



# Teamwork in Engineering Education: Student attitudes, perceptions, and preferences

Abishek Sekhar<sup>a</sup>, Asmar R. bin Mezalan<sup>a</sup>, Sarah Grundy<sup>a</sup>, Peter R. Neal<sup>a</sup>.  
*School of Chemical Engineering, The University of New South Wales, Sydney NSW Australia<sup>a</sup>*  
*Corresponding Author Email: peter.neal@unsw.edu.au*

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## ABSTRACT

### CONTEXT

Teamwork or collaboration skills are an integral part of contemporary engineering practice and are highly valued by employers (Crosthwaite, 2021). Within the design of team-based learning activities it is important to understand student attitudes, perceptions, and preferences. Pfaff and Huddleston (2003) and Tucker and Abbasi (2016) found that positive student attitudes to teamwork were strongly correlated with the amount and distribution of workload, previous teamwork experiences, dedicated class time, and the use of peer evaluation. While Grzimek et al. (2020), found that the attitudes to teamwork vary between disciplines. However, there is limited understanding of how attitudes develop across the program, as well as the effect of study mode.

### PURPOSE OR GOAL

This study explored attitudes of undergraduate engineering students to teamwork in a range of courses across all year levels. We investigated (1) general student attitudes to teamwork and (2) whether there are changes in attitudes across year levels, as well as student preferences (3) around the organisation of teams, and (4) regarding online and face-to-face teams.

### APPROACH OR METHODOLOGY/METHODS

An anonymous survey was developed to elicit student responses consisting of closed-ended questions collated from existing instruments or written by the research team. After internal review and pilot testing, the survey was conducted during class time in two courses at our institution, with additional respondents solicited through advertising the survey in other courses.

### ACTUAL OUTCOMES

This paper reports the results of a preliminary study into student attitudes to teamwork (n=44). We found our respondents are broadly satisfied with the presence of teamwork in the curriculum and believe it teaches valuable professional skills. We did not find trends related to year level, perhaps because of the limited sample. Respondents preferred moderately sized teams, and indicated support for having teams led by two people. Finally, the students preferred face-to-face over online teams, pointing to the impact of mode on relationships, communication, accountability and conflict.

### CONCLUSIONS/RECOMMENDATIONS/SUMMARY

The development of teamwork skills is a critical part of contemporary engineering education. This is most effectively achieved when students are engaged and have a positive attitude to teamwork. Our results indicate students value teamwork and its capacity to enable learning key professional skills. However, teachers must ensure that students are well prepared and supported as they engage in these activities.

### KEYWORDS

Teamwork, student attitudes, student experience

## Introduction

Teamwork is a critical skill for professional engineering practice, and so is incorporated into many areas of engineering degrees. One common location for teamwork is in design and project-based courses, where students apply learned skills and knowledge as a team while engaging with complex problems. Student teamwork skills develop across terms and years as they learn more about managing teams. This begins with applying tools like progress meetings and peer evaluation for the team's benefit, to forgoing inherent biases (Kuehster & Hall, 2010) and developing skills in people management and conflict resolution.

Further, the teaching of teamwork skills is an expected as part of degree accreditation - Engineers Australia Stage 1 Competency standards (EA, 2019) expects graduate engineers will have be able to lead or be part of teams successfully. Finally, students who work better in teams have been found to be more confident, have higher self-esteem, and can build better relationships with one another (Marks & O'Connor, 2013).

However, some studies have shown that university students usually prefer working independently (Lingard & Barkataki, 2011). Further, the shift to online and remote education in response to the pandemic has impacted the way students experience and engage with teamwork. Working in online teams entails considerable differences from in-person teams, especially how groups communicate (Ferrazzi, 2013).

All these factors could promote both positive and negative student attitudes to teamwork and team-based learning activities. Negative student experiences and attitudes around teamwork can reduce their engagement with learning and the discipline, long-term. While positive attitudes could raise their engagement and prepare them for effective professional practice. Therefore, we investigated student attitudes to teamwork in 2022. Specifically, we were interested in understanding student perceptions and preferences surrounding (1) the organisation of teams and teamwork, (2) the integration of teamwork in the curriculum, (3) online and in-person teams, and (4) how these preferences vary across year levels.

## Background

Teams and teamwork are sometimes nebulous terms that can be conflated with the broader concept of groups and group-based activities, as well as the related terms: collaboration, coordination and networks (Reeves et al., 2018). However, teamwork can be defined as the active participation of two or more people in communication, decision-making and the interdependent and accountable mixing of their labour to achieve shared goals (Mickan & Rodger, 2000; Xyrichis & Ream, 2008).

Working in teams allows us to achieve shared interests efficiently, maximizing the productive use of resources to have a greater impact on the problems at hand than would be achieved individually. This is especially the case in the professional practice where the lack of effective communication and teamwork can lead to failures that may cause significant losses in human, environmental and economic terms.

Therefore, it is critical than engineering students both appreciate the importance of teamwork and learn how to be an effective team member. Achieving this goal requires teachers to employ a multi-pronged approach to the development of teamwork skills in their students (Tonso, 2006).

The vital task of inculcating a proper appreciation of teamwork is complicated averse student attitudes based on experiences and perceptions of the unequal distribution of work and unfair assessment practices (Tucker & Abbasi, 2016). In their systematic review, Borrego et al. (2013) found that social loafing is the most common concern among students engaged in team-based activities. However, the nature, causes and reduction of social loafing is complex and need not be simply caused by laziness or seeking a free ride (Hall & Buzwell, 2013).

Students should be given the proper knowledge of the framework of a successful team, and usual team compositions, which would allow them to decide how to pursue the act of getting into said

teams. Their expectations of how the process and integration of teamwork is going to materialize for them should be clearly set beforehand, by facilitators with enough experience to guide them through hiccups along the way (Davis & Ulseth, 2013).

Thoughtful consideration should be given to construct teams to avoid an illusory effect of team responsiveness and dynamic collaboration (Walker & Stott, 1995). Students who are more introverted may feel that their voice often goes unheard, which may lead to them doing little to no satisfactory work, as perception of their capabilities plummet. More extroverted students may instead hold all the reins, which may lead to unfair delegation of work, allowing some members of the team an opportunity to shirk their responsibilities.

However, students tend to also feel more comfortable when operating in teams, because as time goes by, their vested interest in doing the work with the rest of the team, increases significantly. The achieving of a shared goal, or at least the progress towards a shared goal, gives students a sense of comfort that they are not alone when struggling or celebrating (Pfaff & Huddleston, 2003).

Student attitudes towards teamwork has been linked with their overall academic performance, as organizational teams tend to lead to students who are more organized with their work (Hirsch & McKenna, 2008). While, Zou and Ko (2012) investigated student attitudes before and after a systematic intervention for teamwork training over three years in a chemical engineering program. Participants demonstrated a positive attitude to teamwork and became more sophisticated in both their understanding and practice of teamwork.

The perception of students to teamwork was also found to be related to self-efficacy and interest, where students demonstrating a high level of self-efficacy and low level of interest find it challenging to improve their teamwork skills. Konak et al. (2015) compared the perception of online and face-to-face students and found that the latter display a more positive outlook toward teamwork. Based on the findings of this study, the authors hypothesized that teamwork self-efficacy is positively correlated with attitudes toward teamwork.

Marks and O'Connor (2013) investigated student attitudes to teamwork in business and non-business majors. They found students understood the professional reasons for using teamwork, however they were not convinced that this was the primary motivator its use. Students more commonly believed teachers used teamwork to reduce marking loads. Also, they did not find consensus among the students for teamwork over independent work. However, they did find that business students were more likely to prefer working in teams. In a follow-up study, Grzimek et al. (2014) found that students with higher GPAs tended to prefer working independently relative to their peers with lower GPAs. They found similar trends when asking about peer reviews and mark differentiation for team projects.

These studies indicate the importance of careful design and communication of the purposes of team-based activities. A key step is explicit instruction on the nature and characteristics of effective teams, as well as strategies for managing teams and projects. This should be complemented by facilitating meta-cognition through reflective and peer review activities, and careful assessment or activity design. However, good teaching practice and learning design will only have limited effectiveness if it does not engage with student conceptions and misconceptions of teamwork. Thus, it is important to understand student attitudes and preferences for teamwork.

## Method

To assess student attitudes, several research methods were considered including surveys, focus groups and interviews. Surveys were selected as the primary research tool as it gave the opportunity to elicit responses from many students. The development of the survey proceeded through several steps:

1. **Selection Criteria:** Before writing and collating survey questions the research team defined the assessment parameters of interest for this study. The parameters and their associated hypotheses are listed in Table 1.

2. **Question Generation:** The team reviewed existing surveys on attitudes to teamwork and conducted brainstorming to develop a question bank for the survey. This list was revised and edited to trim the survey length to a manageable amount, with a target duration of under 5 minutes. In the end, the survey consisted of 10 questions, of which 5 were multi-part.
3. **Survey Development:** The survey was built in Google Surveys. The format of the questions was tailored according to the level of specificity that was needed, with three types used: multiple choice questions, Likert-scale questions, and binary choice questions. The survey was reviewed under the ethics approval (HC210223) from our institution and approved for release.
4. **Validation:** The final survey was reviewed internally and then tested with a sample audience of 3 students. Feedback collected from the test audience was reviewed, analysed, and used to revise the survey.
5. **Rollout:** The survey was initially deployed to a third-year chemical engineering class and initial results collected. Reflection on the results of this initial run allowed us to further optimise the survey to have an even tighter focus on our hypotheses. Course coordinators from within our department, faculty and institution were contacted about running the survey in their courses. The survey was subsequently promoted to an additional four courses.
6. **Result Analysis:** Following these classes, the collected results were analysed, observations noted, and hypotheses tested. For Likert-scale questions, analysis was done by giving the responses (Strongly Disagree, Disagree, Moderately Disagree, Moderately Agree, Agree, Strongly Agree) numerical values from 1 to 6, and calculating the mean and standard deviation of each question. Combining the proportions of all agreement categories gave a broad Agreement score.

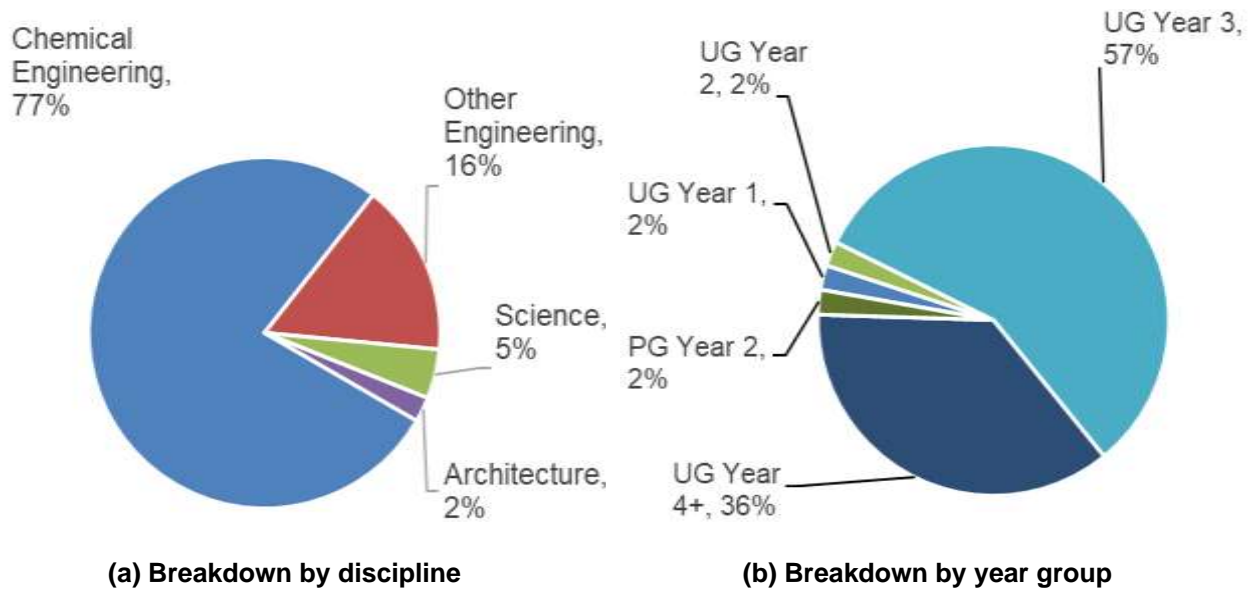
**Table 1: Key Assessment Parameters**

Parameter	Justification/Hypotheses
Prior Teamworking Experience	Respondents' previous experience working in teams and the general nature and dynamics of the teams they worked in will affect their attitudes to teamwork.
General Attitudes towards Teamwork	Respondents' past attitudes towards different aspects and integration of teamwork within the curriculum affect their current attitudes towards teamwork.
Online vs In-Person Teams	Respondents' preferences towards medium of teamworking [online or in-person] and general structure of teams affect their perception of teamwork.
Peer Evaluation	Respondents' attitudes towards the implementation and methodology of peer evaluation affects their attitudes towards teamwork.
Student Roles	Respondents' understanding of their roles and responsibilities within a team and their ability to self-reflect affects their attitudes towards teamwork.

## Results and discussion

### Demographics and previous experience

Responses were collected in class from a third-year and a fourth-year chemical engineering class. Further responses were elicited through invitations to other engineering students and courses in the science and architecture faculties. In total, 44 responses were received. As shown in Figure 1, 77% of respondents were studying chemical engineering, more than half of respondents were 3<sup>rd</sup> year undergraduates and over a third were in 4<sup>th</sup> year. This experience showed that securing in class time for running the survey led to higher response rates. Further, while the number of responses is low and limit the applicability of the results, they serve as a pilot data set and can be used to leverage surveys of larger cohorts in the future.



**Figure 1: Demographics of survey respondents**

In terms of the previous experience of students, almost all respondents (98%) have had experience of predominantly online teams, experienced working under pressure and with tight deadlines (100%), had used technology to facilitate groupwork (98%), and had experienced teachers differentiating marks based on contribution to teamwork (95%).

### General attitudes and cohort effects

The core purpose of the survey was to understand the attitudes of the respondents to teamwork (see Table 2). Students indicated a generally clear agreement with teamwork (Mean=4.64), with a slightly weaker support for teamwork being used more often in classes (Mean=4.18). Stronger levels of agreement were found for the recognition of the importance of teamwork (Mean=5.11) and the associated skills of networking (Mean=5.07) and conflict management (Mean=5.14). In these responses there is clear desire to be taught how to work effectively in a team, as well as clear beliefs that the experience of teamwork in learning activities helps them learn associated skills. This is an encouraging finding as it shows that the anecdotal and literature reports of resistance to teamwork (Tucker & Abbasi, 2016) was not shared by our respondents. It would be helpful in future work to explore the contributors to these positive attitudes.

We also explored if there were changes in attitudes to teamwork across year groups. Given the limited responses, only 3<sup>rd</sup> and 4<sup>th</sup> year students were analysed. A two-sided unequal variance t-test was used to compare the mean scores for 3<sup>rd</sup> and 4<sup>th</sup> year students, with a null hypothesis of no difference. We did not find a statistically significant difference ( $p > 0.300$ ).

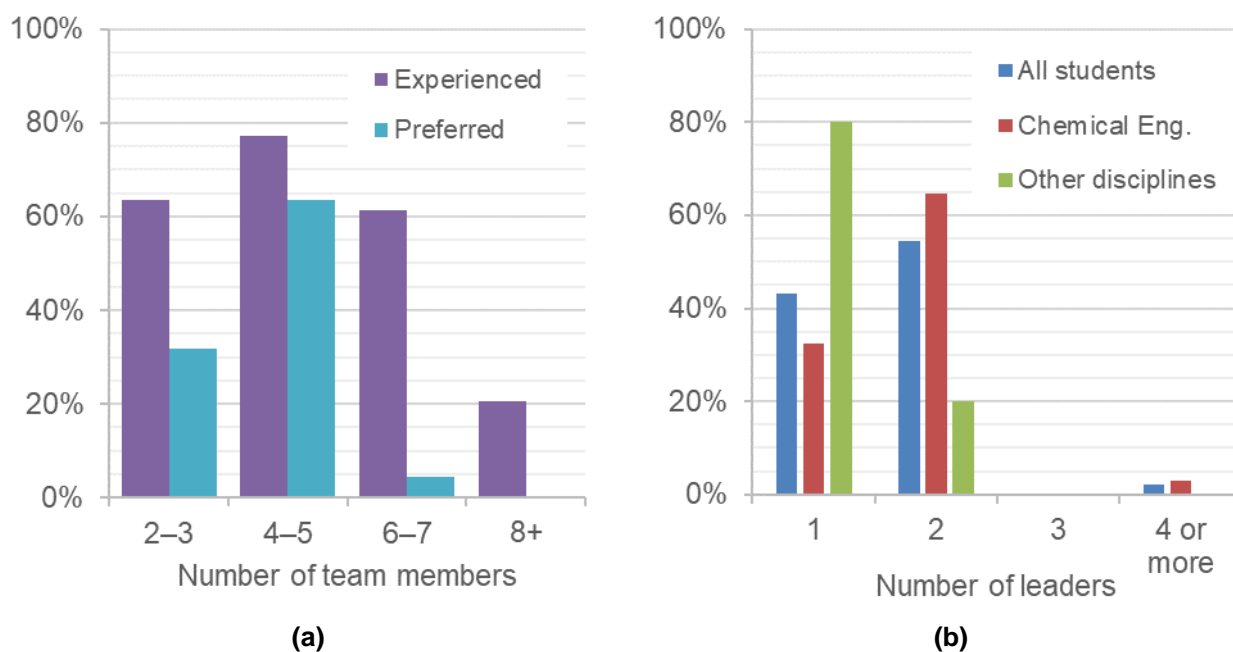
### Organisation of teams

Students were asked several questions about their experience and preferences around the way teams are organised and team-based activities are structured. Most respondents (>60%) had experienced a range of team sizes, with teams of 4-5 being the most common (see Figure 2(a)). Only one fifth of students had worked in teams of 8 or more. When asked about their preferred team size, more than 60% of students indicated that they favoured teams with 4-5 members, and around a third favouring teams with 2-3 members. Thus, the respondents favour small, but not very small, teams. Perhaps this relates to beliefs and experiences about the risks of breakdowns in teamwork because of conflict or the inequitable distribution of work.

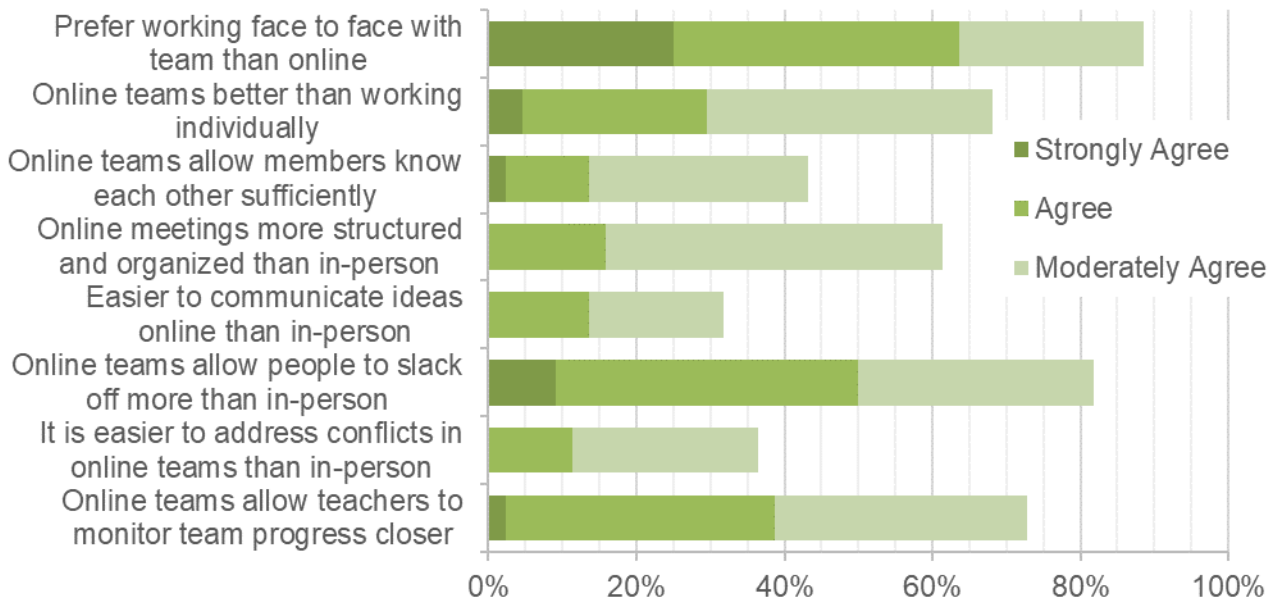
**Table 2: General attitudes to teamwork of 3<sup>rd</sup> year, 4<sup>th</sup> year and all students**

Questions	All years (n=44)		3rd year (n=25)		4th year (n=16)	
	Mean	SD	Mean	SD	Mean	SD
In general, teamwork is a positive experience.	4.64	0.84	4.60	0.65	4.56	1.09
Teamwork should be used more often in classes.	4.18	1.06	4.08	0.95	4.38	1.15
Teamwork is an important skill and courses should highlight how to work in a team effectively.	5.11	0.75	5.00	0.65	5.25	0.93
Effective networking skills are important to enhance career prospects and can be learned through teamwork.	5.07	0.85	4.96	0.98	5.19	0.66
Conflict resolution skills are useful in a professional setting and can be learned through teamwork.	5.14	0.70	5.04	0.61	5.19	0.83

Another aspect investigated was the preferred number of leaders (see Figure 2(b)). Across all respondents, we found that more than half believed that teams operating most efficiently with two leaders. This was a surprising outcome, and so further analyses were made. When the results were divided by discipline into chemical engineering students and other disciplines, we found there was a statistically significant difference in preferred number of leaders ( $p=0.005$ ). While further research is merited to see how reproducible this result, we did see that there was no significant effect of year group within the chemical engineering group ( $p=0.221$ ).



**Figure 2: Respondent preferences for the number of team (a) members and (b) leaders**



**Figure 3: Respondents perspectives on online teams compared to face-to-face teams**

The chemical engineering students were completing complex design projects and perhaps the preference for two leaders is a recognition of the advantages of a limited spread in the coordination workload, or insurance against domineering or apathetic leadership. While most theory outlines sole leadership as providing proper guidance and direction to a team (Aranzabal et al., 2022; Fisher et al., 1998), some theories do suggest that co-leadership is a viable option to consider, which may be even more the case in multidisciplinary teams (Katzenbach & Smith, 1993). However, the lack of open-ended questions meant that it was hard to attribute rationales to the responses. This will be addressed in future versions of the survey.

### Online and in-person teams

As mentioned earlier, most respondents have worked in teams that were predominantly online. However, almost 90% of students said they prefer working face-to-face with their team (see Figure 3). The other results indicate a few reasons for this:

1. **Relationship building:** Around 40% agreed that online teams enabled them to get to know their team mates sufficiently. A lack of intimacy in team relationships can impair the effectiveness of teams and may be a function of more functional interactions online.
2. **Communication:** Very few students (32%) agreed they could communicate their ideas easier in online teams than in-person teams. Ferrazzi (2013) points to a range of factors that can impair communication, such as the lack of non-verbal cues. This can be compounded by higher reliance on text-based communication and weaker relationships.
3. **Accountability:** A large majority (82%) of respondents feel there is more social loafing in online teams. Keeping track of team member progress can be harder in online teams and may give rise to the perception of high rates of social loafing in online teams. However, as Borrego et al. (2013) noted, this concern is common and not limited to online teams.
4. **Conflict resolution:** Almost two-thirds of respondents believe it is harder to address conflicts in online teams. This can be seen as the fruit of the three previous factors, with weaker relationships, poorer communication and reduced accountability resulting in increased difficulties resolving disputes and misunderstandings among team members.

However, the respondents also saw strengths in online teams. More than 60% prefer online teams to working by themselves and believe that online meetings are more structured and organised. Almost three-quarters of respondents believe there is greater transparency of team health to teachers. These findings indicate that there is some support for online teams, however teachers

must ensure that there is significant support and scaffolding to enable good relationship building and communication practices when using online teams.

## Conclusions

We surveyed a total of 44 students from various discipline and year levels to investigate their attitudes to teamwork. The results suggest that students have a generally positive attitude to teamwork, and these opinions are largely the same similar across third and fourth year. Larger sample sizes are required to confirm this finding and show whether there are significant differences in attitudes between earlier and later years.

While exhibiting more organisation and being more transparent to teachers, respondents indicated a prefer for in-person teams compared to online. Teachers can contribute to making online teams more effective by supporting students with building relationships, improving communication, strengthening accountability, and resolving conflicts.

Future versions of the survey will also incorporate open-ended questions to elicit broader understandings of student perspectives. Securing larger numbers of responses from all year groups but especially earlier years, as well as across disciplines, faculties and even institutions will enable stronger conclusions to be drawn about student preferences around teamwork.

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