

Can We Bolt It On? Developing Students' Transferable Skills in Chemical Engineering

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Work in Progress: Developing Students Transferable Skills in Chemical Engineering - Can We Bolt-It On?

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Introduction

In a Chemical Engineering degree programme, teaching the core technical concepts take centre stage, but in order to produce graduates that are prepared for a career in Chemical Engineering, degree courses need to develop so-called transferable skills [1]. Transferable skills, including effective teamwork, communication (both written and verbal), problem solving and leadership are typically gained via assessments such as group project work and presentations. Hereby transferable skills are taught via embedded and experiential learning[2]–[5]. Unfortunately this approach can fail to highlight the importance of transferable skills in education, and their application. Also, when transferable skills are only employed during an assessment, students may fail to apply them independently throughout their learning and into their future careers. Therefore, rather than embedding these skills alongside technical learning, they ought to be taught separately and independently in their own right. The question is, can a “bolt-it on” approach to transferable skills have a lasting impact on the learning of undergraduate students.

In order to “bolt-it on” the Chemical Engineering Department has devised independent workshops, separate from any technical requirements and assessment, to teach students valuable transferable skills. The aim is to teach 3 key transferable skills, teamwork, leadership and communication, in workshops throughout the undergraduate degree course. Using a staggered approach, each transferable skill will be introduced to the cohort in separate years. The ‘TLC’ course will cover teamwork in the 1st year, and communication and leadership in the 2nd and 3rd years respectively. It is hoped that the bolted-on approach will help students realise the importance of the transferable skills training embedded within the course.

Effective teamwork is crucial to success in the students’ degree, as they will have to demonstrate this transferable skill within taught undergraduate laboratory projects and group/design projects throughout the degree course. Starting with teamwork allows us as educators to highlight the importance of collaborative working within the student cohort, with a view to creating an open culture, whereby students are supportive of each other, and can expect support from their peers and staff. The workshop should not only highlight the importance of formal group work, but to allow students to see themselves as an “effective” team throughout their course, even outside of assessments. If students are able to effectively see themselves as a team throughout their degree course, they can maximise their education through peer-to-peer learning and co-operation[6].

The main aims of carrying out the transferable skills teamwork workshop:

- Reinforcing the importance of collaborative working, both with the Chemical Engineering Degree course and in later work
- Give students practical transferable (teamwork) skills
- Enhance the sense of community amongst students

Other secondary aims include, improving student/staff relationships and give the students a fun/relaxing day early on in their degree course (showing that assessment is not the only important way to learn).

Learning context

Organisation of Cohort

All 1st year students (143) on Chemical Engineering Meng degree course in the academic year 2018/19 were mandated to take part in teambuilding workshops. This took place over 2 cycles (73 students on the 22nd October 2019, 70 students on the 5th November 2019). The workshops were arranged to occur early in the year (a month or less after the students arrived at the University). This was to ensure that the concepts introduced during the workshop could be used from the start, and throughout their degree programme, cementing the importance of teamwork in Chemical Engineering early on. Immediately after carrying out the workshop, the students undertook their first group project (1st year design project) where they could immediately put into action what they had just learnt.

Students were placed in groups of between 7-9 students. Students on the Chemical Engineering course are placed in academic tutorial groups (6 students) and personal tutorial groups (4 students), which remain the same throughout their studies. Often there is significant cross-over between personal tutor groups and academic tutor groups, creating silos, meaning students can spend their entire degree without speaking to fellow students. In order to create an environment whereby students could increase interactions with other students it was decided to create unique groups for the workshop. This had the following advantages:

- The size of groups could be enlarged from 6 (academic tutor groups) to 8, to increase the interactions between student and increase the requirement for active teamwork
- Ensure students would interact with students they haven't previously worked with, allowing them to make new friends and improve camaraderie amongst the cohort
- Balance Home/EU and Overseas students in groups to avoid silos based on ethnicity/nationality
- Ensure each groups has a minimum of at least 2 female students

Each group was accompanied by a group facilitator, either a member of staff, or PhD student, whose role it was to introduce to and guide the students through the tasks, to lead the groups in reviews after completion of the tasks and to be a bridge between the students and the workshop co-ordinators. Overall there were 9 groups on each workshop day. Facilitators were recruited on a voluntary basis. On the 22nd of October the facilitators comprised of 6 members of staff and 5 PhD students, each group was assigned at least 1 permanent facilitator. On the 5th of November there were 4 members of staff and 5 PhD students.

Selection of Exercises

Traditionally teamwork and other transferable skills are taught in the Imperial Chemical Engineering undergraduate course via integrated and embedded learning e.g. group projects. Students learn how to work in effective teams by undertaking chemical engineering projects, but receive no formal training in teamwork skills. The bolt-on approach of the teamwork workshop was intended to highlight the importance of teamwork as an integral part of a chemical engineering education in its own right. To achieve this, tasks were selected that had no connection to the practice of chemical engineering. No assessment was linked to the workshop, this was to ensure that the students would not alter their behaviour to gain a favourable grade.

Tasks were selected to reflect Tuckman's teambuilding theory, cycling through four stages of team/group development:

1. Forming - The team get to know one another and bond
2. Storming - The team come up with and interchange ideas. Eventually choosing a course of action
3. Norming - Once the ideas have been finalised the team begins working together. Each team member begins to take on their roles in the team and the rules of engagement are formed.
4. Performing - Teams carry out the task in hand

Details of the exercises performed during workshop can be found in **Table 1**.

Table 1: List of Exercises performed at Teambuilding Workshop

Exercise	Type	Duration	Description
Line-Up	Icebreaker	5 minutes	Each group must form a line based on the order of their birthdays from the earliest in the year to the latest without speaking.
Mr Men Book	Communication	15 minutes	Each group will be given 3 Mr Men books from which the pages will have been ripped from and arranged in a random order. The Mr Men books need to be put back together in the correct order.
Helium Stick	Teamwork	15 minutes	Each group member will be asked to line-up facing each other, holding out their index fingers. Once arranged in two lines a bamboo stick is placed on the fingers of the group members. The stick must be lowered to the ground, while everyone must stay in contact with the stick.
Egg Drop	Egg Drop	1 hour	Groups are given an egg and a collection of items to construct a protective barrier for the egg, which is dropped from a height.

After each exercise the groups conducted a review, led by their facilitator. This review focussed on the going through the Tuckman's teambuilding cycle.

Structure of Workshop

The workshop was led by two coordinators (Teaching Fellows in the Department of Chemical Engineering). The group exercises were interspersed with a Belbin team roles quiz, groups sharing their reviews of the exercises and presentations on aspects of team work such as Maslow's hierarchy of needs and key team working skills. The workshop timetable can be found in **Table 2**.

Table 2: Timetable for Workshop

Time	Activity
10.30	Welcome and introduction
10.50	Line-Up Exercise
11.00	Belbin assessment followed by discussion on Belbin team roles
11.30	Mr Men Book Exercise
11.45	Presentation on Maslow's hierarchy of needs
11.55	Helium Stick Exercise
12.15	Presentation on important teamwork skills
12.20	Lunch
13.20	Egg Drop Exercise
15.00	Closing Remarks

Methodological approach

Evidence of the initial impact on the students' learning was collected via a questionnaire handed out and completed by the students immediately after the workshop. The questionnaire was designed to probe the students' conceptions of teamwork, their opinions on the success of the workshop, and their thoughts on group/team formation. A copy of the questionnaire can be found in **Appendix A**. The design of the survey was based on the 'recipe' proposed by Creswell[7]. We were conscious that the questionnaire had to be designed with rigour if we were to obtain detailed and meaningful responses from our students, especially given that currently, the questionnaires are our sole means of collating data. In accordance with the technique employed by Boynton and Greenhalgh[8], we conducted a scoping exercise to ensure that every question we sought answers to was asked, and this in turn has resulted in different types of questions being asked (e.g. using the Likert scale, open responses etc.).

Results & Discussion

The questionnaire had a high number of respondents (n=130), achieving a response rate of 91%. The high number of respondents was likely due to the students filling in the questionnaire immediately after the workshops. Filling in the questionnaire did not require any additional effort on the students' part, and was seen as part of the workshop.

Figure 1 shows that for just under half the respondents, this was the first time they had undertaken/engaged with a teamwork workshop/course. For those that had previously attended a teamwork event/course, approximately half of those had experienced a workshop similar to that conducted that day. Therefore this workshop introduced concepts, exercises and discussions new to 73.8% of the respondents to the questionnaire.

For the students who had not previously attended teamwork workshops/events (n=59) only 3 indicated that they had not previously received any teamwork training (**Figure 2**). Most students that had not attended specific teamwork events learnt aspects of teamwork through participation in group work in school and extra-curricular activities.

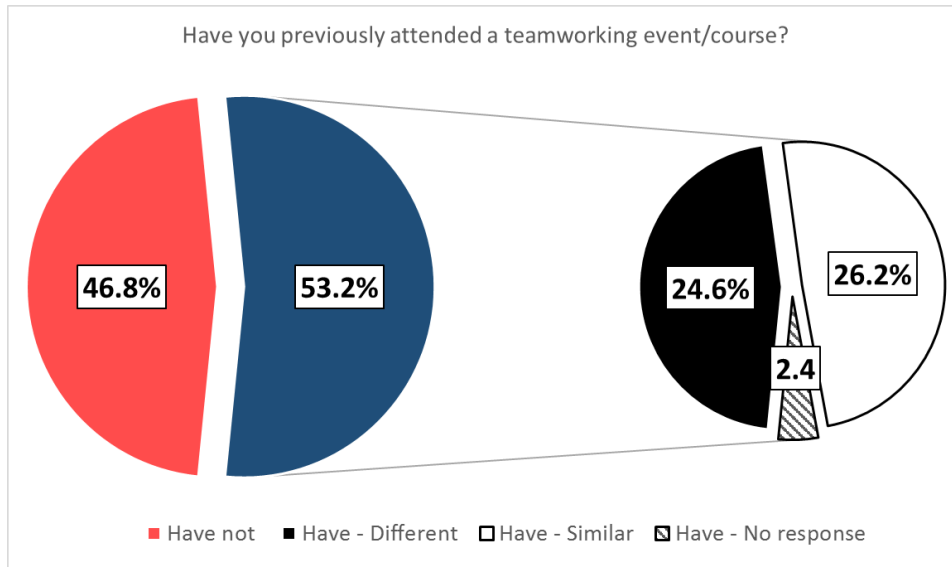


Figure 1: Students previous exposure to dedicated teamwork events, with those that have previously attended a teamwork event broken down into those that have attended similar events versus those that have attended events that are different.

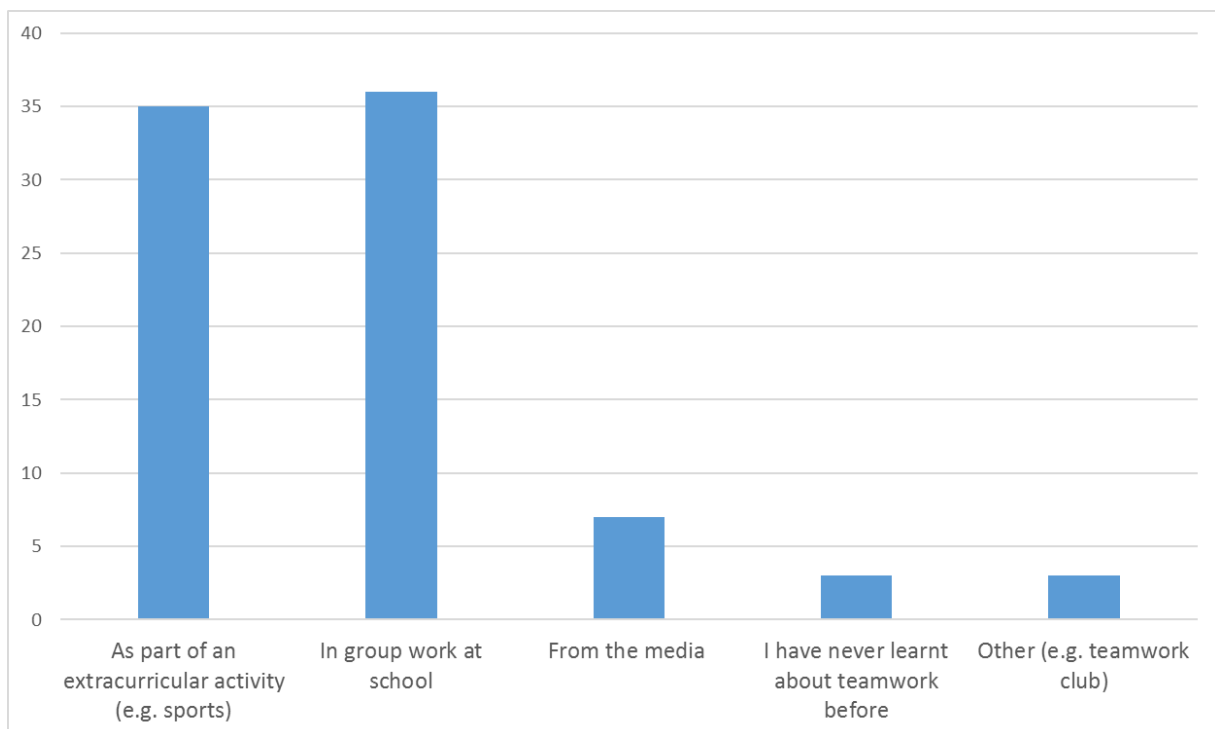


Figure 2: The number of students that have gained experience/training in teamwork skills from sources other than dedicated teamwork events/courses.

To determine the success of the workshop, with regards to the primary aims, students were asked their agreement with 8 statements (**Figure 3 & 4**). A majority of students agreed that the workshop was successful in helping them improve their teamwork skills, make friends

and get to know staff. While 1/3rd of students strongly agreed that the workshop helped them make friends, only 7% strongly agreed it helped them get to know members of staff. While a majority of students either strongly agreed/agreed that the workshop helped them get to know staff, there is a longer ‘tail’ then for making friends, indicating that the role of the facilitators in the workshop could be bolstered. Possibly by increasing their involvement in exercises.

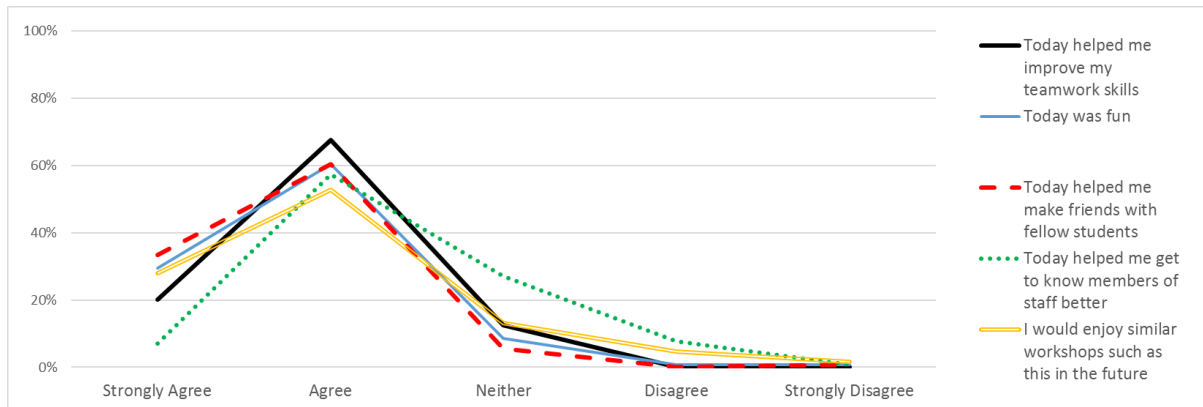


Figure 3: Students’ views on the workshop days, showing percentage of students’ agreement with a statement, using a Likert Scale.

The students indicated that they had fun at the workshop and would enjoy taking part in similar workshops in the future. Meaning that there is buy-in for future workshops on transferable skills in later years.

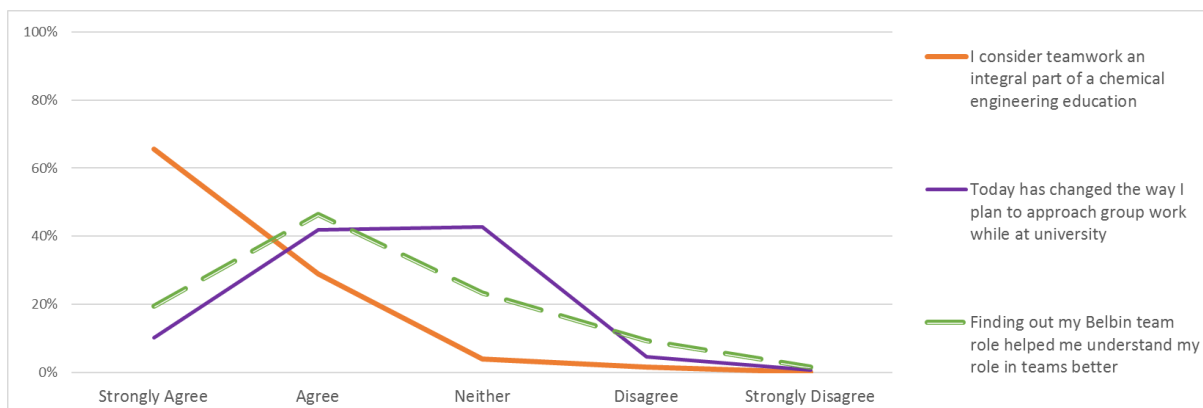


Figure 4: Students’ views on teamwork and their engagement with teamwork skills based on their agreement with the given statement using a Likert scale.

While respondents strongly agree that teamwork is a key component of a chemical engineering degree (>60%), only around 50% would change their approach to teamwork after the workshop. This indicates that many students came into the day believing that teamwork was already important. The question however does not allow us to know what students believe their original approach was to teamwork, and how it might change. This indicates further questions that need answering in follow-up data collection:

1. How would you say you found working in groups during your first year of your course?
2. Did you use any (new) skills developed in the workshop during group work in your first year?

Students were asked 4 exercise specific questions, asked to identify their most/least enjoyable exercise, and which exercises best helped achieve the primary aims of the workshop, improving teamwork and getting to know their fellow students. **Figure 5** shows the student responses indicating the percentage of students picking a particular task to answer the question stated. On both workshop days, the egg drop received the most positive response from student, with a majority of student choosing it as the exercise that best encompassed teamwork, helped them to make friends and was the most enjoyable. Students were given space to expand on why they selected the exercises. When asked which exercise/task best encompassed teamwork, reasons given for the egg drop included the fact that this exercise typically involved the whole group, and that communication was important for this task to be successful. Similar reasons were given for why students believed this exercise best helped them get to know their fellow students, as well as the fact that the exercise was the longest. Word clouds were generated from the explanations given for the students' choices (**Figure 6**). The importance of communication was cited by many students, and indicates that it is an important transferable skill, and would be suitable to be the subject of a transferable skills workshop.

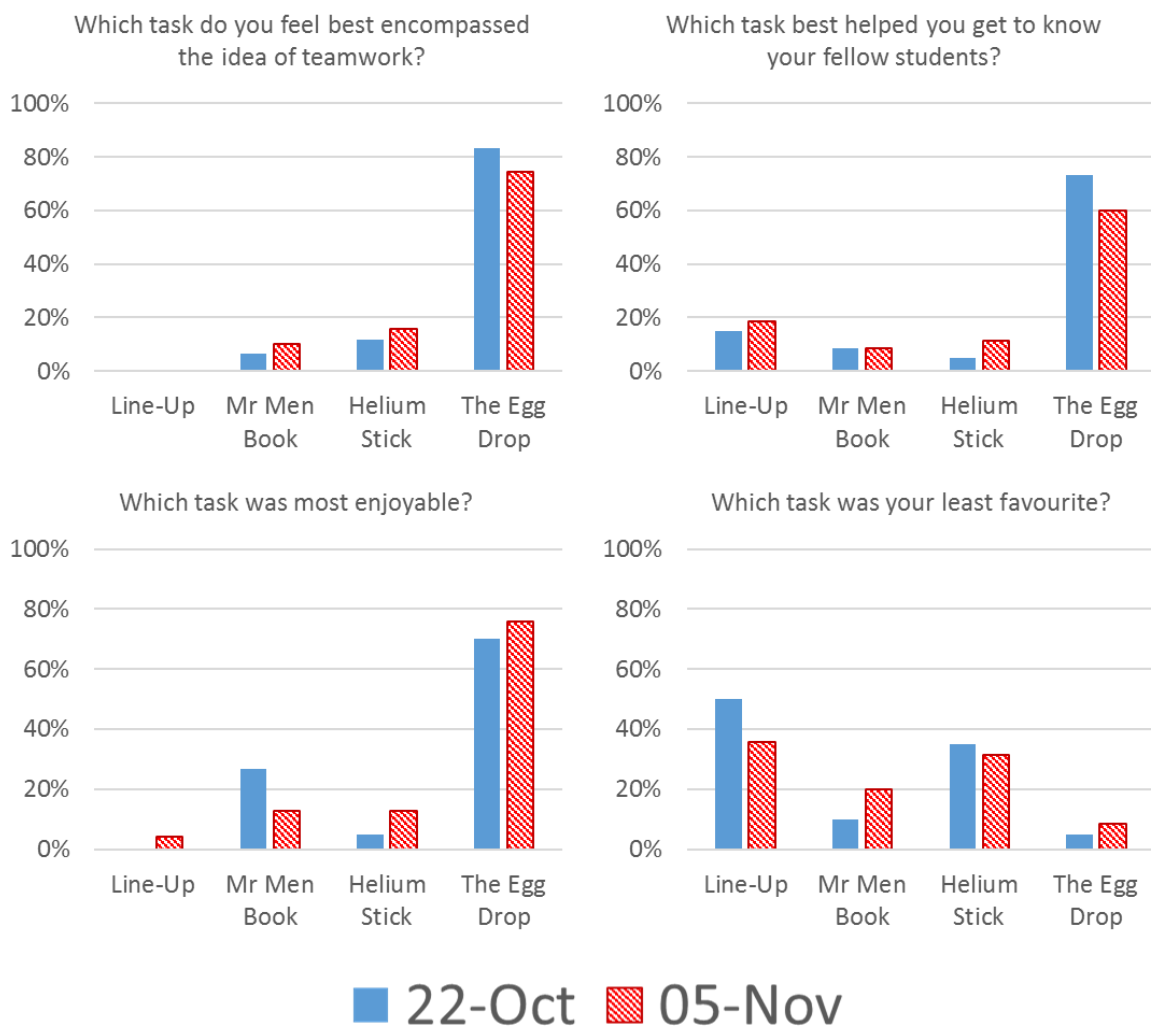


Figure 5: Student assessment of exercises, percentage of students indicating the exercise that best fits the question statement. The percentage is presented for each workshop day, 22nd of October (solid block, blue) and 5th of November (stripes, red)

The Egg Drop was described as the most enjoyable exercise. Students stated that they enjoyed the challenge of the task. In fact, despite the workshop intending to be fun/relaxing, non-assessed and non-technical, students related to this task as it bared the most resemblance to the challenge and difficulty they expect from the degree course:

“The time pressure is exactly what I signed up for as an Imperial student”
 - Respondent 1, Workshop Day 1 (22nd of October)

“This challenged us the most” - Respondent 23 Workshop Day 1

“A little bit competitive against other groups” - Respondent 30, Workshop Day 1

“Had the highest stakes, had to brainstorm innovative ideas” - Respondent 11, Workshop Day 2 (5th of November)

“Most difficult end goal” - Respondent 57, Workshop Day 2

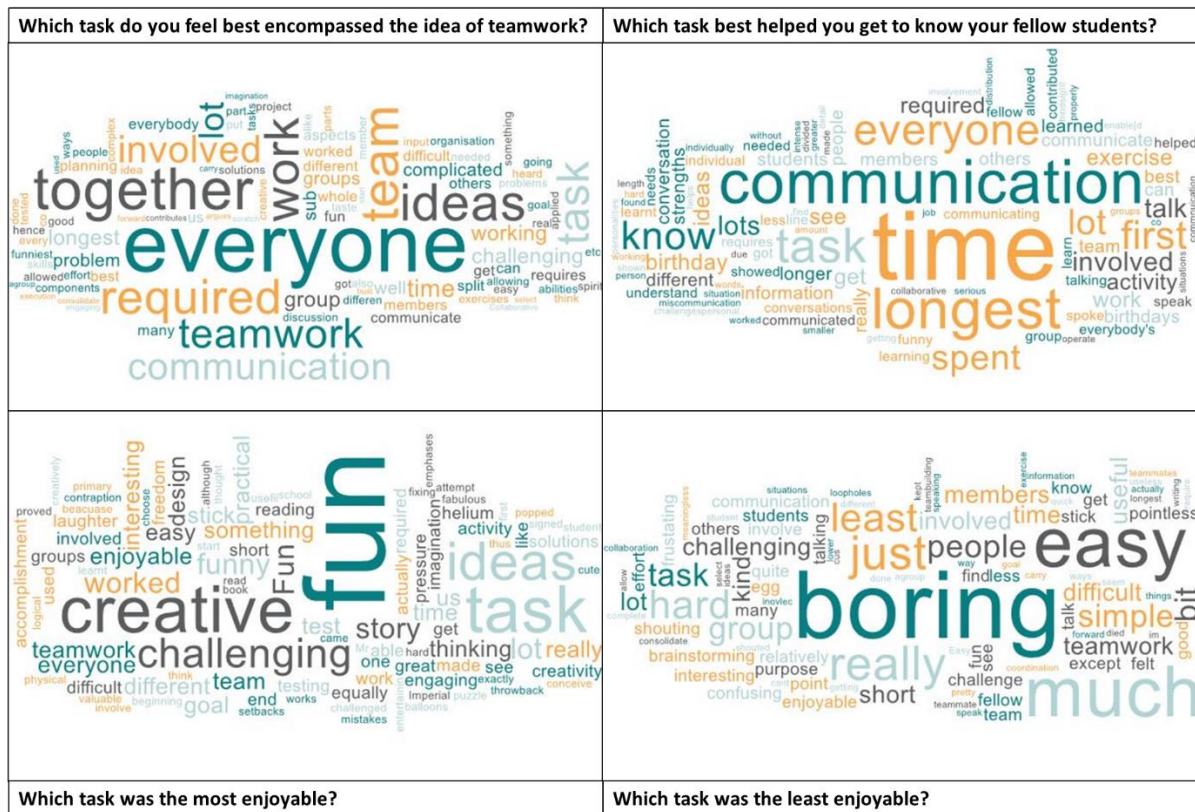


Figure 6: Word clouds generated from student responses to questions about exercises conducted during the Workshop

The Line-Up exercise was the least liked exercise of the day, with the Helium Stick exercise following. Unlike the other questions, where the Egg Drop was the exercise cited by a large majority of the students, the spread was more even for the least enjoyable task. Students responded that they found the Line-Up exercise too easy (the direct opposite of the challenging nature of the Egg Drop), whereas they found the helium stick exercise boring.

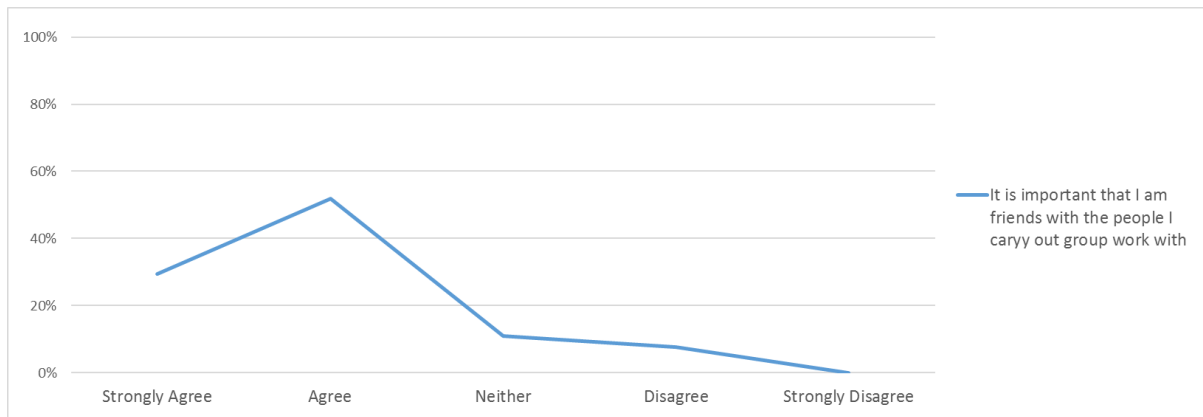


Figure 7: Student preferences for group work with friends, using a Likert scale.

Students were asked their preferences on group formation. As group work constitutes a key part of the undergraduate chemical engineering degree, the selection of groups can effect success on projects and coursework[9]. Over 80% of students strongly agree/agree that “it is important I am friends with the people I carry out group work with”. However, less than a third of the student respondents indicated that they would like to select their own group (**Figure 8**). 75% of students indicated that they would like to be assigned different groups for projects. Despite awareness that self-selected groups may result in better outcomes, students prefer the fairness of assigned groups[10]. Therefore, in order for group work to be successful, with students assigned to different groups throughout their course, it is important for students to become friends with a high number of their cohort. Therefore, achieving the aim of enhancing community amongst the students could lead to improved group work throughout the degree.

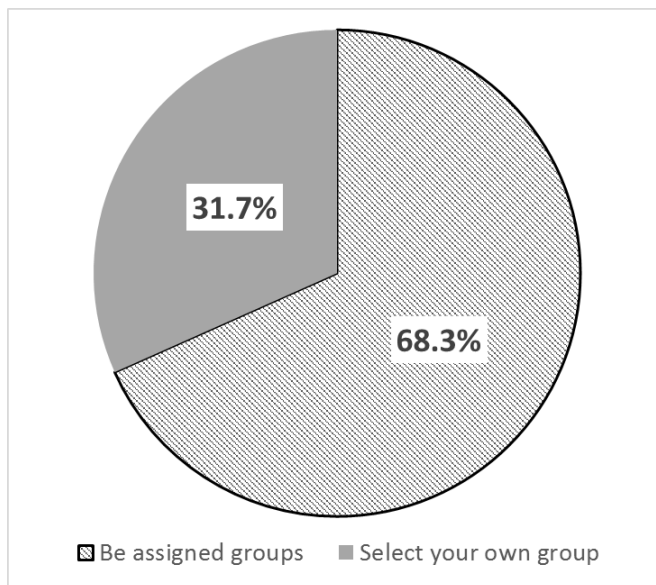


Figure 8: Student’s views on group assignment for project work, the percentage of students that would prefer to select their own group versus the percentage of students that would prefer to be assigned groups

Conclusion

Overall the student responses indicate that the workshop was successful, especially in regards to its primary aims (highlighting the importance of teamwork, giving the students an

introduction to key team working skills and improving the camaraderie amongst the students). The bolted-on approach, allowed for an environment where students could make friends and have fun. However, students still preferred the most challenging and technical exercise of the day. The success of the day means that the teamwork workshop will be continued for the first year students in the academic year 2019/20, and further bolt-on courses will be devised for other transferable skills, including communication, which has been identified as important by the students for several of the exercises. The rich information from the questionnaire gives suggestions on how the workshop could be improved in the future. Changes to the tasks to increase the ‘difficulty’ of the icebreaker exercise and the helium stick exercise could improve student reception of the tasks. Group facilitators could also get more involved in exercises to allow student feel they know staff better. To follow up the results of the questionnaire, focus groups or interviews should be conducted with both the students and facilitators, exploring the lasting effect of the workshop on student behaviours.

Acknowledgements

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Appendix A

Please fill out the following questionnaire on the Teamwork Skills Course you have taken part in today. Please be aware that data from follow questionnaire may be used as part of a research project.

1. Which task do you feel best encompassed the idea of teamwork?

- The Line-up exercise
- The Mr Men Book Exercise
- The Helium Stick Exercise
- The Egg Drop Exercise

Why?

2. Which task best helped you get to know your fellow students?

- The Line-up exercise
- The Mr Men Book Exercise
- The Helium Stick Exercise
- The Egg Drop Exercise

Why?

3. Which task was the most enjoyable?

- The Line-up exercise
- The Mr Men Book Exercise
- The Helium Stick Exercise
- The Egg Drop Exercise

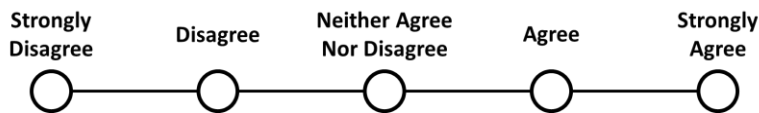
Why?

4. Which task was your least favourite?

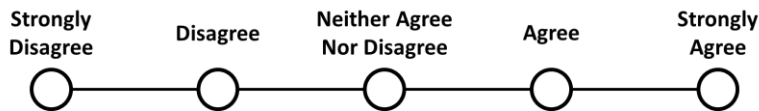
- The Line-up exercise
- The Mr Men Book Exercise
- The Helium Stick Exercise
- The Egg Drop Exercise

Why?

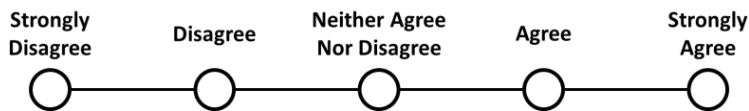
5. Today helped me improve my teamwork skills



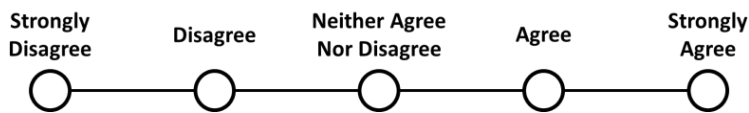
6. Today helped me make friends with fellow students



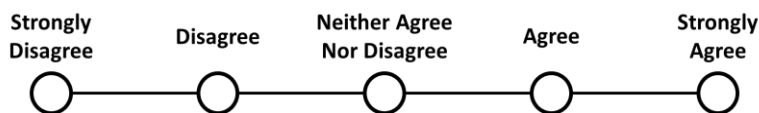
7. Today helped me get to know members of staff better.



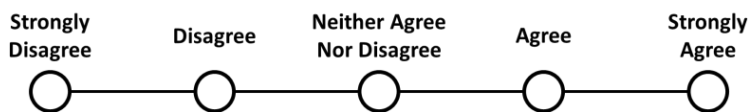
8. Finding out my Belbin team role helped me understand my role in teams better



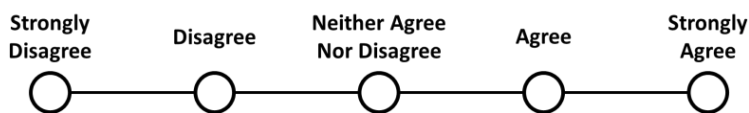
9. Today was fun



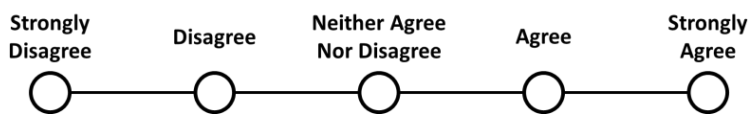
10. I would enjoy similar workshops such as this in the future



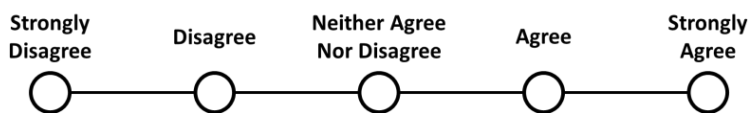
11. I consider teamwork an integral part of a chemical engineering education



12. It is important that I am friends with the people I carry out group work with



13. Today has changed the way I plan to approach group work while at University



14. When carrying out group work, would you prefer to:

- Remain in your academic tutorial group for all projects
Be assigned different groups for all project

Why?

15. When carrying out group work would you prefer to:

- Be assigned groups
Select your own group

Why?

16. Have you previously carried out a course/event intended to teach you teamwork skills?

- Yes
No

17. If you answered yes to question 16, did this course/event differ from the event today?

- Yes
No

If yes, how?

18. If you answered no to question 16, where did you previously learn about teamwork?

- As part of an extracurricular activity (e.g Sports)
In group work at school
From the media (e.g. watching or reading about teamwork)
I have never learnt about teamwork before
Other

If other, please state where: