

Teamwork and student engagement during practical sessions in laboratories

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Abstract

Teamwork is an important pedagogical approach which equips students with the necessary skills required for their learning and develops their employability. This research focuses on teamwork in practical sessions, and it investigates the factors that facilitate students' engagement during practical sessions, the optimum group size and how teamwork contributes to student learning. Students were asked to complete a questionnaire after a team working activity in the laboratory. The responses were quantitatively and qualitatively analysed, and it was found that communication is the most important element which enhanced the team's performance and engagement. The collaboration, discussion and interaction between the members were also found to be important to student engagement. The optimum group size was dependent on the complexity and the nature of the activity. It was found that effective teamwork contributes significantly to the enhancement of student learning and to developing required employability skills.

Keywords: *Teamwork, soft skills, engagement, practical education.*

1. Introduction

Active learning and effective engagement are important, interrelated factors in any higher education institute, requiring students to be engaged in an activity related to a learning outcome to develop their understanding of any given topic. The active learning approach is known to be more effective at engaging students in their learning compared to traditional lectures (Prince, 2004). Although active learning sometimes refers to the instructional activities that are happening inside a classroom, it also includes practical sessions in laboratories since students are actively engaged and thinking about what they are doing.

To ensure that the learning outcomes are delivered, and students gain the required skills in the practical sessions, students need to be engaged in the session. Some articles have reported on the performance of students during practical sessions, however, there is limited research on the extent of engagement of students during those same activities.

Teamwork has many advantages including creating an active and positive learning environment if used effectively. However, there are also some disadvantages of group or teamwork. It is vital to understand the advantages and disadvantages of group work before designing any activity to maximize the benefits and create an effective learning environment. Beebe and Masterson (2003) summarised the advantages of group work saying that groups have more knowledge and members are actively involved in discussion and contribution to decisions and therefore more interaction with others. The disadvantages of this approach include pressure from one group member on the others to agree on a decision to avoid conflict. This might lead to a bad decision and therefore affect the outcome. The dominance of a single individual in the discussion can also lead to dissatisfaction from other members as they feel isolated from the discussion and final decisions. This may also result in other group members relying heavily on the active members and acting as free riders either through choice, dwindling motivation or lack of confidence to put themselves forward.

Despite the disadvantages, group work remains a popular approach in higher education settings to facilitate student application of knowledge. Group work activities result in excellent learning outcomes if there is effective student participation, and the activity is properly designed by the teacher to ensure a positive learning environment is in place.

Group size should be selected carefully based on the complexity of the activity and the time available. According to Beebe and Masterson (2003), a small group is considered to have three members or two. A group size of four and more is large and difficult to coordinate. Research articles reported a different optimum group size, some suggested 3-4 members be the optimum size (Csernica et al., 2002) and others suggested 4-5 to work best (Davis, 1993). The optimum group size depends on the nature and complexity of the activity and the available time. It was reported that a smaller group size works best when the time available is short (Cooper, 1990; Johnson, 1991). However, research suggests that it is important to

create a group with mixed ability levels of skills and experience. This means that the groups are more effective when formed by the teacher or randomly allocated than groups formed by students' self-selection (Felder & Brent, 2001).

Some articles in Engineering education have reported that students liked working in teams and agreed on the benefits of teamwork. Freeman and Greenacre (2011) found that 78% of students agreed that teamwork helped them to learn and gain skills from others. The result (Williams, 2011) also suggested that students learnt more when working on group tasks compared to the traditional tutor presentation. Hammar Chiriatic (2014) attempted to investigate group work in higher education settings. They found that 97% of students from a total of 210 students who participated in the study from two different universities, agreed that working in groups facilitated their learning by improving both their knowledge and their collaborative ability.

However, Freeman and Greenacre (2011) have also reported that a significant part of students also voted against the benefits of teamwork due to the existence of what is called the free riders who rely on others to get marks and rewards. The free rider issue can be overcome through self and peer assessment where each member assesses themselves and other members in the group which then will be considered when determining the final individual mark.

Multidisciplinary Engineering Education (MEE) is a dedicated department in the Faculty of Engineering at the University of Sheffield which is responsible for delivering all practical activities to undergraduate and postgraduate students from all departments at scale. To provide the experience and the required skills to large cohorts, students often work in teams to perform the activities in the laboratories. However, the approach needs to maintain the required level of engagement from the team members to ensure the learning outcomes are met. Some works in the literature investigated teamwork in different fields and others work on group sizes and the advantages and disadvantages of working in teams, however, there is no explicit research on which elements of the teamwork approach help and encourage students to be engaged in the session. This research aims to investigate the factors and elements of teamwork that facilitate student engagement during practical sessions in laboratories.

2. Participants and Methods

Participants in this study were students from Chemical and Biological Engineering at the University of Sheffield. It included students from the foundation year (13.8%), postgraduate taught PGT (25.9%), and 4 undergraduate cohorts UG (60.3%). In these courses, practical activities in laboratories are essential and students must work in the lab to collect data which is then used to complete the post-lab activities. In all the practical activities used in the study, students worked in groups of different sizes (ranging between 2-5 students per group)

depending on the complexity of the activity and the capacity of the laboratory. In the majority of these activities, students self-selected their groups from their peers in the laboratory. These groups only functioned during the lab session and all post-lab activities were based on individual student work. However, students from 2nd year were assigned to groups randomly by the teacher and these groups were functional in the lab and outside the lab throughout the semester. The members of each group met before the practical session to plan the activity, then executed the experiment in the laboratory together, and finally analysed the data.

In this research, data from students was collected using a structured questionnaire, which was ethically approved following the research ethics approval procedure at the University of Sheffield. The questionnaire focused on students' experience while working in laboratories and not outside the lab. It included multiple choice questions about the format of the group, year group and other background information as well as open-ended questions concerning the students' experience and their perceptions of group work. In total, 58 students from different cohorts responded to the questionnaire.

3. Results and discussion

The questionnaire and the data analysis were conducted based on the following research questions:

1. What is the optimum group size for a practical session in a laboratory?
2. What factors of teamwork facilitate students' engagement in the lab?
3. What positive experiences did students gain while working in groups? And how does this contribute to their learning and future?

Students were asked about their views of working in teams in the laboratory. Most students (86%) agreed that working in groups is better and more efficient to complete the tasks in the laboratory than working alone. Only 4% of students suggested that working alone in the laboratory would be more efficient. However, 10 % of students said that this depends on the type and complexity of the activity.

These answers indicate that students value teamwork during practical activities as it is more efficient, bringing more ideas and better chances to solve problems, as evidenced by this student's comments "Team, more ideas and solutions to potential issues". This agrees with the findings of others, where teamwork was found to be a good approach to gaining skills and facilitating students' learning and improving their knowledge and collaborative ability (Freeman & Greenacre, 2011; Hammar Chiriac, 2014; Williams, 2011). This is because teams have more than one way to solve a problem due to different experiences and knowledge of various team members, which results in improving students' performance in the session.

Some students (a very small percentage) preferred working alone, however, looking into the details of their comments, it looks like they wanted to be active all the time and to be more efficient. This indicates that the number of students in the group might have been more than what was required to complete the tasks in the experiment. When investigating this further, it was found that one of the responses came from a PGT student who was experimenting with a team of 3. The reason for their response might be that PGT students are more experienced than UG students and therefore they might be able to carry out more tasks in a shorter time frame.

One of the aims of this work was to gather students' views on the group size and identify the optimum size of a group. A majority of 83% confirmed that the group size (between 2 and 5 for different activities) was appropriate to complete the task in the laboratories. However, the remaining 17% suggested that the group size was not appropriate for the practical activity.

The engagement in the laboratories was investigated, by asking students in each group to rate their engagements between 1-5, 1 being "poor" and 5 being "Excellent Engagement". The majority of 95% have rated this between 4 and 5, which means that their engagement was good or excellent (Figure 1). The average engagement rate was 4.4/5 for the self-selected groups and 4.1/5 for the teacher-selected groups, which could suggest that students are slightly better engaged in groups of their choice. It is believed that better engagement results in better student performance in the session and therefore better learning experience (Crown, 2007).

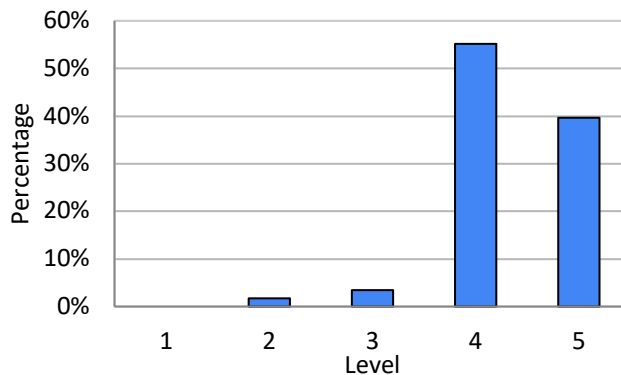


Figure 1: Percentage of students rating their engagement between 1-5, 1 being "poor" and 5 is "Excellent".

The group size can affect the student's engagement during the activity. Some comments suggested reducing the size for the simple experiment to keep everyone engaged and other comments suggested increasing the size for the complex activities. As mentioned earlier, the group size in this study was between 2-5 in each group and 83% confirming that the set group size was appropriate with a higher percentage of them being engaged, indicating that, from

the students' perspective the optimum group size is around 2 to 5 students. This agrees with the findings from others in the literature who reported that the optimum group size is 4-5 (Davis, 1993) and 3-4 (Csernica et al., 2002). However, the definite group size is difficult to determine as it depends on the complexity of the activity and tasks the group must complete during the session.

To explore the factors that enhance students' engagement in the laboratories, students were asked to rank the importance of different elements of teamwork to their engagement based on their experience in the laboratories. The average responses for each element were calculated and are shown in Figure 2. The element that scored 4 and below on average was important, between 4-5 was considered not to be significant and above 5 is not important.

From the results from the survey, it can be concluded that communication, collaboration, interaction, and discussion are found to be important factors/elements of teamwork which enhance students' engagement. On the other hand, punctuality and motivation from peers were found not to be important. There were no clear trends for the categories of feedback from peers, suggestion solutions, and enthusiasm and participation from other team members toward enhancing the engagements within a practical session.

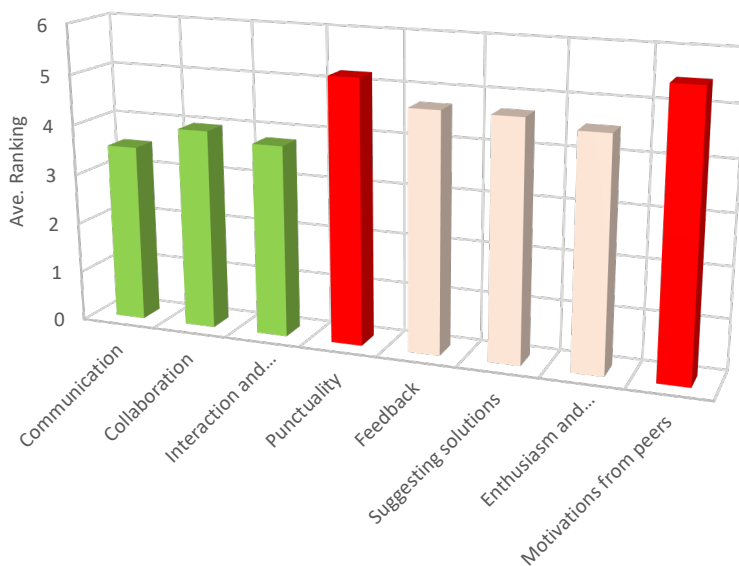


Figure 2: Average ranking of the importance of each of the different elements in teamwork on a 1-8 scale (1 is most important and 8 is least important).

Communication was found to be the most important factor in engaging students in practical sessions. The success of a group in achieving quality work depends on the way the group members communicate, their personalities and how motivated they are in contributing to the

group work. There is clear evidence in the literature that effective communication improves the performance (Beebe & Masterson, 2003). Teams with good communication and clear aims are known to perform better compared to those without clear aims (Crown, 2007).

In order to explore whether teamwork facilitates student learning and helps them gain transferable skills, the questionnaire in this research also included a question on how teamwork contributes to student learning. The responses to this question were also qualitatively analysed and were divided into two categories. As expected, most students confirmed that working in teams during the practical sessions helped them develop employability skills (communication, leadership, time management and problem-solving). There were also a lot of responses which confirmed that teamwork during these sessions improved their understanding and enhanced their knowledge of the subject. Enhancing student learning and helping them develop these soft skills are the reasons why a teamwork approach is used during practical sessions in laboratories.

When the responses were analysed, it was found that 62.5% of the responses were related to employability and other soft skills. Students confirmed that teamwork helped them develop the skills required for their life after university. Students appreciated that teamwork tasks at university address a requirement for this type of skill from industry amongst other contexts they are likely to encounter. The remaining responses (37.5%) were related to enhancing the knowledge of students. Students benefited from the ideas of different members to enhance and reinforce their knowledge. They also valued the diversity in the groups and appreciated the fact that the diversity came from different cultural backgrounds which benefited all team members. A comment about diversity can be seen in one student's comments below:

“Different people come from different backgrounds and have different values. Coming together with all of these traits gives us more diversity. People generally like to invest in something different that would benefit them.”

Gaining employability skills is important for graduates. Skills such as communication, networking, collaboration, and leadership are important attributes which the activities in laboratories provide an opportunity for students to develop. The comments and the feedback received from students suggest that students are aware of the importance of communication, discussion, interaction, and collaboration and how these help enhance their learning.

The fact that this study included participants from different year who were doing different experiments at different levels of difficulty, makes the findings easily applicable to other laboratories. In terms of group size, a size between 2-5 was found to be good (83% agreed on their group size). For example, 2 students per group will be optimum for activities which involve one setup where students only measure a variable. For activities which involve using more than one piece of equipment and students have limited time, then 3 students per group will be optimum to complete the tasks. However, when a pilot scale rig (or industrial scale

equipment) is used in an activity where different unit operations are working simultaneously, then at least 4-5 students are required to complete such an activity. It is also recommended to ensure elements such as communication, collaboration and discussion are properly utilised during the activity to maximize students' engagement. This can be done by incorporating some activities, such as asking questions to encourage team discussion and interactions.

4. Conclusion

Teamwork is an important approach used in universities to enhance student learning and provide the required skills. However, students must be engaged to maximise their learning. The research in this paper investigated the factors in teamwork that will facilitate student engagement and how teamwork contributes to their learning. It was found that communication between the team members is the most important factor to keep students engaged in the session. Good communication between team members enhances team performance and therefore their engagement. Collaboration, discussion, and interaction between team members were also found to be important for student engagement. The optimum group size was also investigated, and it was found that a size between 2-5 students can be considered optimum, however, the exact group size will always depend on the nature of the activity and its complexity. Finally, teamwork makes a significant contribution to student learning, and it helps develop employability skills.

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