DEVELOPING TEAMWORK SKILLS IN UNDERGRADUATE SCIENCE STUDENTS: THE ACADEMIC PERSPECTIVE AND PRACTICE

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ABSTRACT

Learning to function as an effective team member is an important skill for science graduates. A science curriculum that supports the development of teamwork skills ensures graduates are equipped with workplace skills that are required in research and other professional careers. This study used a survey to investigate the academic perspective and practice of teaching teamwork within the undergraduate science curriculum in Australian universities. The findings suggest the majority of science academics are positive about the importance of developing teamwork skills in graduates. Fewer academics are confident that teamwork skills are being sufficiently developed through the curriculum. Respondents primarily assigned teamwork activities because it develops interpersonal skills, encourages peer sharing and mimics a real-world environment. Those respondents, who didn't assign teamwork, thought it wasn't suitable to the course, or believed the challenges associated with group dynamics outweighed the benefits of assigning teamwork activities. Current approaches for the development of teamwork skills are varied, with the majority of respondents favouring curriculum-integrated approaches. With a greater understanding of the academic perspective of teaching teamwork, those involved with leading curriculum change can better develop approaches to ensure these valuable skills are fostered in science graduates.

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INTRODUCTION

Effective teamwork skills are a highly desirable trait in a science graduate. The benefits of teamwork skills in the STEM disciplines (science, engineering, technology and maths) have been well cited (Baker, Day, & Salas, 2006; Drury, Kay, & Losberg, 2003; Felder & Brent, 2007; Fiore, 2008; Mills, 2003). This is because at every stage of learning through to established workforce practices, collaboration and cooperation are essential (Dunne & Rawlins, 2000). Developing the skills learned through teamwork simultaneously helps to promote the deeper cognition associated with peer interaction, such as dialogue, problem solving and cooperation (Edmondson & Maguire 2001; Tarricone & Luca, 2002). Furthermore, the social nature of teamwork improves student mental health and social competence (Smith 1996, Strom and Strom 2011). This broader diversity of skills and stronger social networks creates a more comprehensive educational experience (Bose, Jarreau, Lawrence, & Snyder 2004, Davies 2009).

Teamwork skills for employability

The common approach for teaching science at undergraduate level is to equip students with the technical aptitudes specific to laboratory work and research (Ge & Helfert, 2014; Tjian, 2015; Venville & Dawson, 2004). Research skills are undoubtedly a priority in a science degree, as they develop many important graduate competencies (Hunter, Laursen, & Seymour, 2007). For example, learning about the scientific research process fosters abstract reasoning and problem solving skills (Rowland, Lawrie, Behrendorff, & Gillam, 2013). However, as a consequence of focusing on research training, the skills of interacting and working with other people are often overlooked in the science curriculum (Tjian, 2015). Not surprisingly, science graduates are noted as lacking in teamwork skills by employers (Curtis & Mckenzie, 2001; Sheldon & Thornthwaite, 2005). For example, a report by Prinsley and Baranyai (2015) finds that STEM graduate's interpersonal skills are poorly rated by employers when compared to non-STEM graduates.

For graduates planning to undertake a research career, teamwork skills will enhance their ability to build research collaborations and work within research teams. This is increasingly important as we see the rise of multidisciplinary research teams, where almost every project will draw upon expertise from a range of areas; often across different disciplines, different institutes and even different countries (Fiore, 2008). A rigorous undergraduate science education should prepare all students for the workforce, not just those destined for a scientific career (Tanner, Chatman, & Allen, 2003). For

graduates seeking career pathways beyond science, the ability to work in a team is also highly important (Gibert, Tozer, & Westoby 2017), because many workplaces require cooperation between people and high-level interpersonal skills (Dunne & Rawlins, 2000; Australian Association of Graduate Employers, 2014; Osmani, Weerakkody, Hindi, Al-Esmail, Eldabi, Kapoor & Irani, 2015).

Developing teamwork skills

Assigning teamwork activities has been an approach used within the university curriculum for decades. However, teamwork does not automatically occur as a consequence of putting people together (Lerner, Magrane, & Friedman, 2009). Rather, teamwork is a dynamic skill that requires guidance and mentorship to develop (Cameron-Jones & O'Hara, 1999; Crebert, Bates, Bell, Patrick, & Cragnolini, 2004). Rieb, Girardi, & Whitsed, (2016) outline that the pedagogical approach surrounding teamwork is dependent on a range of interactions including the institutional context, the instructor's experience and the student's perception of undertaking teamwork. They suggest that academics vary widely in their conceptualisation of the pedagogy of teamwork, with many academics placing the emphasis on the final product (output), rather than the skills and attributes (inputs) required to collaboratively work together (Riebe et al., 2016). For example, a common practice is placing student into groups, and leaving them to independently establish how to create a successful and productive team (Dunne & Rawlins, 2000; Tanner et al., 2003). In the context of this study there is a distinction between teaching teamwork (input), and teamwork as an educational objective (output).

It is also important to note that teamwork is defined as distinct from group work, primarily in terms of the cohesion between team and group members. For example, in a group, members will often disperse and go away to work on individual aspects of a project, with very little collaboration actually having taken place. Whereas, in a team, interaction between members regularly takes a much greater significance with the team working collectively towards a common goal, each individual aware of what the others are working on, and with the final product a result of this collaboration (Oakley, Hanna, Kuzmyn, & Felder 2007).

Teamwork skills in science

Although it has been widely advocated that teamwork is an important element in the university curriculum (Dunne & Rawlins, 2000), little is understood about the approaches for teaching teamwork within science degrees. The development of teamwork skills has been frequently considered from the student perspective within disciplines beyond science (Burdett, 2003; Pfaff & Huddleston, 2003; Walker, 2001), and in the more closely related health sciences and engineering disciplines (Black, Blue, Davidson, & McCormack, 2016; Oakley et al., 2007; Pogge, 2013). To the author's knowledge, teamwork skills within science degrees have been given scant attention (but see Bose et al., 2004; Garcia-Bayonas & Gottschall 2008; Gibert et al., 2017; Rahman, Sarkar, Gomes, & Mojumder, 2010; Shibley 2002). For example, in a recent review on teamwork pedagogy, no science-focused studies are cited (Riebe et al., 2016). Fewer studies look at the academic perspective on developing teamwork skills (but see Johnson, Al-Mahmood, & Maier 2012). To gain a complete picture of the complex dynamics of teaching teamwork, the student perceptions must also be considered. In light of this, a further paper investigating the student's perspective of teamwork in science was undertaken simultaneously with this research by Wilson, Ho and Brookes (submitted).

At a time when universities are under increasing pressure to develop work-ready graduates, an understanding of how science academics conceptualise teamwork teaching approaches provides important insights. This may enhance the current practices of teaching teamwork skills and highlight where teaching teamwork in the science undergraduate curriculum is afforded or constrained. This study investigates the academic perspective and practices on the development of teamwork skills through the undergraduate science curriculum. Specifically, it is asked:

- What are the perspectives of academics about the value of teamwork skills for science students?
- What are the practices of these academics within the undergraduate science curriculum?

METHODOLOGY

This research used a mixed-methodological approach comprising both quantitative and qualitative data (Sadan, 2014). The quantitative data was gathered using online survey responses with Likert-attitude scale question responses of one (least important) to seven (most important). The qualitative data consisted of ranked responses, and open-ended comments. Open-ended questions were used

to gain a more nuanced understanding of the quantitative data and so that respondents could express their thoughts more freely (Bogdan & Biklen, 1998). Relying on a survey for the data collection enabled a larger number of academics from a broad range of universities to be included within the study.

Survey procedures

The survey questioned academic and professional staff about their opinion and professional practice related to teaching teamwork in the undergraduate science curriculum. Before proceeding with the survey, respondents needed to confirm they had been actively teaching within the last year. To interrogate the difference between teamwork being focused on the product (outcome) and teamwork teaching (input), the survey questions made a distinction between *teaching* teamwork (e.g. '*Teaching teamwork actively occurs in your faculty, choose an answer…*') and *assigning* teamwork activities (e.g. *'do you assign teamwork activities within the units or courses that you teach?*').

A suitable survey instrument could not be established from the existing literature to use in this study. Therefore, where possible aspects of the survey were based upon prior literature on teamwork in higher education. For instance, rank-list questions interrogating the reasons teamwork skills were taught were derived from Walker (2001) and questions about the current practices for teaching teamwork were developed by drawing upon key themes discussed by Davies (2009).

Prior to administering the survey, the draft survey questions were piloted by five actively teaching science academics. Amendments were made to the order and wording of the existing questions and further questions were added based upon the feedback from groups. Respondents were invited to complete an anonymous online survey during March–May 2016. The survey was distributed either by direct survey invite, newsletter advertisement, or via snowballing, where existing participants recruited further participants from their networks. The data was collected using the online survey tool *SurveyMonkey*. The survey was comprised of 33 questions with sections on demographic information (e.g. university, academic role, length of teaching experience), how much respondents valued teamwork as a skill and their opinion about current teaching approaches. The survey required 10 to 15 minutes to complete. The Monash University Human Ethics Research Committee provided approval for the research approach #CF16/728 – 2016000356.

Data analysis

A total of 70 respondents from 13 higher education (HE) institutions in Australia completed the survey (Fig. 1). The respondents represented a broad range of roles and scientific disciplines (Figs. 2 & 3). Survey responses were analysised via one of two main methods. The qualitative responses were coded using *NVivo 10* (QSR International Pty Ltd., 2012) with open coding to establish dominant themes. The quantitative survey data were summarised and presented as a frequency. For the purpose of analysis, scores of 2 and 3 were counted as 'agree,' and scores of 5 and 6 were counted as 'disagree'. A single-factor non-parametric analysis of variance (Kruskal-Wallis test) was conducted to test for significant differences in the questions with ranked order responses (Allan & Seaman, 2007). These questions related to the value of teamwork skills at university and the best way to integrate teamwork into the curriculum. The significance threshold was set at 0.05. These tests were followed by a post-hoc Dunn's test with a Bonferroni correction to contrast the different responses.

Responses were also compared among disciplines and academic roles (e.g. teaching associate, professor), using single-factor analysis of variance (ANOVA) in Excel (Version 15.16). The significance threshold was set at 0.05, wherein a P value of <0.05 shows a statistically significant result. As no significant difference among participants' scientific disciplines and academic roles was identified (F values ranging 0.058–0.280, and P values ranging 0.893–0.997), the survey results across scientific disciplines were subsequently aggregated.

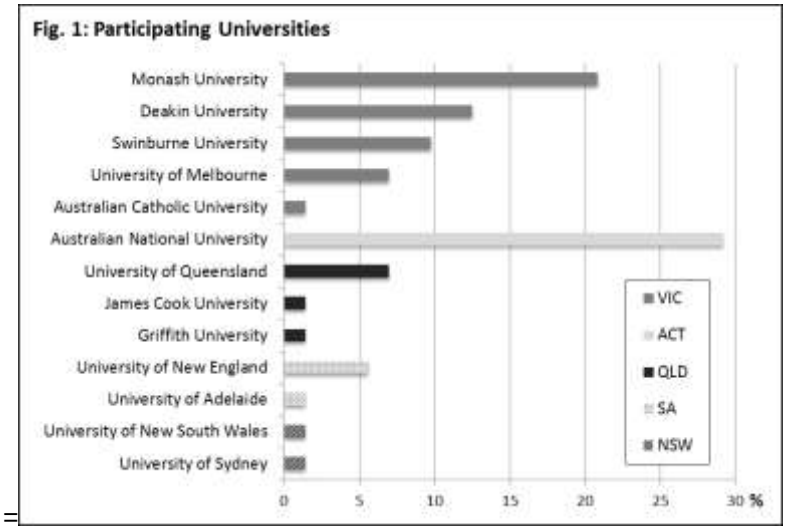

Figure 1: Summary of participating universities. Figure legend acronyms: VIC = Victoria; ACT = Australian Capital Territory; QLD = Queensland; SA – South Australia; NSW = New South Wales.

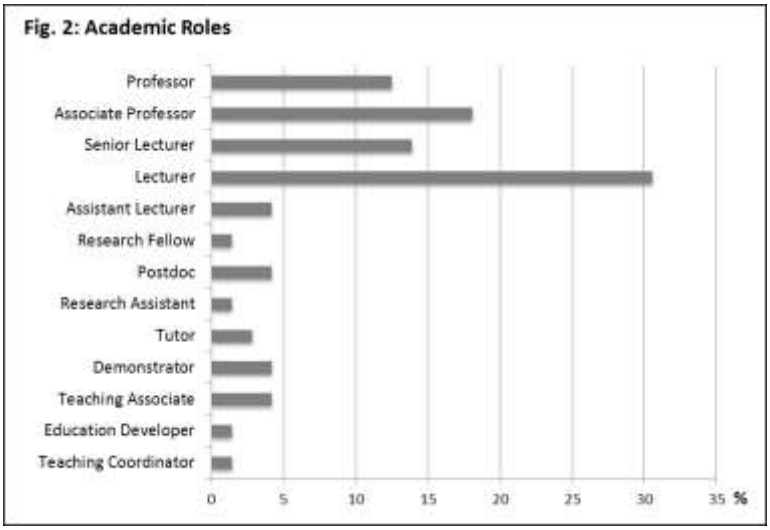

Figure 2: Distribution of roles held by survey respondents.

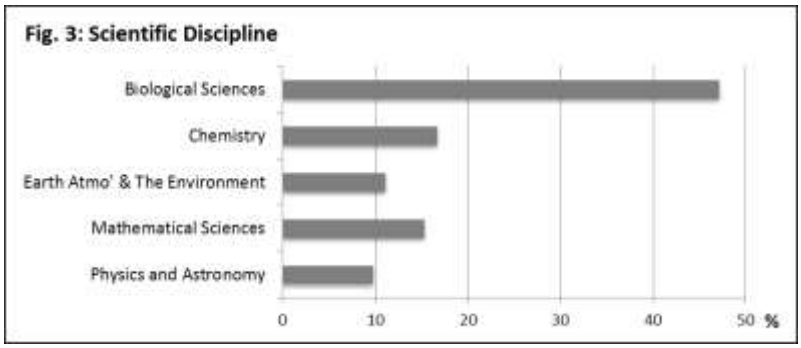

Figure 3: Respondent's science disciplines.

RESULTS

The academic perspective of teaching teamwork

The majority of respondents indicated a positive attitude about the value of teamwork for science graduates. A higher number of respondents agreed, or strongly agreed, that teamwork was an essential skills for both science and non-science careers (Table 1). In addition, respondents believed that universities have a responsibility to ensure science students are graduating with the teamwork skills needed for employment (Table 1). Markedly fewer respondents agreed, or strongly agreed, that students are currently graduating from university well equipped with teamwork skills (Table 1).

Table 1: Summary of responses about the value of teaching teamwork. 'SA' = Strongly agree, 'A' = Agree, 'N' = Neutral, 'D' = Disagree and 'SD' = Strongly disagree. *n = 70*

Survey Question	SA *n*/(%)	A *n*/(%)	N *n*/(%)	D *n*/(%)	SD *n*/(%)
Teamwork is an essential skill for science graduates in preparation for future research, or employment in SCIENCE based careers.	33/(47)	24/(34)	4/(6)	8(11)	1(1)
Teamwork is an essential skill for science graduates in preparation for future employment in NON-SCIENCE careers.	37/(53)	23/(33)	2/(3)	7/(10)	1(1)
University undergraduate science degrees should be ensuring students are graduating with the teamwork skills needed for employment.	31/(44)	27/(38)	3/(4)	6/(8)	3/(4)
In your experience, science students are graduating well equipped with the team skills needed for their future careers, in science or otherwise.	2/(3)	21/(30)	27/(38)	16/(23)	4/(6)

Reasons for including teamwork

Respondents were asked to rank the reasons why they believed teamwork was an important skill for students to learn from a range of attributes (1 = most important, 7 = least important). Following a Kruskal-Wallis test, it was found that the medians within each group of attributes varied significantly (P <0.05). Respondents valued teamwork for *'promoting the sharing of ideas and expertise'* more highly than all other reasons except *'helping to develop interpersonal communication skills'* and *'mimicking a real working environment'* (Dunn's test P values ranging from < 0.05 to < 0.0001). Respondents least-valued teamwork for *'distributing the workload,'* which was rated lower than *'promoting the sharing of ideas and expertise'*, *'developing interpersonal communication skills'* and *'promoting working towards a common goal'* (Dunn's test P < 0.0001; Fig. 4).

When respondents were asked in an open-ended question, "*Do you have any additional reasons why students should be learning teamwork skills at university?"* several dominant themes emerged (Fig. 5). These themes largely supported the ranked data. Again, the most frequently cited benefit of including teamwork activities was its importance for facilitating sharing of ideas and expertise (cited by 16% of respondents; Fig. 5). Responses included comments such as: *"Best way to learn is to teach. They work together, explain things to each other, understand the material better themselves.* And: *"Learning that each person has skills and knowledge that together can complement the rest... 'the whole is greater than the sum of its parts.'"*

Many respondents recalled the importance of teaching teamwork for the promotion of communication and creating authentic learning (cited by 13% of respondents for both themes; Fig. 5). A physics and astronomy respondent commented about the development of communication skills: *"It helps students understand that perspectives on the same matter can vary considerably. Ideally, they'd get a taste of conflict resolution."* In discussing the importance of developing teamwork skills in biological sciences, a respondent stated: *"It's a critical workplace skill. We should be teaching it for that reason alone."*

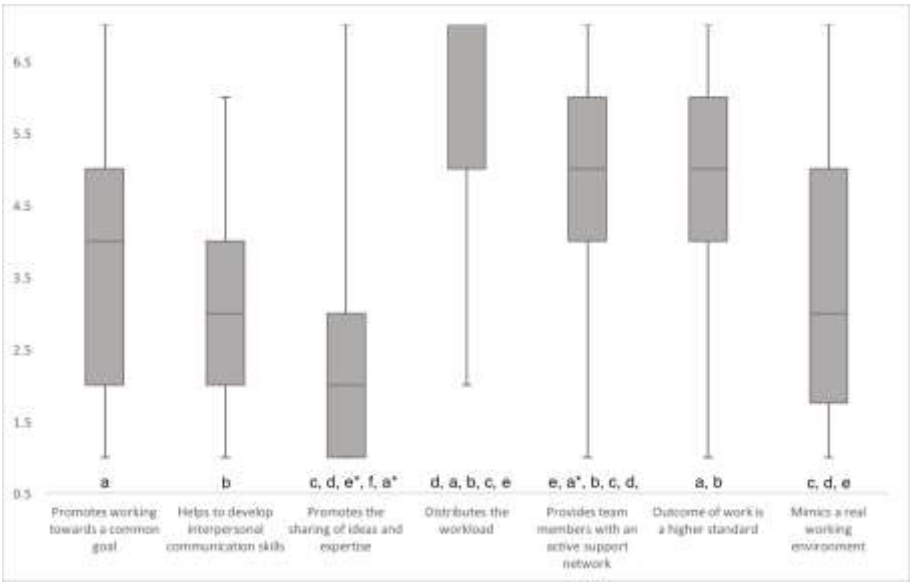

Figure 4: Box plot showing ranking of responses to the statement *'teamwork is an important skill for students to learn while they at university because:'.* The lines inside the boxes denote the medians. The boxes mark the interval between the 25th and 75th percentiles. The whiskers denote the interval between the 10th and 90th percentiles. Common letters show a statistical difference between median scores of the groups (*P* <0.001). When the letter is followed by *, the difference between medians is *P* <0.05.

Teamwork was also valued because it teaches students how to work collaboratively towards a common goal (7% of survey respondents). For example, one respondent from mathematics noted: *"It teaches them the value of working with people with diverse backgrounds and develops skills for collaboration."* Other themes that were represented included peer-to-peer learning (6%), the promotion of collegiality (6%), and exposure to working with a diverse range of people (6%; Fig. 5).

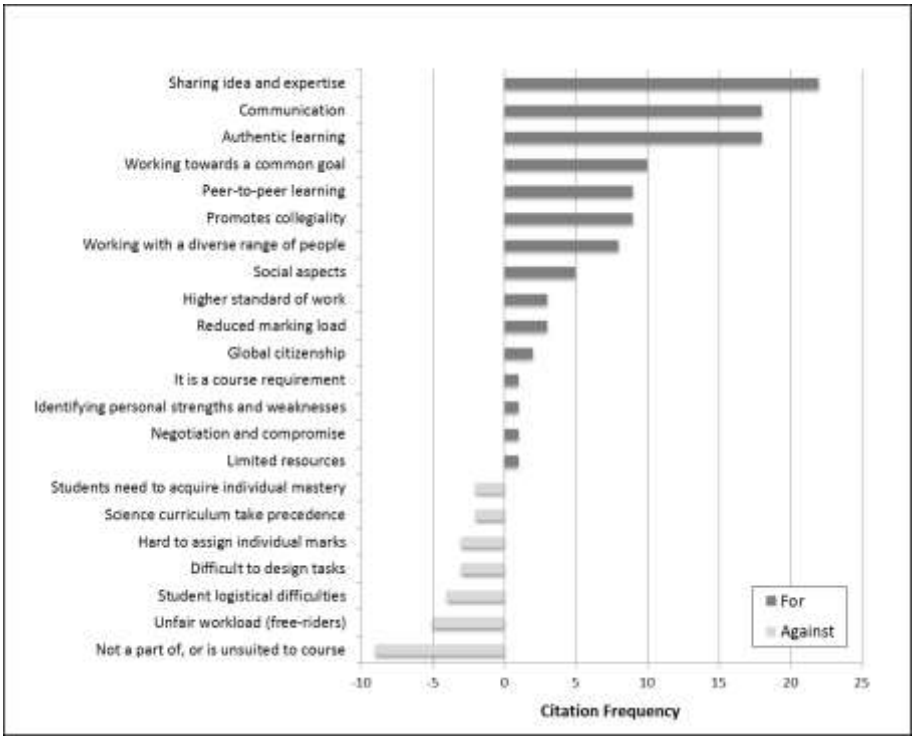

Figure 5. Citation frequency showing themes from coding of open-ended questions asking, '*please list any additional reasons why students should be learning teamwork skills'* and '*please explain why you do not assign group/teamwork tasks*'.

Reasons for not including teamwork
When asked in an open-ended question '*why they don't assign teamwork activities'*, a minority of respondents (*n* = 25) discussed their reasons for not teaching teamwork (Fig. 5). The most frequently cited reason was its unsuitability to the discipline in question (12%), followed by the notion of 'free-riders' (e.g. students not completing an fair amount of work), (4%), student logistical difficulties (3%) and the challenges associated with equitable marking (3%). Comments were included such as: *"Students always complain about students who don't contribute their share."* And: *"I don't use them for assessment, as it can lead to mismatches in effort and some students getting marks that don't reflect their work."*

And:

"It is a terrible teaching method, as many students fail to learn how to complete tasks themselves. It is an even worse assessment method. For poor students, it teaches laziness and encourages incompetence. For good students it has little benefit, since they would do most of the work themselves in any event."

Comments on various organisational difficulties, such as student logistics (3% of respondents), task design (2% of respondents) and assignments of individual marks (2% of respondents) were also received. Those included: *"I allow students to collaborate, but it's essential that they individually demonstrate mastery of the material, and this is not possible in group work."* And: *"Not all tasks are best suited to teamwork. Some lab based experiments that learn skills are best done individually."*

Teaching teamwork
Respondents were asked to provide insight into the ways teamwork was currently taught in their faculty. The majority selected *'Yes, as an integrated part of the science curriculum'* (49%), 12% selected *'Yes, but as a supplementary or external program'*, 15% selected *'No'* and 24% selected *'Don't know'* (*n* = 66).

When asked if teamwork activities were assigned in their units or courses, 74% responded that they assigned teamwork and 26% responded that they did not assign teamwork activities. When asked to select where teamwork activities took place in their units or course, 66% of respondents selected during workshops or laboratories, 58% selected assessments undertaken out of class, 52% selected during tutorial sessions and 50% selected during in-class sessions (lectures).

When asked to rank the following statement *'To include teamwork in the curriculum is important, and it is good practice to dedicate some curriculum time to this'*, 78% of respondents agreed or strongly agreed, 17% were neutral and 5% disagreed, or strongly disagreed.

Respondents were asked to rank '*The best way to integrate teamwork into the curriculum'*, from a range of options including curricular and extra-curricular approaches. A Kruskal-Wallis test showed that the medians of the responses varied significantly (*P* <0.001; Fig. 6). Respondents selected that *'teamwork 'should be developed through participation in teamwork activities (though not explicitly taught)'* more frequently than students should be *'taught teamwork through separate 'bolt-on' courses'*, or *'in extracurricular classes'* (*P* = 0.0001). *'Teaching teamwork as an integrated part of the curriculum'* was also a highly-valued approach, however this approach was only statically different from *'students learning teamwork as an extracurricular class'* (*P* = 0.0001). The lowest median scores for the best way to integrate teamwork were *'teamwork being taught as a separate 'bolt-on' part of the academic program'* and *'students learning teamwork within extracurricular classes'.*

An open-ended question prompted respondents to elaborate on their own teamwork teaching approaches. These comments varied from people actively teaching teamwork, such as:

"In our first-year Biology class, we actively teach the students about the nature and practice of teamwork using a recently released MOOC for one of their major assessment tasks. This is then followed with various opportunities in 2nd and 3rd level classes."

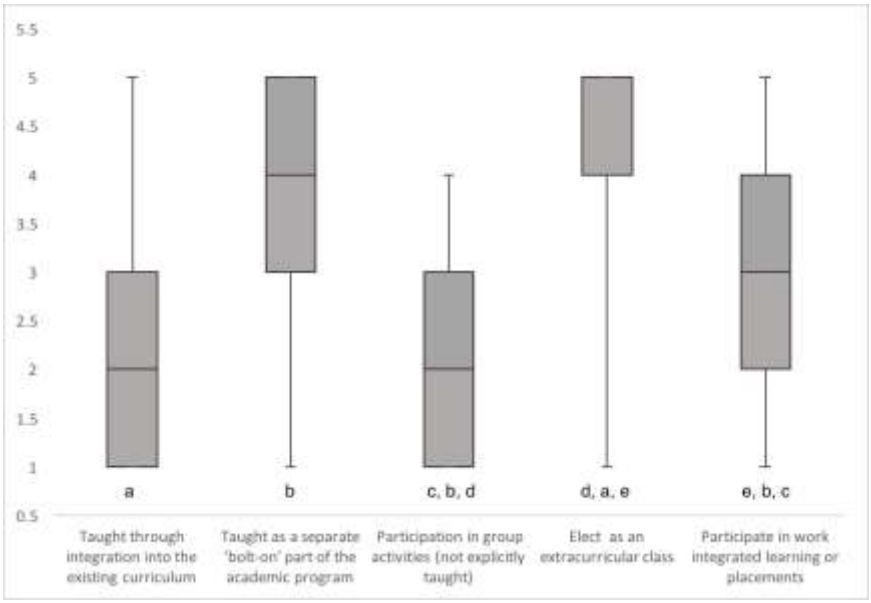

Figure 6: Box plot showing ranking of responses to the statement *'The best way to integrate teamwork into the curriculum is:'.* The lines inside the boxes denote the medians. The boxes mark the interval between the 25th and 75th percentiles. Common letters show a statistical difference between median scores of the groups (*P* <0.001).

Through to those academics simply assigning teamwork activities: *"While often expected to work in teams, students are not taught how to do this, they are simply put in teams and expected to get on with their task."*

A few respondents commented about why they did not explicitly teach teamwork, such as:

"Our focus is on teaching the technical skills and concepts, not the soft skills that accompany them. While acknowledging that these are valuable to develop, I'm skeptical of a pedagogy of teamwork." And: *"I do not teach sociology! I let teamwork skills develop naturally, as in the past 5000 years of human culture."*

And:

"Not really. There are certainly team-based activities, most notably in laboratories, and in a learn-by-doing sense students should be learning some teamwork skills. However, it would be a stretch to say we are "actively" teaching students how to work in teams."

When asked to rank whether they believed *'their current approaches for teaching teamwork sufficiently prepared students for employment'*, 48% of the respondents agreed or strongly agreed, 27% were neutral and 25% respondents indicated they disagreed, or strongly disagreed, that they were adequately preparing graduates with teamwork skills (*n = 59)*.

Respondents were asked '*would you be happy to alter your current methodology to include a greater focus on the development of team skills'*. Slightly more than half (57%) indicating they were positive, or strongly positive, about their willingness to alter their current approaches.

Respondents were asked to suggest ways to integrate teamwork skills into a science curriculum to enhance employability. These included suggestions ranging from taking a course-wide approach, through to greater resourcing (Table 2).

Table 2: Selected responses on ways to integrate teamwork skills into a science curriculum.

Approach	Suggestions: ***'Based upon your own experience, in what ways could the university better integrate teamwork into the curriculum with a view for preparing graduates for employment'?***
Pedagogical approach	*"Providing students with a way to assess their skills so that they could approach a group knowing what skills they are most suitable for."* – A/Prof., Earth, Atmosphere and Environment
	"I think teamwork activities are reasonably embedded into the current curriculum, most notably in the laboratory program. I think what is lacking is explicit teaching of teamwork skills and associated metacognitive skills like reflection." – Senior Lecturer, Physics and Astronomy
Course-wide approach	*"Develop plans for assessment across programs rather than in individual courses. This can be applied to other generic skills, as well as teamwork."* – A/Prof., Biological Sciences
	"A good start would be to measure the outcomes - what specifically are the team-work skills of incoming and outgoing students, and what specifically are the missing skills in our graduates. Then lots of experimentation to find out what approaches work best to remedy these. Teamwork skills are diverse, and some are surely not teachable - simply having more team exercises may make no difference." – A/Prof., Physics and Astronomy
Academic development	*"Getting academics to have improving student outcomes as their first priority would be a good first step. Most academics seem to teach under sufferance and then only as a means to get the best students to do graduate work in their lab. They are disinterested in the vast majority of students who will not ultimately become research scientists"* – Lecturer, Biological Sciences
	"Start by training the academics--particularly in terms of emotional intelligence, which I often find lacking amongst the higher-ups in research. Many of us think we're good at teamwork but are actually fairly ineffective at ensuring our teams achieve their highest potential." – ARC Fellow, Physics and Astronomy
Transferable skills	*"I think that in general degrees it is extremely difficult to prepare students with specific skills for specific employment since their destinations are so varied. I think what is important is to identify the core principles for team work and ensure students learn those in a way that enables them to transfer that learning to new contexts, such as in the workplace. Much of the design of undergraduate classes primarily focusses on learning the discipline - student learning needs to take priority over specific workplace skills, but should at the same time equip students with important principles and practices which they can then transfer to new contexts."* – Lecturer, Biological Sciences
Contextualisation	*"We could probably do better at explaining/promoting the 'philosophy of teamwork'. Top notch scientific developments are almost always now the result of significant team work."* Prof., Chemistry
Beyond undergraduate curriculum	*"A higher objective should be to improve the general standard of graduates. Teamwork, either official or de facto, is an essential requirement at Honours level doing research in technical faculties and can/should be left till then*." – Prof., Chemistry
Work integrated learning	*"While moves are occurring, I think we need a greater emphasis on students being embedded within prospective employers and greater emphasis on bringing students together from different faculties."* – A/Prof., Earth, Atmosphere and Environment
Teaching spaces Assessment	*"Better teaching spaces"* – Lecturer, Mathematical Sciences *"Improving the culture of the way students approach assessment*." – Lecturer, Mathematical Sciences
	"The current ways in which teamwork skills are assessed are somewhat naïve and don't consider the human elements of the students' behaviour. For example, if grades are important, then teamwork will be sacrificed and the project/task will be undertaken in a way which is not conducive to team work but will achieve a higher mark. How one goes about fairly assessing group assignments is difficult." – Tutor, Physics and Astronomy
Resources	*"Make available more resources for people trying to develop this component into existing units."* – Senior Lecturer, Physics and Astronomy

DISCUSSION

This study shows that many academics value the importance of teamwork skills for science undergraduates. Yet, fewer believe that science graduates are equipped with the teamwork skills needed for future employment. These results are consistent with prior studies demonstrating that both science graduates and their employers believe teamwork skills need greater development (Prinsley & Baranyai, 2015; Sarkar et al., 2016). To ensure science students have adequate team skills upon graduation, it is important to look more closely at the science curriculum, assessment and pedagogical approaches.

Teamwork skills were valued because of the importance of sharing ideas and expertise between students, the development of communication skills and the authentic learning environment teamwork activities created. These views echo the reasons why teamwork is highly valued in other disciplines (Lerner et al., 2009, Lingard, 2010) and within the workplace (Dunne & Rawlins, 2000; Prinsley & Baranyai, 2015). This suggests that the majority of science academics clearly have a strong understanding of the benefits of teamwork, the skills that are acquired through teamwork and it's importance in the workplace.

A small number of respondents strongly believed that teaching teamwork was not appropriate for their science discipline. The most common reasons for this view was that teamwork skills were not appropriate for the discipline and because of the difficulty of managing 'free riders' in groups. 'Free-riders' are those students who contribute very little, or lower amounts of work, than the rest of the team. In the eyes of some researchers, there is a notion that teaching 'soft-skills', such as teamwork, may undermine the purity and orthodoxy of academia. For example, Zakaria & Iksan, (2007) finds opposition to the idea of explicitly teaching team skills on the grounds that this inclusion will require significant extra preparation. Whereas, Bellanca & Brandt, (2010) noted in their study a concern that teaching teamwork comes at the expense of important subject content. Furthermore, Johnson et al., (2012) identified that some science academics have a strong opinion that teamwork is a skill that should be acquired through practice rather than explicitly teaching it in the science undergraduate curriculum. They found that academics thought that resilient teams naturally evolve through prolonged exposure to the authentic research laboratory (Johnson, et al., 2012).

Most respondents were already teaching teamwork skills as an integrated part of the science curriculum (49%). Integrating teamwork into the curriculum is ideal as it provides students the opportunity to develop these skills within the context of their discipline. Experiential learning, where the student is immersed in an activity that simulates the real world, helps students acquire the knowledge, skills and attitudes in a powerful learning environment (Banerjee, Slagle, Mercaldo, Booker, Miller, France, Rawn & Weinger 2016). Even if experiential learning is not possible, a curriculum-integrated approach will provide opportunities for immediate application and reinforcement of the skills. It is important to note, that this integration of soft skills does not need to come at the expense of discipline content, as both can be taught simultaneously. A greater number of academics explicitly teaching teamwork may also support students, by not only better fostering valuable skills, but also ensuring a more positive experience. This is because many studies indicate one of the biggest factors impacting a positive teamwork experience for students is the scheduling of time to work together due to study timetables and work commitments (Burdett, 2003; Garcia-Bayonas & Gottschall, 2008).

When asked what the best way was to develop teamwork skills, respondent's equally valued approaches where teamwork was explicitly taught, as well as when it was solely acquired through undertaking teamwork activities without guidance (Fig. 6). These two approaches may achieve significantly different outcomes for students. Without receiving instruction about how to effectively approach teamwork processes, students are often found lacking in the very skills needed to negotiate teamwork challenges (Huxham & Land, 2000). Despite the reported benefits of working in a team, this lack of skills development may be a significant contributor to why teamwork and group tasks are not always viewed positively by students (Burdett, 2003). Previous research shows that to work together effectively, members of a team need to know what each other are doing, possess knowledge of both their own and their teammates responsibilities, communicate ideas and results, and understand the strengths and limitations of individuals in the team (Baker et al., 2006; Herrmann, 2013). Working in a team at university is often a lesson in professionalism and poses many of the challenges that students

will face during work with regards to collaboration and interpersonal relationships (Tarricone & Luca, 2002).

Without guidance, there is no guarantee that the teamwork experience will be one that will be accompanied by positive learning outcomes. Commonly students assign themselves individual subtasks within the group, and then they go away and approach each element as a separate endeavour, not interacting again until completion and thus eliminating the requirement to develop many of the other fundamental teamwork skills (Felder and Brent (2007). This 'jigsaw' approach also can result in significant knowledge gaps for each individual team member with each student only learning about their area of specialization (Pfaff & Huddleston, 2003). This approach can pose a substantial issue with regards to developing an understanding of the entire project and means that students to not gain the secondary skills of communication, negotiation and peer learning related to teamwork. In most cases, students may learn teamwork skills through exposure to tasks that require group cohesion. Johnson, Johnson and Smith (1998) suggest that operating successfully as a team is not always fundamentally obvious to students, and often it is through trial and error that they learn these skills. To ensure development of these skills, a teamwork activity should ideally instruct the students on both the product required from the assignment, and the process that the students can follow to get there. To accomplish this, greater application of explicitly teaching teamwork skills in the science curriculum is needed.

Limitations

This study investigates the academic perspective of *teaching* teamwork. Whilst the questions specifically probed about practices related to *teaching* teamwork, some academics may have interpreted these questions as the practice of assigning students into groups for assignments without explicitly teaching teamwork skills. Should this misinterpretation have been made, this may have inflated some results. For example, 48% of respondents thought that their current approach to *teaching* teamwork was sufficient. However, some of these respondents may be basing their responses on just allocating teamwork assignments rather than *teaching* teamwork.

CONCLUSION

Developing teamwork skills for undergraduate science students is clearly not new. However, based upon reports from employers and the students themselves, teamwork skills of science undergraduate students need strengthening. This study shows strong academic support for teamwork as an important graduate outcome for science students and a broad willingness for a greater introduction of approaches where teamwork is taught in the science undergraduate curriculum. However, many academics indicate they are not confident that their institutes, or their current approaches, sufficiently support teamwork skills in graduates. These insights suggest a greater need for Science Faculties to encourage stronger practices for teaching teamwork skills with their educational staff.

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