'normplot' command can create a normal probability plot, which includes not only the normal distribution of the data but also all the sample points of the original data. The normal probability plots for the total grades in 2016 and 2017 are presented in Figure 5. The horizontal and vertical axes of the plot indicate the total grade and its probability, respectively. The markers correspond to the original data points of the total grades, and the lines indicate the theoretical normal distribution of the total grades. Moreover, the black solid line and black diamond markers correspond to the total grade in 2016, while the red dashed line and red cross markers correspond to those in 2017. As seen in the figure, the total grades for both 2016 and 2017 follow a normal distribution, because non-normal distributions would be represented as a curve rather than a straight line in such plots. It can also be seen that the markers and lines for 2017 are generally located to the right in 2016. This indicates that the total grades of students in 2017 have improved significantly compared with 2016.

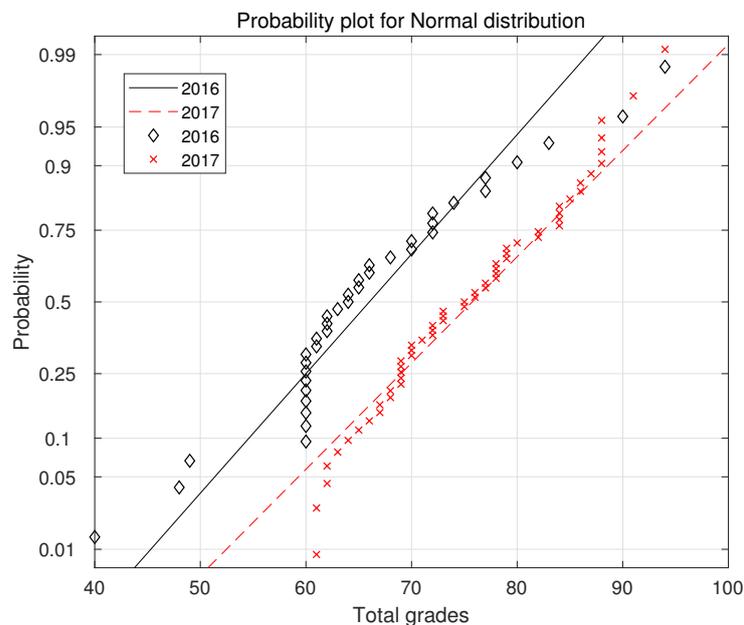


Figure 5. The normal probability plots for the total grades in 2016 and 2017.

The normal probability plots for the total grades in 2017–2019 are presented in Figure 6, in which the blue dash-dotted line and blue circle markers correspond to the total grade in 2018, and the black dotted line and black square markers correspond to those in 2019. As can be seen, although following a normal distribution, the total grades in 2018 dropped significantly compared with 2017, because its markers and line are generally on the left side in 2017. The main reason for this is that, in 2018, this course changed the teaching team and replaced the hardware experiments with simulation experiments, as described in the previous section. However, after one year of running the course with these changes, the total grades of students in 2019 returned to the same level or exceeded those in 2017. As shown in the figure, the slope of the straight line in 2019 is significantly higher than that in 2017. This indicates that the total grades in 2019 are not only better but also more concentrated than those in 2017.

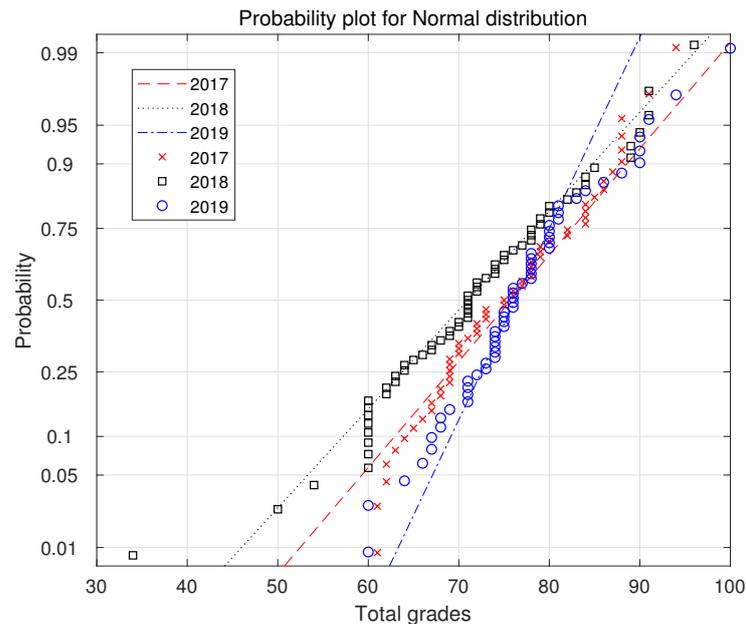


Figure 6. The normal probability plots for the total grades in 2017–2019.

In addition, we can find that, in 2016 and 2018, there is a large number of data samples on the 60 mark point, which deviates significantly from the normal distribution. This is because the pass rate plays a very important role in the WUST teaching evaluation system, and this will inevitably affect the teachers' grading scale (within the allowable range), especially when most students' grades are generally not high.

4.1.2. Comparison between 2016–2019 Using 'boxplot'

Second, we compared the total grades of this course in the four years using the 'boxplot' function of MATLAB. The results are presented in Figure 7. As shown in the figure, each box corresponds to the total grades of each year. The top and bottom edges of the boxes represent the 75th and 25th percentiles of the total grades. The dashed lines above and below the boxes indicate the other non-outlier points, and the red plus sign markers represent the so-called outlier points of the total grades. It can be seen that the maximum grades in 2016–2019 are 94, 94, 96, and 100, respectively, and the minimum grades in 2016–2019 are 40, 61, 34, and 60, respectively. It should be noted that the red lines in the boxes are the median values of the total grades, not the average grades. The median grades in 2016–2019 are 64, 75, 71, and 76, respectively, but the average grades in 2016–2019 are 65.86, 75.46, 71.52, and 76.77, respectively. Moreover, a similar conclusion to Figures 5 and 6 can be drawn from this figure, that is, the total grades in 2017 were better than those in 2016, and after falling back in 2018, the total grades in 2019 returned to the level observed in 2017.

4.1.3. Comparison between 2016–2019 Using Stacked Bar Plot

Third, we conducted a statistical analysis of the total grades for the course over four years from the perspective of grade points. At WUST, there is a corresponding relationship between percentile grades and grade points as follows. The grades 90–100, 80–89, 70–79, 60–69, and <60 correspond to the grade points of 4.0–5.0, 3.0–3.9, 2.0–2.9, 1.0–1.9, and 0, respectively. Therefore, we give the percentage distributions of each segment of the four-year grades in the form of a stacked bar plot, as shown in Figure 8. As can be seen in the figure, the percentages of medium [70, 80) and good grades [80, 90) in 2017 improved significantly compared to 2016, which increased from 21.62% and 5.41% to 38.6% and 26.32%, respectively. Moreover, the failure rate in 2016 was 8.12%, while in 2017, all students passed the course. Although there were, again, students (4.92%) who failed in 2018, we achieved a zero failure rate again in 2019. It can also be seen that, from 2017 to

2019, the percentage of the excellent grade [90, 100) increased year by year, i.e., from 3.51%, to 6.56% to 10.71%.

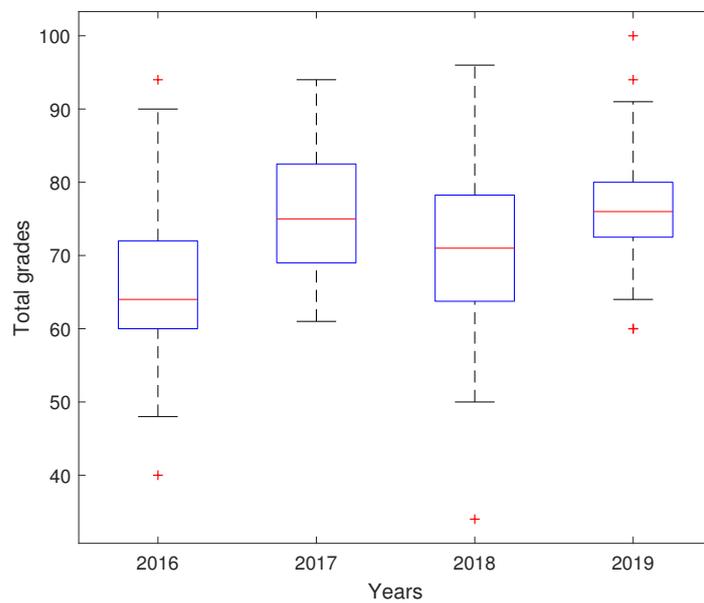


Figure 7. Comparison of total grades between 2016 and 2019 using boxplot.

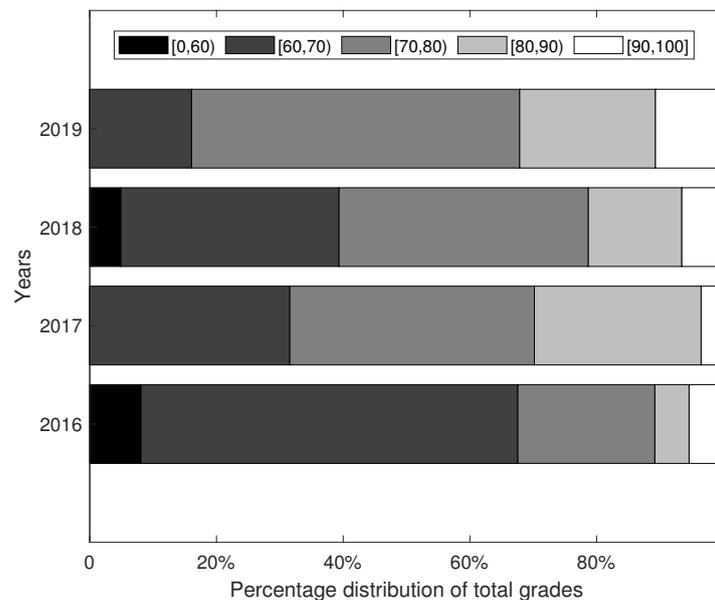


Figure 8. Comparison of total grades between 2016 and 2019 using stacked bar plot.

4.2. Evaluation of Students' Questionnaires

Since the comparison between the course implementations in 2017 and 2016 is the core of this study, the questionnaires were mainly focused on the students in those two years.

4.2.1. Survey for the 2016 Course

In the 2016 course, a straightforward assessment survey (anonymous) was administered at the conclusion of the teaching period to gather student feedback on the unit [35]. Specifically, students were primarily prompted with six questions, comprising three single-choice questions and three open-ended questions, as outlined below:

- (1) This lesson topic was helpful.
- (2) The lesson held my attention.
- (3) The lesson was easy to understand.
- (1) What I liked about the lessons.
- (2) What I did not like about the lessons.
- (3) What I would suggest to improve the lessons.

For the single-choice questions, students could circle an appropriate number (from 1 to 5) to give their answer, where 1 = 'Not at all', 2 = 'Very little', 3 = 'Somewhat', 4 = 'Quite a bit', and 5 = 'Extremely'. The results are shown in Figure 9. It can be seen from the figure that we finally collected 35 valid survey responses. As shown, the majority of students indicated that the course was very helpful, specifically including 57.14% for 'Quite a bit' and 20% for 'Extremely' helpful. However, 14.3% of students reported that the current lesson did not hold their attention (including 2.86% for 'Not at all' and 11.43% for 'Very little'), and 14.29% of students answered that the lesson was very hard to understand. For the first open question, few students gave their answers. For the second open question, we received a variety of comments such as 'difficult to understand', 'too many formulas', 'lack of practice', 'content boring', 'foreign language', 'time-table', etc. For the last open question, we obtained several suggestions, including 'more practice', 'need some experiments', 'more discussion', 'speak more slowly', 'uploading the teaching material before the class', etc. We focused on the comments and suggestions repeatedly mentioned, which indicated common concerns within the student cohort. In short, most students indicated that it was difficult to absorb the knowledge in a short period of time in 2016, and suggested to have more practicals in future.

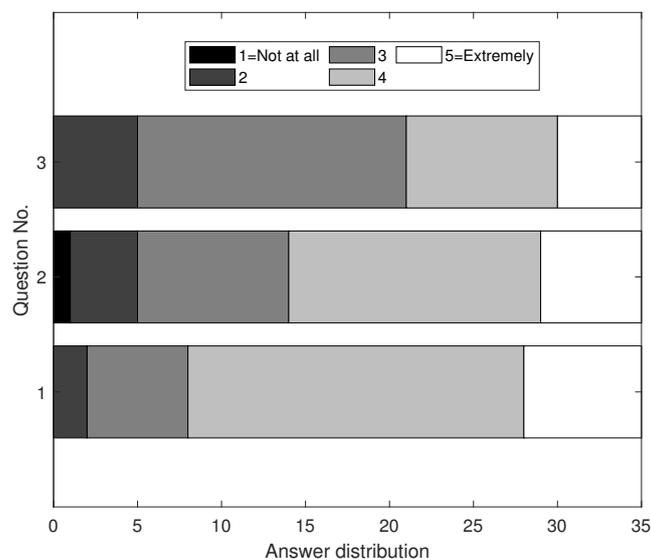


Figure 9. The 2016 students' feedback.

4.2.2. Survey for the 2017 Course

For the 2017 course, two kinds of assessment surveys were administered to obtain students' evaluations and feedback on the new teaching approaches used during this year. The first one was a survey on the flipped classroom teaching method, which included twelve single-choice questions and two open questions, as follows:

- (1) How much effort do you invest in self-studying before class?
- (2) How do you think about your performance so far?
- (3) Do you realize that new teaching improves your self-studying?
- (4) Do you realize that new teaching improves your teamwork skills?
- (5) Do you realize that new teaching improves your communication skills?
- (6) Do you agree that new teaching helps you focus more on the subject?

- (7) Do you agree that new teaching helps you understand the subject better?
 - (8) Do you think that new teaching and learning benefit your future career as an engineer?
 - (9) Do you realize that students is the centre and teacher is just a facilitator in the new teaching?
 - (10) The lecturer was helpful.
 - (11) The lecturer was communicative and interactive.
 - (12) Overall, how do you find the usefulness of the new teaching?
- (1) Reflect on your self-studying and give comments on what and how you will do to learn better in the future.
 - (2) Give comments on aspect(s) that this class can do better for you in the future.

Similarly, students were asked to answer the single-choice questions by circling an appropriate number from 1 to 5, with 1–5 corresponding to ‘Not at all’–‘Extremely’. This survey was also administered at the end of the teaching period. We ended up collecting 33 valid survey responses. The results are displayed in Figure 10. As seen in the figure, the number of students who spend more (‘Quite a bit’ and ‘Extremely’) and less (‘Not at all’ and ‘Very little’) time on self-studying before class are equal, both at 24.24%. The number of students who are satisfied (‘Quite a bit’ and ‘Extremely’) and dissatisfied (‘Not at all’ and ‘Very little’) with their performance are also equal, which are both at 27.27%. Most students reported that the new teaching method had improved their self-studying, teamwork, and communication skills, with negative feedback from just 12.12%, 15.15%, and 15.15%, respectively. Moreover, most students agreed that the method can help them focus more on and better understand the subject, the negative feedback for both of which are 6.06%. More than half of the students (51.52%) strongly recognized that this teaching method would benefit their future career as engineers. The same number of students (51.52%) strongly agreed that this teaching method centers on the student rather than the teacher. More than half of the students gave positive feedback on the teachers’ help (57.58%), communication, and interaction (57.58%). In addition, very few students gave negative feedback for the helpfulness of the new teaching method, with only 6.06% for ‘Very little’ and 0% for ‘Not at all’.

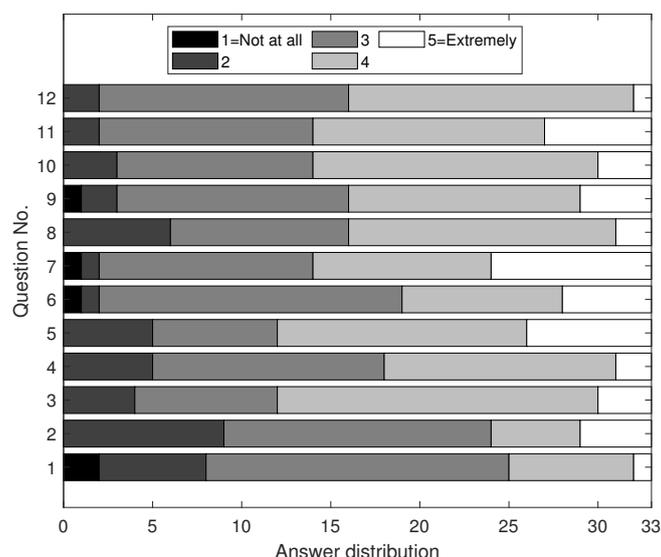


Figure 10. The 2017 students’ feedback on flipped classroom teaching method.

The second kind of assessment survey for the 2017 course is mainly about the DBL method. This survey was carried out twice in total, once at the end of the teaching semester in 2017 and once in 2019 on the same cohort of students. This survey gave students ten single-choice questions (four similar questions were grouped together) and one open question, as follows:

- (1) I am motivated to learn and achieve the learning goals in this design based learning unit.
 - (2) I feel comfortable to participate and interact in the practical activities.
 - (3) I found the individual/group based practical activities most helpful to achieve learning goals.
 - (4) The practical activity task help me to practice and obtain:
 - design (coding) skills;
 - problem-solving skills;
 - communication skills;
 - teamwork skills.
 - (5) I enhance my self-study skills by being involved in the flipped classroom teaching approach.
 - (6) Overall I am satisfied with the new teaching approach (practical and flipped classroom).
 - (7) The practical activity task enhanced my learning when compared to traditional lecture classes.
- (1) What did you find most useful in this unit?

For the single-choice questions, students gave an answer by checking one of the following four options, i.e., 'Strongly disagree', 'Disagree', 'Agree', and 'Strongly agree'. The results are presented in Figure 11. We finally obtained 40 valid survey responses from students. As shown in the figure, most of the students indicated that they were motivated by the DBL method, with 57.5% selecting 'Agree' and 37.5% selecting 'Strongly agree'. Moreover, up to 97.5% of students gave positive feedback on the practical activities and individual-/group-based practical activities. It can also be seen that 92.5%, 95%, 97.5%, 97.5%, and 87.5% of students agreed (or strongly agreed) that the new teaching methods improved their design (coding), problem-solving, communication, teamwork, and self-studying skills, respectively. As a result, most students expressed satisfaction with the new teaching methods (92.5%), especially when compared to the traditional teaching methods (97.5%). For the open question, we also obtained a number of survey responses, some of which were mentioned repeatedly, such as 'team work', 'self-studying', 'group activities', 'practical activities', 'communication', and so on.

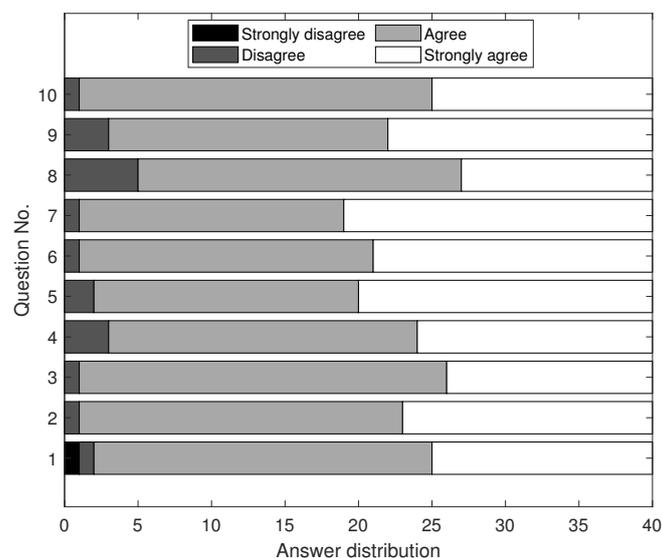


Figure 11. The first round of feedback from 2017 students on the DBL method.

A second DBL survey for the 2017 course was conducted in 2019, when the majority of these 2017 students had graduated. Therefore, this survey was implemented through online technology, i.e., QQ survey of Tencent software (QQ 2019). Students were asked almost the same questions as the first survey. The slight difference is that we changed the affirmative sentence for the first survey into an interrogative statement and separated the

grouped question into four different questions. Specifically, the ten single-choice questions and one open question are as follows:

- (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?
- (1) What did you find most useful in this unit?

The results for the single-choice questions are presented in Figure 12. We ended up collecting 35 survey responses. As shown in the figure, most students gave very positive feedback on all questions, with ‘Strongly agree’ percentages of 74.29%, 65.71%, 74.29%, 68.57%, 62.86%, 71.43%, 71.43%, 68.57%, 82.86%, and 74.29% for questions 1 to 10, respectively. Only 8.57% of students did not agree that the practical activities improved their problem-solving skills. Moreover, only 2.81% of the students gave negative feedback on questions 1, 2, 4, 8, and 10, and only 5.71% gave negative feedback on questions 7 and 9. In addition, all students indicated that the individual-/group-based practical activities were the most helpful in achieving learning goals. For the open question, these students, who were already working as mechanical engineers, gave several new comments informed by their practical work. For example, one student indicated that ‘This course has taught me a lot of useful things that will help me in my study and work’. Another student reported that ‘When we go to work, thinking from the perspective of practical activities improves our efficiency in dealing with things. Practice is the only criterion to test the truth, especially for the students of Mechanical Engineering’.

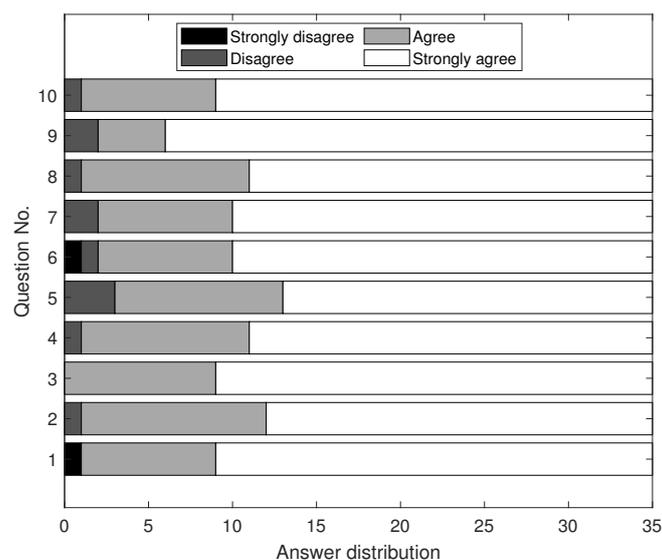


Figure 12. The second round of feedback from 2017 students on the DBL method.

5. Discussion

Overall, the application of the proposed innovative PBL-based teaching methodology, incorporating group activities, teamwork activities, and flipped classroom techniques within the 'Electromechanical Systems' course of the Sino-Australian Cooperation Program, has produced positive and promising outcomes. These results will be comprehensively analyzed and discussed in chronological order below.

In 2016, we launched the course for the first time. Despite our thorough preparation for potential challenges, the outcomes fell short of expectations. This particular year saw the highest failure rate and the greatest proportion of grades falling within the [60–70] range compared to the aggregate scores of the subsequent three years. Moreover, the mean, median, and maximum scores for 2016 were the lowest across the four-year period. Additionally, insights from the student feedback survey underscored the need for enhancing satisfaction with the course. The primary issue with the 2016 iteration lay in the fact that WUST students were solely exposed to internationalized teaching materials and teachers, without exposure to advanced active learning methodologies.

In 2017, we redesigned the course, introducing a student-centered learning strategy centered around PBL. The results showed significant improvement in student performance, with a 100% pass rate and an average score of 75.46. Additionally, we introduced a teaching assessment strategy that enables students to engage deeply and sustainably. The survey results, spanning not only the current semester but also post-graduation, demonstrated that the new teaching method not only enhanced students' academic performance and satisfaction with the course but also facilitated their career planning. Furthermore, as an initial step in pedagogical transformation in this program, we facilitated WUST faculty training at Deakin, focusing on PBL and other relevant topics. This proved to be another crucial factor in the successful adoption of the new teaching method. Additionally, although there was a slight dip in overall student achievement in 2018 attributed to changes in faculty team members, the results in 2019 not only rebounded to but also surpassed the levels seen in 2017. This serves as further evidence of the efficacy of the proposed methodology.

6. Conclusions

This paper delves into the transfer and adaptation strategies of active learning teaching methods within a cross-cultural context. Specifically, it introduces a teaching methodology centered around PBL for a course within a Sino-foreign cooperative undergraduate engineering program, complemented by an evaluation approach that emphasizes deep student engagement and sustainable survey feedback. The findings highlight significant improvements in both student learning outcomes and satisfaction levels. Furthermore, there has been notable enhancement in the active learning teaching competencies of faculty members in China. As a result, it can be inferred that the proposed strategy effectively and consistently facilitates the high-quality implementation of Sino-foreign cooperative programs and may offer insights for the transformation of undergraduate engineering education in China.

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