

Team-Based Learning to Improve Diversity and Inclusion of Environmental Engineering Students: A Mixed Methods Case Study*

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In engineering education, numerous ranges of diversity are needed. With the growing number of international students, it is essential to enhance the inclusion in higher education. Team-based learning (TBL) has been applied in engineering education to boost diversity and inclusion. This study applied a mixed methods approach, a combination of quantitative (questionnaire) and qualitative (interview) methods, to research the effect of TBL on the diversity and inclusion of Chinese students and British students in the Environmental Engineering programme at one UK university. Nearly 70% of Chinese students considered their learning experiences with British students to be positive or very positive. Approximately 64% of students believed that they learned most when they were “discussing and preparing group seminar work/presentation together in library/classroom/other places”. “Enjoying a different culture” and “Learning from others with different educational backgrounds” are two primary reasons for Chinese students liking learning with British teammates. The interviews indicated substantial beneficial effects of TBL on enhancing diversity and inclusion in engineering education. Many students welcome the difference and consider it an opportunity to comprehend the foreign culture. The research results shed light on that embracing diversity and producing an inclusive setting have favourable effects on the academic and social development of engineering students. The COVID-19 pandemic exacerbated racism in some areas. Due to international travel restrictions, most international students have to study online. Further studies are required to understand the new challenges brought about by the pandemic.

Keywords: team-based learning; environmental engineering education; diversity; inclusion; China; UK

1. Introduction

A climbing demand for engineers triggers a boom in engineering education. Diversity of engineering graduates is important for enterprises to achieve international solutions to challenges, produce new products and serve wider customers, while around over one-third business report difficulties in finding diverse engineers to meet the sustainable requirements of project design and operation [1]. In engineering education, numerous ranges of diversity are required, consisting of, at the minimum, racial, ethnic, and gender.

In the UK, engineering education programs have developed rapidly in the recent decades. However, reports by the UK Royal Academy of Engineering [2] and UNESCO [3] on engineering education have suggested issues concerning the inadequate quality of engineering graduates. Rapid advances in new technology and globalisation currently call for the workforce to excel in the academic and obtain numerous work proficiencies, particularly diversity and inclusion. For example, the comparison between teams with racial diversity to teams without racial diversity indicated that the former teams overmatch the latter teams [4].

Diversity consists of all the ways in which individuals vary, and it incorporates all the various

attributes that make one person or group different from others [5]. Diversity includes not only gender, ethnicity, race, but also age, nationality, disability, religion, sexual orientation, marital status, and others. It also includes various values, perspectives, and ideas [5]. Inclusion is authentically embracing typically excluded people and/or groups into activities, processes, and decision making in such a way that shares power, make all feel more accepted, respected, and paid attention to [5]. There is an increasing number of studies on diversity and inclusion in Higher Education. Traditionally, racism has been one of the focuses of research. Public racism is less common today, but racism is still a significant problem. For example, African American students continue to feel unwelcome in engineering programmes at some universities. In interviews conducted by McGee and Martin [6], African American students described the subtle and blatant racism, including a constant awareness that being African American was an indicator of inferiority in engineering education. Other groups of students also experienced similar racism, such as Asian Americans [7] and Latinas [8] in engineering education. The entire education sector should work to improve diversity and inclusion, while faculty play an important role. According to Vernā Myers' powerful metaphor “Diversity is about being

asked to the party; inclusion is being asked to dance” [9], bringing staff and students in is just the first step in diversity and inclusion practices. Newman [10] suggested that faculty play a crucial role in encouraging or dissuading students to persist in their respective majors and become involved in study and research. Properly organized educational practices (i.e., curriculum, teaching and broader learning experiences) can foster inclusion and help diverse learners develop [11]. Various theories have also been developed to better understand the diverse experiences of students in engineering education, for example, social identity theory [12].

The number of engineering students enrolling in UK universities has increased substantially, with approximately 30% of students being international ones, for example from China, India, and other countries [13]. Improving diversity and inclusion in the learning environment for both home and international students is essential for the success of engineering education. Scholars have found that unsuccessful adaptation to the foreign cultures can likely cause academic failure among international students. Worse, many international students may additionally deal with psychological and physical difficulties or behavioural issues, with some significant impacts [14].

To enhance inclusion in the study environment, the team-based learning (TBL) has been increasingly applied in the educational environment with both home and international students [15]. TBL, a type of active learning, entails establishing teaching and studying practices that allow small teams of students to learn together in the classroom or beyond [16]. TBL pedagogy typically has students in small teams studying together and delivering presentations to all students. Making use of teacher guided in person time in the classroom enables self-managed team study and team assignments. TBL provides students with a team identity and co-responsibility. Learning in small teams, all students deal with a common job and share a common mark, which inspires students to make contributions to the whole team’s success. The pedagogical strategy behind TBL is to encourage prior study through team study and testing, and to improve diversity and inclusion by means of group cooperation [17]. In the TBL, it is important to create a risk-free environment for all individuals in which all students feel comfortable for raising questions and conducting teamwork. Gurin et al. [18] have confirmed that diverse and inclusive classrooms have advantages including improving learning and increasing social interactions. Nevertheless, a diverse mix of students does not automatically create inclusion in the learning environment. When students do not appreciate inclusion in the

learning environment, a diverse classroom environment does not really exist [19].

China has become the world’s largest exporter of international students. In 2019, more than 0.7 million Chinese students studied abroad [20]. Scholars have investigated the inclusiveness of the learning environments, including Chinese students and European/American students. Chinese students often experience various levels of stress when they study and reside far from home in a foreign country. Yan and Berliner summarized that culture shock can conveniently cause life and psychological stress, resulting in study failure, or even drop out [21]. Some scholars have suggested that unsuccessful adjusting to a different culture can easily cause international students to fail academically [22–24]. In the UK, a number of scholars have researched the inter-cultural adaptation when Chinese students transferred from China to the UK [25–27]. These researchers offer good empirical studies regarding the challenging experience of Chinese students’ inter-cultural adjustment and study experience in the UK. Generally, the majority of Chinese students succeeded in adjusting to the different study environments and developing inter-cultural competencies, while there still were big challenges, including social involvement and English proficiency. Cross-cultural adaptation and learning throughout the study abroad period is one of the largest obstacles for not only Chinese students but also other international students.

However, the inclusiveness of Chinese students at UK universities is far from clearly understood. An in-depth investigation into the diversity and inclusion of Chinese students is still largely needed. It is this lesser-explored facet which the following study aims to analyse. This research focuses on an Environmental Engineering programme at one British university. The main aims of this research are to (1) investigate engineering students’ study experience in a cross-culture study environment; and (2) assess the effect of TBL on the diversity and inclusion of engineering students. The findings of this study will expand the literature of this under-studied area and provide empirical evidence to various stakeholders who are involved in the education of international students and committed to improving diversity and inclusion of students.

2. Methods

To boost the diversity and inclusion of this Environmental Engineering programme, one change we have made to our teaching is to have students to study in formed small teams following the teaching strategy recommendation, integrating students’ race and gender.

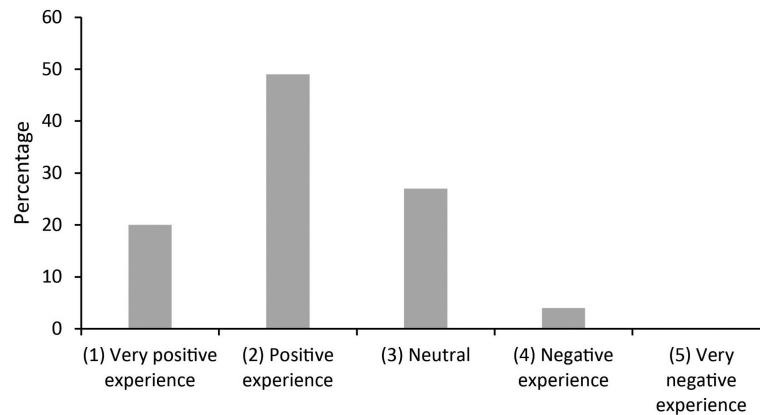


Fig. 1. Chinese students' evaluation of their learning experience with British students.

This research takes advantage of a mixed methods approach utilizing a combination of quantitative and qualitative methods [28]. An online questionnaire survey was carried out to understand Chinese students' study experiences in small teams. Questions consist of students' study experience at one UK university, academic performance of individual and group coursework, and students' backgrounds. The survey was conducted in June 2020.

The semi-standardized interviews were performed to produce a micro-level view of the students' study situation and factors which influence their learning experience in groups. In total, 10 Chinese students were interviewed to understand: (1) Chinese students' learning experience with British students; (2) obstacles to stop Chinese students' studying with British students; (3) suggestions to improve learning experience.

In terms of the questionnaire results, this research adopted quantitative analysis using statistical software SPSS version 24 (IBM Corp, USA). Chi-square tests were conducted to examine the significance of differences in one variable among various categories of other variables [29].

Interviews were recorded and transcribed for further analysis. A thematic analysis was performed for the interview data [30]. The analysis started with inductive coding each line. The coded outcomes were then organized according to conceptual categories and themes [31]. Software NVivo version 12 (QSR International Pty Ltd, Australia) was used to generate and organize the codes, categories and themes [32].

This research is subject to ethical review in conformity with the standards established by the Research Ethics Committee, University of Reading, and has been allowed to proceed. All students who took part in the interviews were provided pseudonyms to ensure their anonymity.

3. Results

3.1 Questionnaire Results

In total, 101 Chinese students took part in the online questionnaire, including 75 female and 26 male students. Almost 70% of participants thought that their studying experiences with British students were positive or very positive (Fig. 1). In contrast, just 4% of Chinese students considered them as negative experiences. There were no students who viewed it as very negative experience. The Chi-square test indicated no significant difference in the students' opinions on their study experience between male and female students ($p = 0.8376$), indicating that both genders confirmed a positive or very positive learning experience with British students.

The three leading situations where Chinese students considered they enjoyed most with British students are: discussing and preparing group seminar work/presentation together in library/classroom/other places (49%), sharing non-study topics, for example, culture, life, and others (47%) and having lectures together in classroom (40%) (Fig. 2(a)).

Regarding situations where Chinese students viewed they learned most with British students, the leading three circumstances are: discussing and preparing group seminar work/presentation together in library/classroom/other places (64%), presenting group seminar work/presentation together in classroom (44%) and sharing non-study topics, for example, culture, life and others (34%) (Fig. 2(b)).

The three leading situations where Chinese students considered they learned least with British students are: having lectures together in classroom (33%), doing laboratory work/visit laboratory together (31%), and doing field work (27%) (Fig. 2(c)).

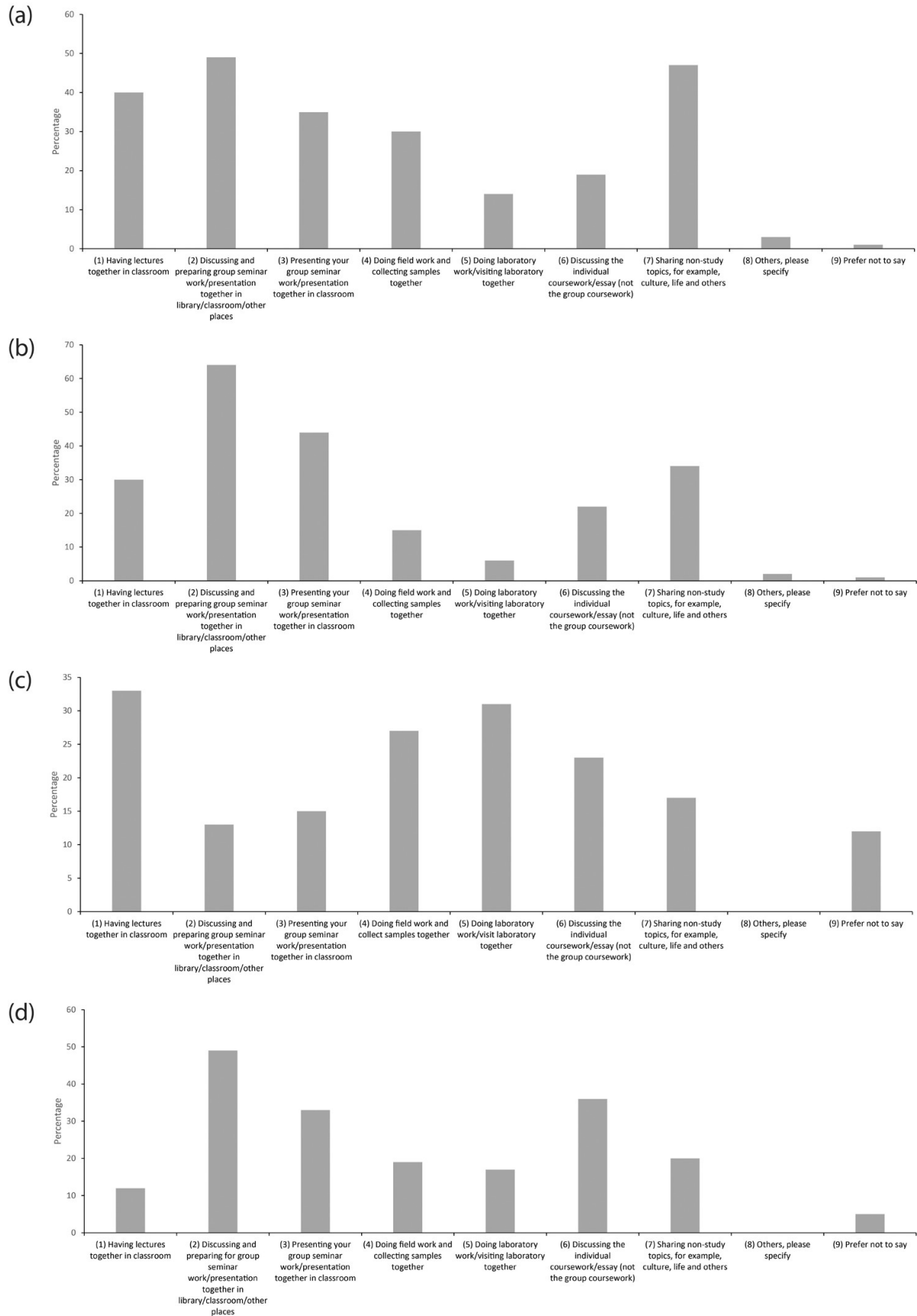


Fig. 2. The circumstances where Chinese students considered they enjoyed most (a), learned most (b), learned least (c), and felt most difficult (d), when they learned with the British students.

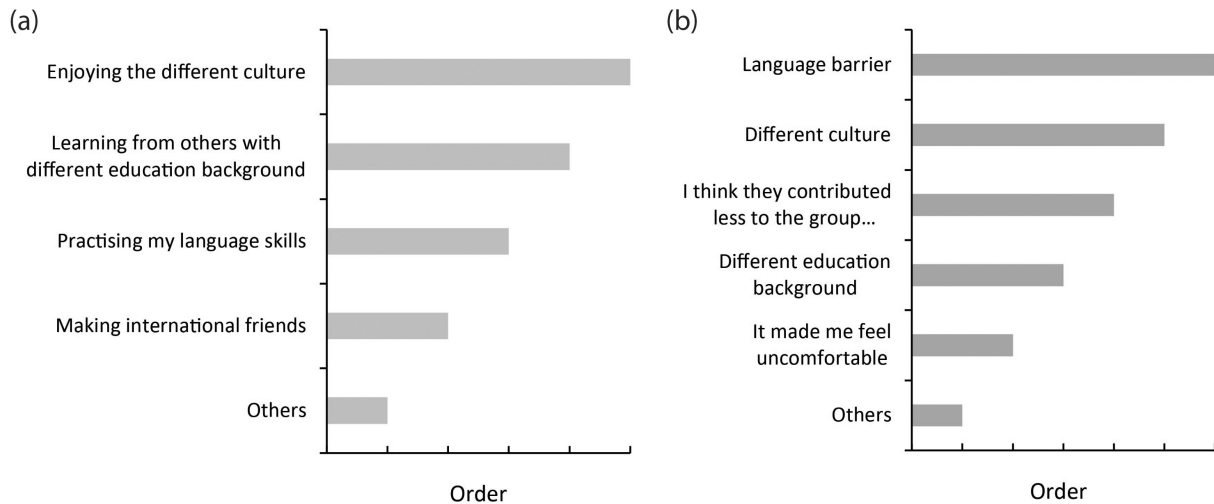


Fig. 3. The factors causing Chinese students to like (a) or dislike (b) their learning experience with British students. For instance, “Enjoying the different culture” is the 1st most important factor causing Chinese students’ to like their learning experience with British students; “Language barrier” is the 1st most important factor causing Chinese students’ to dislike their learning experience with British students.

When it comes to the situations where Chinese students viewed their experience as being most difficult, the leading three circumstances are: discussing and preparing for group seminar work/presentation together in library/classroom/other places (49%), discussing the individual coursework/essay (36%), and presenting group seminar work/presentation together in classroom (33%) (Fig. 2(d)).

Pertaining to the reasons for Chinese students liking learning together with British students, the top three reasons are: “Enjoying the different culture”, “Learning from others with different education background” and “Practising language skills” (Fig. 3(a)). Nevertheless, several factors also lead to Chinese students’ dislike learning together with British students. The leading factors is “Language barrier” (Fig. 3(b)).

Regarding the satisfaction levels of coursework grades, more Chinese students were satisfied or very satisfied with the grades of their team coursework (61%) (Fig. 4(a)) than the grades of their individual coursework (54%) (Fig. 4(b)), indicating that learn-

ing together with British students increased Chinese students’ marks.

In terms of the contribution of British students to the team coursework, 61% of Chinese students thought the British students made satisfactory or very satisfactory contributions to the team coursework (Fig. 5).

To enhance their learning experience and create a more inclusive study environment, over 60% of Chinese students considered teaching staff (lecturers, professors, and tutors) need to do more (Fig. 6). Additionally, 54% of Chinese students thought more contribution was needed from Chinese students and other international students. In contrast, only 43% of Chinese students considered that British students needed to make more contributions.

3.2 Interview Results

3.2.1 Overall Positive Learning Experiences with British Students

The overall learning experience of Chinese students

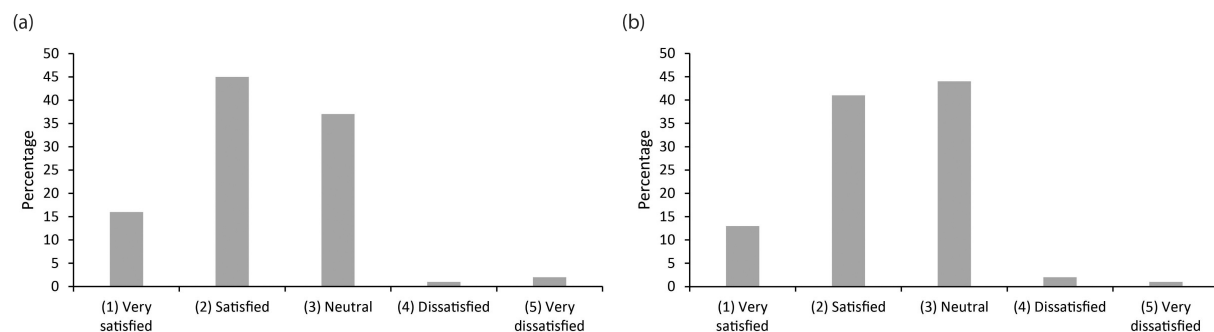


Fig. 4. Chinese students’ satisfaction levels of their grades of team coursework with British students (a) and individual coursework (b).

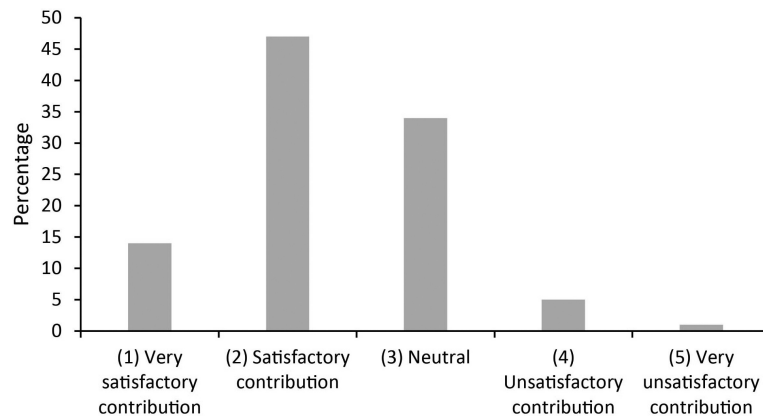


Fig. 5. Chinese students' views regarding British students' contributions to the team coursework.

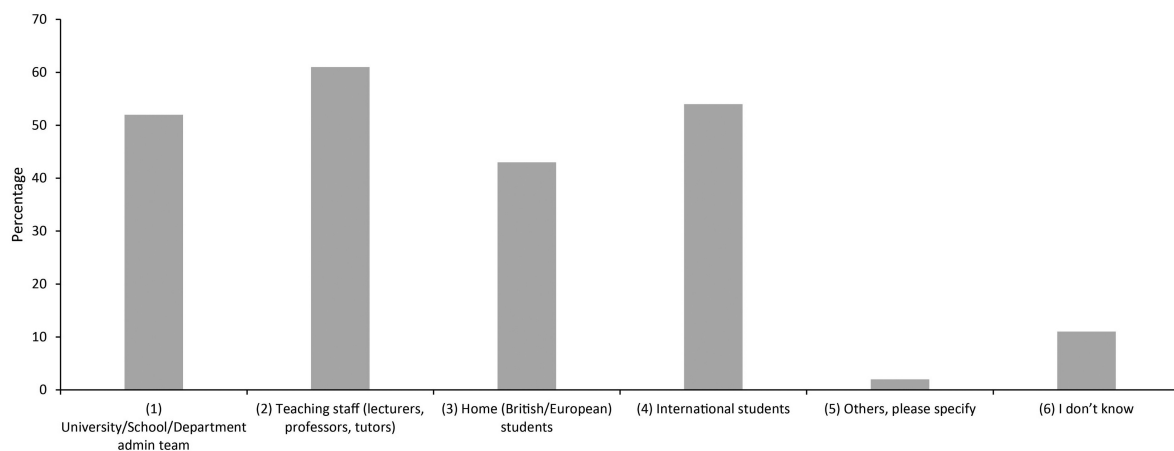


Fig. 6. Chinese students' views regarding who needs to contribute more to improve the diversity and inclusion.

with British teammates is very positive or positive. This reverberates with numerous students, as exhibited by the following comment:

“It is generally very pleasant to get along with the foreign students.”

3.2.2 Adaptation to the New Learning Environment Including Team-Based Learning

Undoubtedly, Chinese students have experienced the large difference in the study environment between China and the UK. For instance, one student elaborated:

“When I come to study in the England, I find a lot of differences from China. There is more personal time, and it requires me to have the ability to learn by myself. For example, I have to use library resources by myself, or use some online resources, and I have to learn to be more active when learning new knowledge.”

Various learning habits between British and Chinese students is one of the study shocks struggled by many Chinese students, particularly at the beginning of their studies in the UK. More importantly,

new types of assessments, for instance, team presentation and group coursework, can become big challenges for some Chinese students. In spite of difficulties, most students learned to adapt to the new changes. For instance, one student stated:

“Group coursework can expand your thinking in many ways. For example, I might think about how air pollution is produced, but other students either think about the details, or from a different point of view. Chinese students look at air pollution from a user's point of view, while British students look at it from the point of view of governments and companies. For me, it broadens my knowledge. When I searched for material, I started to be interested in companies and legal standards. It complements my shortcomings. Because we all made contribution in the process, it showed the efforts we made together.”

3.2.3 English Proficiency Affects Team-Based Learning

Although the major of Chinese students confirmed their positive study experience with British students, some students' learning experience was also

constrained by their English proficiency. This is mirrored in the following quote:

“To be frank, when you go abroad, it does provide a very good and very practical environment for learning English. However, sometimes you will encounter problems like not having enough knowledge to express your feelings or your situation.”

English may affect Chinese students' communication with British students in the team, but it may not be vital. One student commented:

“But as long as you can express the meaning clearly, people will not correct your grammar. As long as they can understand you, it is normal communication. Just relax and enjoy.”

3.2.4 *Extracurricular Life Promotes Learning*

Together with the generally enjoyable study experience, students emphasized extracurricular life and considered it a booster for group study. This is exemplified by one student:

“We asked each other to discuss our holiday plans and where we would go. He said home, and I said I would take a trip to Iceland. We then talked about the aurora. Although we were not familiar with the aurora, we were able to communicate with each other using some very simple words.”

3.2.5 *Chinese Students welcome a Diverse Culture*

The cultural differences between China and the UK are enormous, for example the dominating Confucian Heritage Culture (CHC) in China. Nevertheless, many Chinese students embrace the difference and consider it an opportunity to learn different cultures. For instance, one student commented:

“I realize the cultural differences between us (Chinese students and British students), but it is not unpleasant. On the contrary, it gives us an opportunity to understand each other's culture.”

4. Discussion

4.1 *Team-based Learning Pedagogy can improve Diversity and Inclusivity in Engineering Education*

The main education aim for engineering students is to equip them with the capability to deal with complex problems in the world. Engineer teams with strong diversity can increase the possibility of obtaining a better solution. In addition, the refined engineering solutions, established by diverse teams, enable companies to meet their financial and social goals. With poor team diversity, engineering students often fail to comprehend the restrictions that cause engineering problems, with the consequence of non-inclusive solutions [33]. Therefore, accepting diversity and developing an inclusive environment

can create valuable impacts on the academic and social development of engineering students.

TBL is an important type of active learning and can induce cooperative and interactive learning. During the team-based learning process, many students wind up being more active and engaged in their teams where they can share, discuss, and analyse numerous ideas from varied backgrounds. The survey results shed light on that the diversity and inclusion delivered success to teams.

Almost 70% of Chinese students viewed that they had very positive or positive experiences of learning together with British students (Fig. 1). Nearly half of the students selected “discussing and preparing group seminar work/presentation together in library/classroom/other places” as their most enjoyable part of their experience of learning together with British students (Fig. 2(a)). Notably, the survey shows most Chinese students were very satisfied or satisfied with the results of their team coursework (61%) (Fig. 4(a)) than the marks of their own individual coursework (54%) (Fig. 4(b)). In other words, the TBL can reduce the BAME student attainment gap. Furthermore, more than 60% of Chinese students considered the British students made very satisfactory or satisfactory contributions to the group work (Fig. 5).

Despite the favourable effects of team-based learning on diversity and inclusion, students still expect more to be done in the near future. Over 60% of Chinese students hope teaching staff can contribute more to further improve diversity and inclusion in learning environment (Fig. 6). In addition, 54% of Chinese students noted they were responsibility for the improvement.

To more accurately evaluate the effects of TBL on students' learning, it is better to compare student learning experiences between TBL and other approaches. However, due to data limitations, such comparisons are unavailable in the current research. Notably, some studies have confirmed the superiority of TBL over traditional lectures, even problem-based learning (PBL) [34–36]. For example, a comparison between TBL and traditional lectures in a randomized, crossover design study indicated better study outcomes among students with the TBL (mean test scores of 89.2%) than students with lecture (mean test scores of 85.0%) [34]. Interviews of students also show that TBL is superior to lecture [35]. Students emphasized deep learning via TBL. TBL provides a more complete understanding of the learning material. One interviewee mentioned “my understanding would have been lacking”, if only via lectures without TBL. PBL, a student-centred approach in which students study by working to solve a problem, has also been increasingly used in engineering education, includ-

ing environmental engineering [37]. Compared with the PBL, TBL can achieve similarly good learning outcomes. At the same time, TBL can conserve precious staff resources [36] and can be facilitated in large classrooms, for example, with more than 100 students [38].

Although the current study focuses on student learning experience and diversity and inclusion of students at one British university, the findings have broad implications for various stakeholders. Education globalization has advanced rapidly due to economic internationalization in the last decades. For example, the number of Chinese students studying abroad has grown by 114%, from 284,000 to 608,000 between 2010 and 2017. In the UK, the number of Chinese students has grown by 58% during the same period. COVID-19 has disrupted international travel, but the globalization of education is predicted to continue in the post-COVID-19 era [39]. Attracting more international students to British universities has become increasingly challenging and important, particularly after Brexit. Improving international students' learning experience and promoting diversity and inclusion of students has become crucial. The TBL has been successfully applied at one British university in the current study. International students praised the positive learning experience with home students via TBL. The current research is specific to the Environmental Engineering programme, while the TBL approach is applicable to any engineering course. Wider application of TBL in more engineering education programmes in more institutes can increase diversity and strengthen inclusion, along with improved student learning experience and performance.

4.2 Challenges for Chinese students in Team-Based Learning

The learning habits of international students are inevitably heavily affected by their culture and education in their home country. For example, Chinese students are familiar with China's education system. Teaching in China is primarily via lectures, study is mainly independent learning, and assessment is almost always done through paper exams [40].

Comparatively, British universities pay more attention to the collaborative study between students. Knowledge exchange and academic discussions in small groups are encouraged to improve all students' academic performance, along with the development of communication and teamwork skills [41].

When Chinese students study abroad, they are often unacquainted with the TBL, especially at the

first stage. There is no denying that transferring from China's conventional learning methods to TBL is not easy. In interviews, Chinese students mentioned that they had participated in a lot of team coursework in the UK. In the TBL process, Chinese students sometimes struggled with language proficiency and intercultural communication. The questionnaire results clearly show that language barrier has been considered to be the largest obstacle for Chinese students studying together with British students (Fig. 4(b)). Students also addressed the difficulty of inter-cultural communication.

On the other hand, the majority of Chinese students (>60%) appreciated British students' large contributions to the group coursework (Fig. 5).

4.3 The Influence of Traditional Chinese Culture on Team-Based Learning

This survey found that most Chinese students enjoyed the different culture in the UK. Almost half of the students (48%) considered "sharing non-study topics, for example, culture, life and others" as the most joyful part of their life at the British university (Fig. 3(b)). Notably, "enjoying different culture" was widely selected as the leading reason for their liking the learning together with British students (Fig. 3(a)). Ironically, "different culture" is also the second leaning reason, just below "language barrier", considered by many Chinese students' for their disliking the learning experience with British students (Fig. 3(b)).

China is rich in traditional culture and Chinese students are heavily influenced by the traditional culture. For example, Confucian Heritage Culture values saving "face" and collective orientation [42]. In China's instruction mode, it is dominated by student-passive and teacher-centred instruction [43]. Because of the heavy influence of CHC, it is difficult for many Chinese students to rapidly adapt to the "academic discussions with questions and doubts encouraged" environment at the British university. In team coursework, Chinese students often consider if a "stupid" question will lose their "faces" and if their questions will disturb lecturers in their teaching. In interviews, several Chinese students commented on their struggles in asking questions in the team and lecture sessions.

4.4 Limitations and Future Work

Similar to other studies, there are several limitations in the current study which raise some caution when applying the results in a wider environment. The current study was conducted at one UK university. More study at other universities will improve our

understanding of the effect of TBL on diversity and inclusion in engineering education. Several new studies have found that the complicity of the inclusiveness of international students with home students is in several sub-fields [44, 45]. This research focused on students' learning experience in small groups, and more detailed studies on students' lives are needed. The participants for this survey and interviews were based on voluntary nominations. It is possible that students who failed their studies were reluctant to participate in the survey and their experiences and opinions may be different from other students [46]. The future study involving these students in in-depth interview is important but challenging.

The COVID-19 pandemic has exacerbated racism in some areas. For example, a Chinese lecturer and a Singaporean Chinese student were attacked in Southampton and London, UK. The pandemic has largely constrained international travel and mobility of international students. The majority of international students, including Chinese students, have to take online learning. More research is needed to understand the diversity and inclusion of international and home students in online learning environments.

5. Conclusions

This study explored the diversity and inclusion of Chinese students and British students at one UK university. An online questionnaire and semi-standardized interviews were performed to investigate Chinese students' satisfactory level of study experience with British students and identify the factors affecting students' learning experience in small groups. The main conclusions are drawn as follows:

- (1) Team-based learning improved the diversity and inclusion of engineering students;
- (2) Almost 70% of Chinese students are very satisfied or satisfied with their experience of learning together with British students;
- (3) Chinese students enjoy the different cultures, while cultural differences, particularly the Confucian Heritage Culture, also become an obstacle affecting their study at the British university;
- (4) English proficiency remains one of the largest obstacles for some Chinese students in their studies, including team-based learning.

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Appendix

Table S1. Codes, description, sources and references

| Codes | Description | Source | References |
|----------------------------|--|--------|------------|
| Team-based learning | Team-based learning is a collaborative learning that enables students to follow a structured process to enhance student engagement and the quality of student learning. | 1 | 11 |
| Positive experience | Chinese students are happy about their study experience with British students and think of the good aspects of their learning experience. | 1 | 9 |
| Diverse cultures | Diverse cultures represent different ideas, customs, and social behaviour between British and Chinese students. | 1 | 19 |
| Confucian Heritage Culture | As the cornerstone of traditional Chinese culture, Confucian traditions emphasize group orientation, interpersonal harmony, acceptance of authority, and the importance of education and academic attainments. | 1 | 15 |
| Welcome culture difference | Chinese students are pleased about the culture difference between the UK and China. | 1 | 1 |
| English proficiency | Chinese students' ability to use English to make and communicate meaning verbally and in writing in their study and daily life. | 1 | 12 |
| Good communication | Good communication involves understanding requests, asking questions and relaying key information. | 1 | 4 |
| Extracurricular life | An extracurricular life is an activity, performed by students, that falls outside the realm of the normal curriculum of education. | 1 | 3 |

Note: The Codebook is produced by NVivo. Source is 1, and it is a combined document of all interviews.