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Online Versus In-person Teamwork: A Program-Wide Study

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CONTEXT

Teamwork is one of the important graduate competencies expected of Engineering graduates by Engineers Australia. Engineering courses tend to teach teamwork in less structured ways, although in-person teamwork is systematically studied and implemented across a few programs. The transition to online learning during COVID-19 has explored options for online teamwork.

PURPOSE OR GOAL

This study aims to investigate the development of teamwork skills in electrical engineering courses. The idea is to explore and compare the experiences of online versus in-person teamwork in courses at different levels. The questions that will be addressed in this study are: (i) How do in-person and online team dynamics differ regarding challenges and strategies? (ii) How does students' experience of teamwork and leadership skills differ in different levels and types of courses?

APPROACH

Three courses that have teamwork activities are selected for this study. These courses are a large first year undergraduate (UG) course with about 500 students, a final year UG design course with about 100 students and a postgraduate course with about 200 students. The characteristics of these courses are widely different in terms of diversity, group collaboration, the teamwork task, and its assessment. The study then discusses the various models of the teamwork in these courses, both during the in-person and the online offerings.

OUTCOMES

The outcome of this study includes a reflection and comparison of the in-person and online offerings of the teamwork models in each of these courses based on student surveys and course performance. Recommendations for implementing teamwork based on the observations from the analysis are outlined.

CONCLUSIONS

The results indicated that there is no single dominant model for how teamwork skills are developed within an engineering program. However, a consistent model for implementing teamwork skills within the entire program may prove beneficial for students to develop these skills systematically and strategically. This study has demonstrated that teamwork skills awareness and development should be supported and evaluated within a degree program. Such a program-wide outlook for online versus in-person teamwork would benefit in informing future blended/hybrid options, post pandemic.

KEYWORDS

Teamwork, Online, In-person

Introduction

The emergence of the digital revolution and Industry 4.0 has brought about several changes in the field of engineering. Engineers in the 21st century are not only expected to possess strong technical knowledge, critical thinking and problem-solving skills, but also expected to possess professional skills like teamwork, leadership and communication skills (Elayyan, 2021). Universities need to ensure students can operate in high performing teams to make them job ready after graduation. Engineers Australia is a professional body responsible for the accreditation of engineering degrees in Australia. Engineers Australia (EA) Stage 1 competencies require students to possess effective team membership and team leadership skills, as specified in the mandatory element 3.6 (Australia, 2017).

The importance of Teamwork and Leadership (T&L) skills have been identified since the past decade where a study conducted in Australia (Male, et al., 2011), surveyed industry professionals with varied experience and identified “leadership” and “working in diverse teams” to be in the top five skills required by the industry. It is therefore evident that universities and regulating bodies have recognised the importance of T&L skills and have created several teaching pedagogies to achieve them, but there is no consensus on a structured approach in teaching these skills at a program level (Chowdhury & Murzi, 2019). However, a program wide approach to teaching other professional skills has been successfully implemented in several universities. Colorado State University (Siller, et al., 2009) created a four-year program wide framework to develop professional skills that included communication, innovation and ethics. There were professional development workshops in addition to the courses that needed to be completed before the end of each year. This approach allows for the skills to be staged over the years depending on student’s maturity level and experience. However, these skills were developed through extracurricular activities rather than in mainstream courses. Griffith university has implemented a Professional Practice and Employability Skills Partner (PPESP) stream within their programs to improve the employability of students. This stream is designed for students to experience the PPESP courses at a regular interval using a staggered approach to expose students to professional practice and training throughout the program (Simon, et al., 2018). The University of Adelaide has introduced a range of professional communication skills into specifically modified courses in the school of mechanical engineering (Missingham, 2006). These courses are classified according to the levels and staggered throughout the undergraduate and postgraduate courses to reinforce the skills at regular intervals. The learning outcomes of the engineering courses were meshed with the ability of students to express their knowledge in various forms of communication.

The rise of online education during COVID 19 pandemic has introduced several challenges in effectively running teamwork activities (Wildman, et al., 2021). Universities have adapted to these changes and are now starting to implement both in-person and online delivery of teamwork activities. A selective Latin American university (Goñi, et al., 2020), investigated the difference in teamwork learning presented in online and in-person scenarios. However, the analysis was done for a single course and a program wide outlook with other courses from different levels was not considered.

Teamwork and leadership skills are taught in engineering courses by adapting team-based teaching pedagogies that suit the circumstances and type of the course. These skills are often the by-product of the outcome of the team project and the students are not guided on the teamwork process. A more structured and targeted approach to building these skills could be the key to prepare students for the workplace.

This paper analyses three case studies involving courses at undergraduate level 1 and level 4 and a postgraduate level in the UNSW Electrical Engineering program, having a varied approach and structure to teach teamwork. These courses were compared on the teamwork teaching methods, learning process, assessment methods, and performance in the online and in-person offerings. Level 2 and level 3 courses involving teamwork were not considered in

this study as majority of these courses incorporate teamwork skills in standard assignments and labs without scaffolded development.

Program Wide Case Study

Case 1: First Year Undergraduate Course

Electrical Circuit Fundamentals is a first-year course which introduces fundamental electrical elements and circuits, as well as the technical skills to analyse and implement such circuits. The course is not only for Electrical Engineering students, but also for all other engineering disciplines across the Faculty of Engineering. This course has 1000+ students annually which are spread across two terms. The teamwork activity in the first offering of the course in 2021 had a mixture of online and in-person teams, depending on whether students attended in-person or online tutorials. There was a total of 139 teams (113 in-person teams and 26 online teams) with 3-4 students per team.

The teamwork task involved completing six online quizzes. Each quiz had to be solved individually out of class first, and then in groups. This gave students the opportunity to discuss those questions which they found particularly challenging when working individually. Group discussions were initiated in class, during tutorials, so that the tutor had an opportunity to monitor group discussions and teamwork. Discussions continued out of class in those cases where it was not possible for students to complete the group quiz in class. Once the group quiz was submitted, detailed feedback was released. The individual and group work were equally weighted. The overall mark for this assignment accounted for 15% of the total course mark.

The teamwork task in this course was intended to:

- Foster collaboration and build learning communities, something particularly relevant during the first year of study, where most students experience learning in isolation.
- Train students in the process of teamwork from the very first year of their program, to progressively build their capacity in dealing with different team-based situations.
- Provide regular and timely feedback, and help students consolidate their learning, build their knowledge, and make timely decisions concerning their studies.

For those students in in-person teams, groups were self-selected at the end of the first tutorial session. Students who did not attend the first tutorial were allocated randomly. For those students doing the course online, groups were randomly formed.

At the end of each tutorial session, students were given 30 minutes to work on the group quiz. Students attending in-person tutorials met in allocated rooms, whereas students attending the online tutorial met in pre-allocated break-out groups in Microsoft Teams. If students did not have time to finish the group quiz within the allocated 30 minutes, or were not able to attend the tutorial, they were given five days' time to organise alternative arrangements to finalise it.

Given that the main objective of the teamwork task was to foster collaboration and build learning communities, T&L skills were not specifically assessed, although the tutor encouraged and monitored effective communication and accountability.

Challenges

One of the main challenges, which affected in-person and online delivery equally, was the difficulty to have stable groups during the first four weeks (out of ten) of the term. The reason for this was the changing nature of enrolment until Week 4, which is the deadline for students to drop the course without financial and academic penalty. In some cases, enrolment changes involved dropping the course, whereas in others it involved changing the time of the tutorial session. Meeting the requirement of having a minimum of three, and a maximum of four team members in a group became challenging due to these changes, and continuous monitoring and re-structuring of the groups was necessary. Nevertheless, while desirable, having stable groups was not critical for this task, since students submitted their answers individually (even though answers were the same for all members of the same group).

Another major challenge affecting both in-person and online delivery was the lack of an effective framework to properly introduce and evaluate T&L skills. While students were aware that the tutor monitored communication and accountability, these teamwork elements were not introduced in detail or evaluated, so students underestimated their importance. Also, a single tutor was not enough to formally evaluate the T&L skills in the short time available to work on the activity while in class (i.e., 30 minutes).

In the case of online delivery, an additional challenge was to keep students engaged in the task throughout the term. Given the much more limited interaction between students in the large online tutorial, online students were not as keen as in-person students to use the allocated 30 minutes to work in the group quiz. Instead, since all students were given five days to organise alternative arrangements and finalise the group quiz, most of them chose alternative ways to meet, so it was difficult to monitor teamwork, in contrast to in-person teams.

Outcomes

In the case of in-person delivery, tutorial attendance and participation in the task were very good (85.3% participation in group quiz on average, as per data in Table 1), since students found it more convenient to complete the group quizzes in-person during their tutorial times, rather than looking for a different time to meet. Also, as weeks passed, students felt more comfortable working together, so they did not only collaborate during the last part of the tutorial while doing the group quiz, but throughout the whole tutorial (as solving tutorial problems collaboratively was encouraged). In the case of online delivery, participation in the task was not severely affected (84% participation in group quiz on average), but tutorial attendance was considerably lower than the in-person tutorials, since students did not see any additional value in attending the tutorials to do the group quizzes, given the challenges explained before.

Table 1. Comparison of in-person and online teamwork task in the first-year course

	Quiz 1	Quiz 2	Quiz 3	Quiz 4	Quiz 5	Quiz 6
INDIVIDUAL QUIZ – In-person						
Average Mark (out of 50)	39.15	35.07	21.01	32.02	29.93	34.31
Number of participants (out of 348)	326	327	271	302	305	295
GROUP QUIZ – In-person						
Average Mark (out of 50)	41.93	36.25	25.33	32.11	30.15	34.60
Number of participants (out of 348)	336	324	274	295	275	277
INDIVIDUAL QUIZ – Online						
Average Mark (out of 50)	41.26	33.10	24.38	33.94	31.60	37.90
Number of participants (out of 81)	74	69	68	72	68	72
GROUP QUIZ – Online						
Average Mark (out of 50)	42.00	34.84	26.23	33.69	31.28	34.20
Number of participants (out of 81)	75	71	67	65	68	64

In terms of performance, according to the data in Table 1, group quizzes' performance (33.4/50 on average) was better than individual quizzes' performance (31.9/50 on average) for the in-person delivery. This improvement was expected, given that group quizzes are solved collaboratively; however, the improvement is not very noticeable as the platform used to create the quizzes randomises problem variables and there is no possibility to ensure that all students in a group get the same problem variables. This means that students could discuss the methods to solve the problems, but they still needed to re-do the working. This increases the chances to obtain a wrong response, which is something that does not usually happen when all students get the same problem variables and can check whether their answers match. In the case of online delivery, the performance was identical (33.7/50 on average for both individual and group quizzes), which suggests that the group interactions did not have a major effect in improving students' understanding.

The impact of the teamwork activity has also been assessed by comparing the results from the standardised evaluation tool before (Term 3, 2020) and after (Term 1, 2021) introducing the online quizzes. It is important to note that all course activities and pieces of assessment were identical in both terms, with the exception of the online quizzes, which were introduced for the first time in Term 1, 2021. Feedback provided for all assessment items was also identical, except for the additional feedback provided by the quizzes.

In terms of the first objective of the teamwork task (fostering collaboration and building learning communities), the task was clearly effective, as shown by students' answer to the question "I felt part of a learning community": 94.6% agreement in Term 1, 2021 versus 85.8% agreement in Term 3, 2020. In terms of the second objective (training students in the process of teamwork from the beginning of the program), the teamwork task helped to start building students' capacity in dealing with different team-based situations and made them aware of different behavioural attributes that lead to effective communication, accountability and trust, which were actively encouraged by the tutor. In terms of the third objective (providing regular and timely feedback, and help students consolidate their learning and build their knowledge), the teamwork task was also clearly effective, as shown by students' answer to the question "The feedback helped me learn": 92.8% agreement in Term 1, 2021 versus 86.4% agreement in Term 3, 2020. Specific comments shown below also support the effectiveness of the task in this regard:

"The quizzes helped consolidate content and it was easier to understand concepts."
"[…] this also created a friendly community of struggling students who were willing to help each other simply because we understood the sheer difficulty of the subject."
"The constant small assessments (weekly quizzes) meant that the coursework was ingested as it was presented."

Case 2: Fourth Year Undergraduate Design Course

Electrical Design Proficiency is a final year undergraduate design course with around 130 students. The course involves four separate design tasks with three core topics and one elective topic. This course was not offered online as it is heavily hands-on, but it has been considered in this study to assess the teamwork skills developed in a design-based course and compare them with those in non-design courses (Cases 1 and 3 in this study). It should be noted that in any design course there must be an element of teamwork in the conduct of the project and the assessment, as part of EA Competency Stage 1 (Australia, 2017).

In this course, the core design topics are done individually, but the elective topic, which is more comprehensive, is a teamwork design task. Each elective topic is presented with a description of the project and the objectives, a set of requirements that must be achieved along with constraints, as well as marking criteria. Each team member has a designated role, and all members are encouraged to work together throughout the laboratory time.

Team members have the authority to decide how the team should conduct the teamwork, as it is expected from final year engineering students. The course requirements do not enforce a specific approach to the way teams should operate. Students choose their own team members. In cases where some students are not able to find team members, the course coordinator forms the team with the remaining individual students. As this is a final year course, many students already know each other and are familiar with the strengths and capabilities of other students. Therefore, the teamwork dynamics would be more effective compared to randomly chosen teams. Also, due to the short duration of the elective task (~3 weeks), it makes sense to allow students to choose their team members themselves.

A dedicated mentor is assigned to each team. The mentor observes the teamwork and the interaction of team members in each laboratory session. The teams can discuss some of their design decisions with the mentor and receive feedback on their work from the mentor. The observations recorded are then used by the mentor to award the team performance mark. The weekly feedback from the mentor helps to improve the performance of each team.

During the final assessment of the task, each team member is interviewed, and the team presents the results to their mentor and an assessor (both are laboratory demonstrators in the course). They must also write a team report outlining how the team assigned different sections of the project to team members, as well as a reflection activity outlining their experience and answering some reflective questions. The final mark is then divided into achieving the requirements (9%), team performance (3%), team report (7%) and understanding of the task (9%, assessed individually).

Challenges

Adapting the course and the teamwork activity to be run in online mode is the main challenge, due to the practical nature of the course. Maintaining the hands-on experience as a major learning outcome would mean that some form of at-home experimentation must be introduced for the online mode. This raises workplace health and safety issues that must be carefully looked at before expecting students to conduct any form of electronics experiment at home. Some realistic virtual experiment could be designed as an alternative for such circumstances where physical lab access may not be feasible.

Another challenge is ensuring a good trade-off between completing team-based design tasks and ensuring development of individual skills and knowledge. Teamwork activities must be meticulously designed to ensure that each team member carries their individual contribution in completing the project equally, as well as to reflect students' skills when working together towards achieving the requirements of the design tasks, so it is necessary to provide a well-structured set of instructions on how each team needs to use daily briefings, minutes taking, and task distribution amongst the members to build the teamwork skills and utilise them in completing the project.

Outcomes

The average teamwork-related marks obtained in this course for in-person delivery were 79.22% for team performance and 82% for team report, which demonstrate good engagement in the teamwork task. In addition to this, the standardised evaluation tool recorded a course satisfaction of 98%. Specific comments shown below further support the effectiveness of the teamwork task:

"The best things were the ability to work with peers to solve problems and being able to see the results in front of us"

"For the question on "I felt part of a learning community" – I normally just 'Agree'. This is the first course where I checked 'Strongly Agree'. […] the way in which it was delivered FAR exceeded my expectations."

As previously mentioned, due to the practical nature of the course, in-person delivery is highly encouraged whenever possible, as introducing online delivery negates the practical hands-on experience required.

Case 3: Postgraduate Course

Electrical Safety is a postgraduate elective course in the power engineering specialisation, with an enrolment of about 200 students. High calibre undergraduate students are allowed to enrol in this course via an approval process. 90% of the students in the course are international students. The teamwork task in this course is a project-based learning task that was introduced to enable students to critically analyse the course content and apply it by presenting solutions for real world scenarios which is best achieved via brainstorming within a team. The teamwork activity in this course requires students to investigate and analyse electrical safety incidents to propose engineering, administrative, related laws and standards and personal protective equipment solutions in the form of a presentation which is marked by industry experts. The course was in-person in 2019 and was modified to be offered completely online in 2020. Teams were assessed in both the offerings using the VALUE rubric (McConnell, et al., 2019). This task contributes 30% towards the course.

In-person Teamwork

The 2019 offering of the course was designed to be run in collaborative learning spaces shared by multiple teams. There were 199 enrolments and teams of maximum 10 students were created. Teams were formed in random ensuring diversity based on the demographics and gender. This ensured that the prior knowledge of the students in the basics of electrical power engineering was broad enough to manage the teamwork activity, as the students had completed their undergraduate degree in different universities Worldwide. Each team met every week for 1.5 hours during the timetabled class hours, to discuss the teamwork activity. One mentor was allocated to four teams. The mentor acted as an observer and was able to walk around the teams in the collaborative learning space observing their participation and answering their queries. They also marked the individual students in the teams against the VALUE rubric and provided weekly feedback on their team performance. At the end of the term, the teams presented their analysis to industry experts, who marked their presentation and offered their live feedback. The other teams also attended these presentations and were required to provide peer assessment to at least three teams.

Online Teamwork

The 2020 offering of the course was completely run in an online mode. Team formation was done based on geographical location to accommodate people living in different time zones to be able to organise their weekly team meetings with the mentors. Some mentors were also overseas to better coordinate with time zones. An experiential learning approach was adopted with structured teamwork training modules created for every week simulating an industrial environment (Thite et al, 2020), following the Tuckman's model of teamwork development (Bonebright, 2010).

The structure of the team activity was changed in the following ways:

- There were smaller teams of five.
- The final presentation was replaced by a team video presenting the case study analysis which was marked by industry experts.
- Separate team meetings were scheduled exclusive to the class time. There were two weekly meetings of one hour each: (i) Team meeting with mentor and (ii) Team meeting without mentor.
- Team meetings with the mentor included the following aspects in different phases of team building: concept plan, role assignment and rotation, structured tasks and milestones, introduction to teamwork concepts, team building activities, and reflection activities.
- The teamwork topics introduced to students were communication, leadership, accountability and trust, and conflict management. The leadership role was carried out by every team member at least once throughout the term.
- Mentors marked the students weekly against the VALUE rubric. The marks of the teamwork task were then individualised based on this rubric.

Challenges

In the in-person teamwork, the main challenges were: (i) The size of each team (10 students), which made it difficult for mentors to provide personalised feedback to each team member and (ii) Exclusive team meetings among the students themselves were not mandated, so students felt less connected outside the classroom.

In the online implementation, the main challenges were: (i) The time needed for planning, as the team building activities which are usually face to face needed to be chosen and tailored to be able to run online; (ii) Handling and providing feedback to a large number of teams for their case study analysis – for example, in the 2019 offering there were 20 teams of 9-10 students each and hence 20 projects to mark, whereas in the 2021 offering, there were 36 teams of 4-5 students each, so more casual staff were needed to mentor all the teams; (iii) Students did not get the opportunity to meet with the industry experts, although they offered their feedback asynchronously; (iv) Students were not able to look at other teams' video, as there were no

opportunities for a general showcase due to lack of time during the term; (v) Some students had challenges in giving their full participation due to poor internet connections.

Outcomes

In both modes, the teamwork assessment was rated as the most helpful learning activity in the course. Table 2 shows the comparison of the 2019 in-person and 2020 online offerings. From the table, it is clear that the online teamwork has produced similar results as the in-person mode in terms of course satisfaction, but students performed better (as indicated by the mean course grade and high distinctions). Additionally, the engagement and collaboration levels in the teams were noticed to have increased in the 2020 online version with an average of 22% improvement of teamwork marks in 76% of students, whereas this was only 12% in the 2019 in-person offering in 68% of students. Due to COVID in 2020, there were 23% of students taking this course online as the first course in the university from their respective countries. The teamwork activity helped them connect with their peers. The response rate on the standardised evaluation tool also drastically increased to 76.2% (highest among all courses in the school) for the online offering, which shows the improvement in engagement level in the course, attributed to the teamwork task.

Table 2. Comparison of in-person and online teamwork in the postgraduate course

Category	2019 in-person mode	2020 online mode
Enrolments	199	172
Course satisfaction	96.5%	96.2%
Response rate on survey	57.8%	76.2%
Course mean grade	69.5%	76.5%
High distinction	2.5%	4.7%

Team bonding and engagement is usually affected negatively in online teams. However, due to a structured approach which included team building activities, reflection activities, and weekly tasks and milestones, the team bonding was counterintuitively noticed to be consistently high for all the teams. This was also reflected in the quality of the final videos. Some other advantages were noted in terms of flexibility and improved work efficiency due to digital means like screen sharing and live documents.

Some specific comments by students in 2020 include:

"Structured weekly meetings with mentors in MS Teams helped us to collaborate well."
"I enjoyed the online teamwork – a convenient and time-saving activity. Breaking our tasks down into smaller weekly tasks helped us accomplish the overall goal easily."
"Since this is the first term of my postgraduate study, I loved the way I got connected to my peers."

Conclusion

Three courses, with different expectations and motivations, have been considered to analyse how in-person and online team dynamics differ regarding strategies and challenges at different levels. The first-year course (Case 1) used online group quizzes to create a learning community, improve feedback, and serve as an introduction to teamwork. The main challenges identified were the difficulty to have stable groups at the beginning of the term due to enrolment changes, the lack of an effective framework to properly introduce and evaluate T&L skills, and the difficulty to keep online students engaged. The fourth-year design course (Case 2) used a teamwork design task to implement T&L skills in accordance with EA Stage 1 competencies. While the teamwork task was evaluated very positively by in-person students, maintaining the hands-on experience as a major learning outcome in an online delivery mode was identified as the main challenge. Finally, the postgraduate course (Case 3) used a project-based learning task to deepen student's understanding while focusing on improving T&L skills in a more structured, industry-oriented manner. The main challenges identified in the online mode were increased number of teams for marking the task, lack of time in the term to help students watch and peer mark other teams' videos and the limitations to interact with industry experts.

In all three courses, students' perceptions of the effectiveness of team learning are shown to be positive, although there was mixed experience in terms of challenges and benefits of online teamwork. In Case 1, there was a drop in engagement during online activities whereas a more structured and scaffolded online instruction in Case 3 showcased improved engagement and bonding within the teams. A similar trend was noticed in the performance of students where Case 1 reported marginally better performance in the in-person mode whereas Case 3 reported an improved performance in the online mode.

Going forward, T&L skills' development requires a more structured and staggered plan for an undergraduate degree incorporating the four pillars of teamwork skills development: team formation, team building, team feedback and team performance. In the case of postgraduate courses, effectively incorporating T&L skills in a staggered manner is challenging, since most of the postgraduate students in Australia are international students, who have maximum two years to complete their degree, can choose their courses (mostly electives) in any order during the program, and have significantly different past T&L experience which is usually on the lower side. A more direct, broader, structured, and scaffolded approach is then required for postgraduate degrees that provides students insights into the expected skills of the Australian industrial work culture.

Overall, this study highlights the importance of supporting and evaluating awareness and development of T&L skills within a degree program, and proposes strategies to do so, highlighting the main challenges to overcome. Although the results indicate that there is no single dominant model for how teamwork skills are developed within an engineering program, such program-wide outlook for online versus in-person teamwork would benefit in informing future blended/hybrid options, post pandemic.

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