Written Reflection Influences Science Students' Perceptions of Their Own and Their Peers' Teamwork and Related Employability Skills

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Abstract

The impact of written reflection on tertiary students' self-efficacy, and corresponding evaluation of their peers' abilities, is often imprecise and lacking in clarity. This study thus sought to assess the effects of a written reflective diary on science undergraduates' teamwork-related and other employability skills. Employability skills, in particular students' teamwork-related skills, are crucial to students' career development and progression. Assessment was carried out using a series of pre- and post-reflection online surveys, the TeamQ assessment rubric, and student focus groups. Participants identified five key teamwork skills, the importance of which remained constant over time. Written reflection had a significant, positive effect on students' self-efficacy of their oral communication skills. Students' written reflections were also important in shaping their perceptions about the domain of fostering a team climate, both in terms of their own self-efficacy and perceptions of their peers' abilities. This study has interesting implications for future research into science students' teamwork and other employability skills.

Introduction

The value of students' reflective practice is evidenced by a lengthy and burgeoning body of literature, especially in regard to impact of reflection on their learning and achievement (Richardson & Maltby, 1995; Sterling et al., 2016). Across a range of courses, disciplines and institution types, reflection can ameliorate students' misconceptions (Sabel, Dauer, & Forbes, 2017), facilitate and improve social (McGuire, Lay, & Peters, 2009) and generic skills (Fritson et al., 2013), and enhance a range of teamwork abilities (Hoo, 2018; Kemery & Stickney, 2014; Mayne, 2012). Given the value that employers place on graduates' teamwork skills (Rayner & Papakonstantinou, 2015), the embedding of reflection into student team-based projects may become a core element of curriculum development and renewal. There is also increasing evidence of the potential synergies between reflection and self-efficacy, which Bandura (1997) defines as a self-belief in one's ability to manage and undertake actions that generate a certain result. For example, reflection combined with goal-setting enables students to more accurately monitor and assess their progress on certain tasks and self-efficacy of skills related to such tasks (van Dinther, Dochy, & Segers, 2011). Similarly, Loo and Thorpe (2002) found that the use of learning journals improved individual and team performance, and Mayne (2012) reported that students' retrospective evaluation of reflective diaries allowed them to

deconstruct their experience of teamwork and develop insights of teamwork-related skills. While the value of student reflections about their practice and development of employability skills has been reported (Pozzi & Bonson, 2019), there is a lack of broader scholarship regarding the potential value of reflection on students' refinement of their employability skills.

In relation to this, the importance of graduates' employability and enterprise skills has been reinforced considerably over the past two decades (Suleman, 2018), and as a consequence of a range of interacting factors. These include considerably greater competition for graduate jobs (Mavromaras et al., 2013), the changing nature of work (Djankov & Soliala, 2018), and technological innovation (Datta, 2018). Overtoom (2000) defined employability skills as "transferable core skill groups that represent essential functional and enabling knowledge, skills, and attitudes required by the 21st century workplace" (p.1). In distilling the broad range of graduate skills, key employability competencies include problem solving, teamwork and interpersonal skills, communication, creativity, leadership skills, self-management, adaptability (Osmani et al., 2015), decision-making (Suarta, Suwintana, & Sudhana, 2017), and self-efficacy (Cake et al., 2016; Little & ESECT Colleagues, 2006).

Employability skills have been increasingly researched over the past two decades, in response to a range of potential factors, including massification of university education (Mok & Neubauer, 2016), and increasing vocal calls from employers for more finely tuned graduates' competencies (Rayner & Papakonstantinou, 2015; Sarkar, Overton, Thompson, & Rayner, 2019). Students' perceptions of the value of employability skills to their career, together with their self-efficacy of such skills, have the potential to inform their career choices and competitiveness in rapidly-changing work environments. In addition to course-related skills development, co- and extra-curricular activities (Green, Carbone, & Rayner, 2019) can enhance students' development of employability skills, and more accurately inform and shape their awareness of such skills (Galloway, 2017). Ho, Wong, Tham, and Brookes (2016) found that science students preferred transferable skills that broadened their potential employment options, flexibility and competitiveness in rapidly shifting industries. However, the connection between the perceived value of such skills and students' self-efficacy of them appears to be poorly explored in the scholarly literature.

Of the range of employability skills, employers place considerable importance on science graduates' teamwork skills (Gibert, Tozer, & Westoby, 2017), but have long perceived such skills to be lacking in graduates (Curtis & McKenzie, 2001; Sheldon & Thornthwaite, 2005). The importance of teamwork skills cannot be understated, given the potential value of effective cooperation through use of interpersonal skills (Osmani et al., 2015). By working in teams, students build social, interpersonal and managerial skills that can influence their professional success (Mendo-Lázaro et al., 2018). While science students recognise the importance of teamwork skills in their future employment, they consider such skills to be poorly inculcated over their degree (Wilson, Ho, & Brookes, 2018). Quantitative assessment of teamwork skills is difficult due to the nature of teamwork processes (Hughes & Jones, 2011) or products (Riebe, Roepen, Santarelli, & Marchioro, 2010). In an effort to redress this limitation, several teamwork assessment tools have been developed, including TeamQ (Britton, Simper, Leger, & Stephenson, 2017), an adaptation of the TeamUP rubric (Parratt et al., 2014). The TeamQ rubric, designed for self- and peer-assessment, has high inter-rater reliability and aligns with other teamwork indices (Britton et al., 2017). Five teamwork domains (Hastie, Fahy & Parratt, 2014) underpin TeamQ: (i) contribution, (ii) contribution facilitation, (iii) planning and management, (iv) fostering a team climate and (v) conflict management (Appendix 2, in Supplementary Material).

On the basis of the concepts discussed above, we propose that students' reflection on engaging in a team-based project may have several potential effects, including a reshaping of their perspectives of team-related skills, and whether students' self-efficacy of team-related skills influences their employability skills. Given this, together with previously identified gaps and opportunities for research regarding the various interactions among self-reflection and teamwork in an employability context, the following research questions were framed:

1. Does student engagement in a team-based project affect their pre-existing perceptions of teamwork-related skills?
2. Does a written reflective exercise affect students' awareness of their teamwork-related skills, and that of their peers (fellow team members)?
3. Do teamwork-related skills increase students' self-efficacy regarding certain aspects of teamwork, teamwork domains, and/or other employability skills?

Methods

Study setting, student cohorts and the reflective exercise

Study participants were undergraduates enrolled in the unit 'Scientific Practice and Communication (SCI2010)' at Monash University Clayton campus, over a 12-week semester from August to October, 2019. Participants (n=720) were randomly allocated to teams comprising 4-5 students, on projects related to recent, popular scientific topics. Each project was assessed as an oral presentation in week 5. Prior to their presentation, participants discussed the assignment format and task allocation, including presentation format and assignment of team member roles.

In week 1, participants were arbitrarily split into two groups: an 'active' and control (Fig. 1). Students in the active cohort (n=368) undertook a reflective exercise (weeks 2-4), which aimed at improving their teamwork ability, while those in the control cohort (n=352) did not. The reflective exercise was implemented in specific tutorial groups, comprising ~20 participants. The active students completed a weekly diary about their own actions, and their interactions with their group members. In this diary, students noted how they and their fellow team members performed regarding key teamwork skills, as well as listing any advances or setbacks they encountered each week. Each participant's reflective diary was reviewed by their tutor each week, with feedback about how to improve their oral presentation.

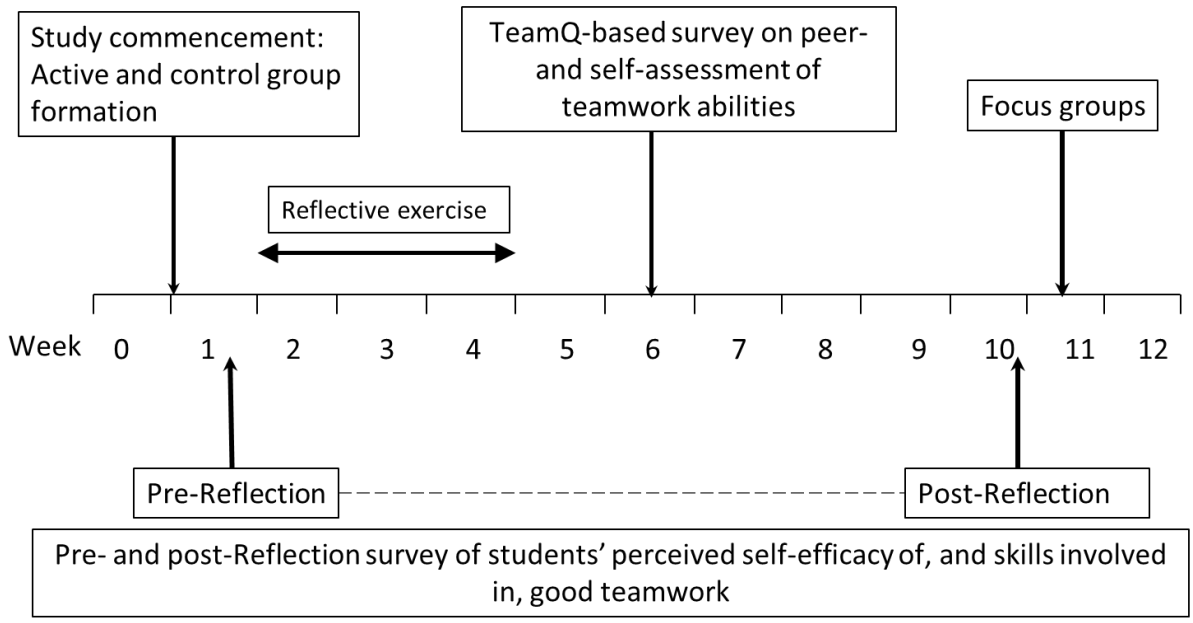

Figure 1. Project timeline illustrating the components and sequencing of the study

Pre- and post-reflective exercise surveys of student perceptions of teamwork skills
During weeks 1 and 10 (Fig. 1), participants were asked to select skills involved in good teamwork, choosing from a list of eleven options (per Sarkar, Overton, Thompson, & Rayner, 2016) via an online Qualtrics survey. These skills were: 1) Adaptability & flexibility, 2) Independence & initiative, 3) Commercial awareness, 4) Creativity, 5) Written communication, 6) Oral communication, 7) Management & organisation, 8) Thinking & problem-solving, 9) Numeracy, 10) Computer/technology skills, and 11) Individual responsibility & accountability. The post-reflective exercise survey was conducted in week 10 to avoid conflict with the TeamQ survey (see below) and other unit coursework components.

Teamwork self-efficacy
Study participants were asked to estimate their self-efficacy of six teamwork-related skills via the same online survey tool, using a three level Likert scale (1=novice, 2=intermediate, 3=expert). These were: 1) Adaptability, 2) Independence & initiative, 3) Written communication, 4) Oral communication, 5) Organisation & time management, and 6) Thinking & problem-solving. Only a small proportion (~5%) of students chose to take part in both surveys, before (n_{total}=85; n_{active}=42, $n_{control}$=43) and after (n_{total}=51; n_{active}=13, $n_{control}$=38) the reflective exercise.

Online survey participant details were per Appendix 1a (Supplementary Material). In the active and control cohorts for both survey time points, there was no significant difference in the relative proportions of males compared to females according to chi-squared analysis, which tests the degree of normality of these proportions (Moore, 1982). The majority of survey participants (>85%) were between 17-21 years old, and in the second year of their degree/s, for the active and control cohorts in both surveys (Appendix 1a, Supplementary Material).

TeamQ teamwork assessment
Students' perceptions of their own teamwork abilities and that of fellow team members were surveyed in week 6 using TeamQ (Fig. 1), based on a five-point Likert scale (1=Never, 2=Sometimes, 3=Usually, 4=Regularly, 5=Always agree) for self assessment (SA) and peer

assessment (PA) questions (Appendix 2, Supplementary Material). The weighted mean Likert rating of each teamwork attribute was calculated for active and control cohorts, for each of the SA ($n_{\text{active SA}}$=663, $n_{\text{control SA}}$=312) and PA surveys ($n_{\text{active PA}}$=676, $n_{\text{control PA}}$=728). A weighted mean approach was used to reduce error variability of data and generate values for comparison (Tan, 1998).

Student responses were collected after the end of each SCI2010 workshop during week 6. Approximately 50% of survey participants took part in both the SA (n_{total}=75; n_{active}=51, n_{control}=24) and PA (n_{total}=108; n_{active}=52, n_{control}=56) surveys. Chi-squared analyses showed no significant difference in the expected proportions of males and females comparing (i) the SA active and SA control cohorts, and (ii) the PA active and PA control cohorts (Appendix 1b, Supplementary Material). For both the SA and PA groups, the majority of survey participants were within the 17-21 year age bracket, and in the second year of their science degree/s (Appendix 1b, Supplementary Material).

Focus groups

In week 11, students (n=25) voluntarily attended focus groups (Fig. 1), so as to obtain qualitative insights on the reflective exercise, and students' perception of teamwork (and other employability skills) for their future study and career ambitions. Session recordings were transcribed and thematically coded to identify major themes and their frequencies using a grounded theory approach (Creswell & Poth, 2017). This approach provided explanations about the value of reflection in shaping students' conceptions of employability skills. To better identify the main themes and subthemes, students' responses below a threshold of three codable themes or subthemes, were judged to be outliers (per Appendix 3, Supplementary Material).

Data analyses

Analyses of differences between means were carried out using unpaired Student's *t*-test (Gossett, 1908). All analyses were carried out in *MS Excel*™, using $p < 0.05$ as the threshold of significance for all comparisons. Tests of association among categorical variables were conducted using chi-squared analysis incorporating Yates' correction, which is more conservative and less likely to generate a type 1 error (Preacher, 2001). Focus group qualitative data was coded using two independent coders assessing the audio transcript. Codings were combined, and any discrepancies resolved using Appendix 2 (Supplementary Material) and the approaches described by Creswell and Poth (2017).

Ethics

All activities and surveys were conducted in accordance with Monash University Human Research Ethics guidelines (MUHREC approval no. 21007), which covered all researchers.

Results

Student perceptions of key teamwork skills

At both the start and the end points of the study, students identified five out of the eleven possible skills that they perceived as important for good teamwork. These were: 1) oral communication, 2) thinking and problem-solving, 3) adaptability & flexibility, 4) management & organisation, and 5) individual responsibility & accountability. There were no significant changes over time, as the frequency of these five skills ranged between 15% and 25% for the active and control groups, both before and after the reflective exercise. There were no significant differences among any of these frequencies, both before and after the reflective exercise, based on chi-squared analyses.

Teamwork self-efficacy

Of the six teamwork skills, only active students' self-efficacy of their oral communication increased significantly between the pre- to post-reflection phases of the study (Fig. 2a). For the control cohort, students' self-efficacy did not change significantly for any of these skills over the course of the study (Fig. 2b).

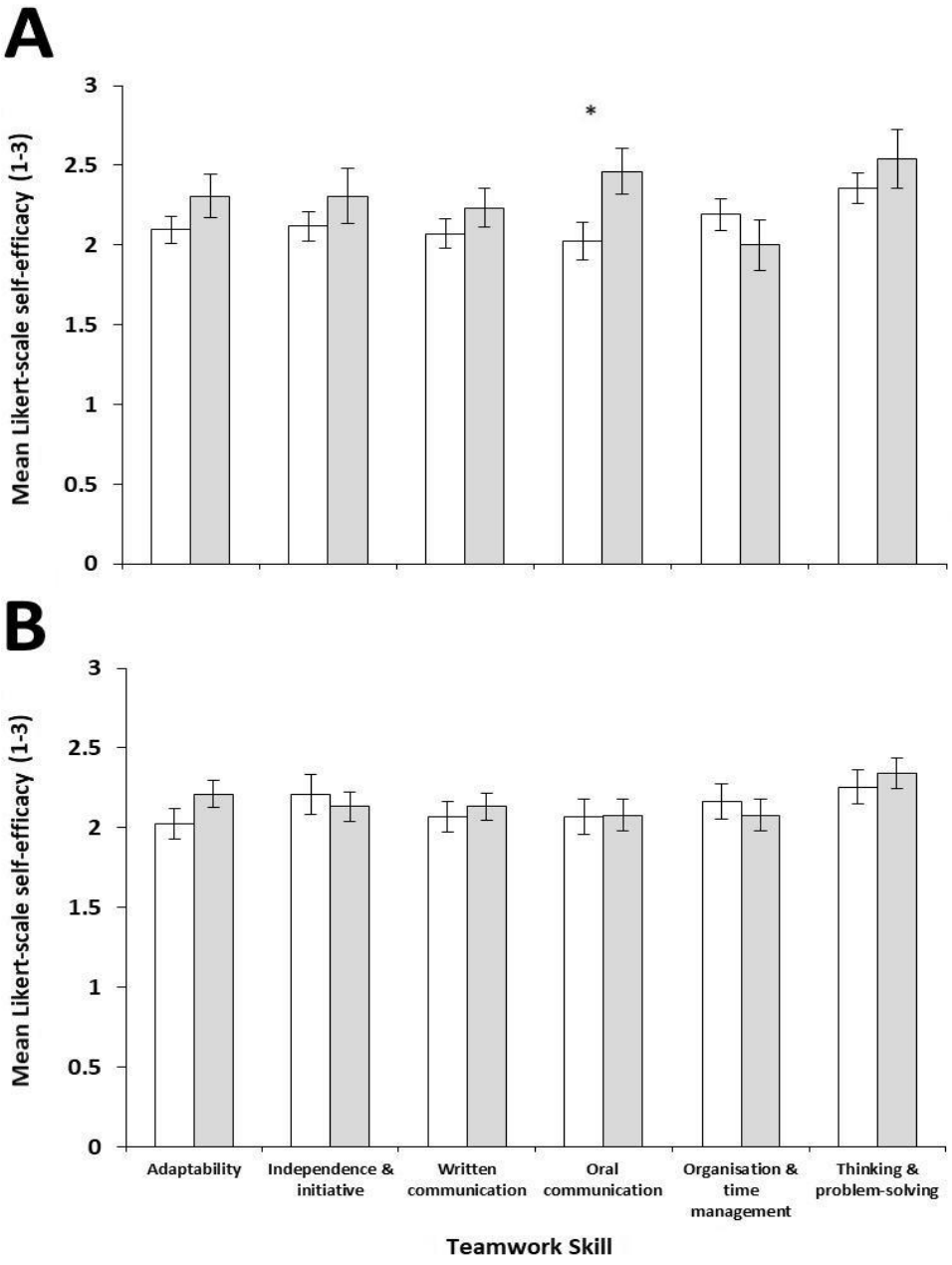

Figure 2. Student self-efficacy of various teamwork skills for (A) active and (B) control cohorts. White and grey columns denote pre- and post-reflection respectively (means +/- SEM). * denotes $p<0.05$.

TeamQ teamwork assessment

There was no significant difference in weighted means between active and control students' perceptions of their self-efficacy, for the combined aspects of their teamwork skills (Fig. 3). However, the mean weighted score for active students' evaluation of their peers' abilities was significantly higher than that of control students (Fig. 3). The weighted mean of active students'

self-efficacy was significantly lower (T=5.01, p<0.0001) than the weighted mean of the abilities of their peers (compare two white columns in Fig. 3). This result was consistent for control students (compare two grey columns, Fig 3; T=1.41, p=0.002).

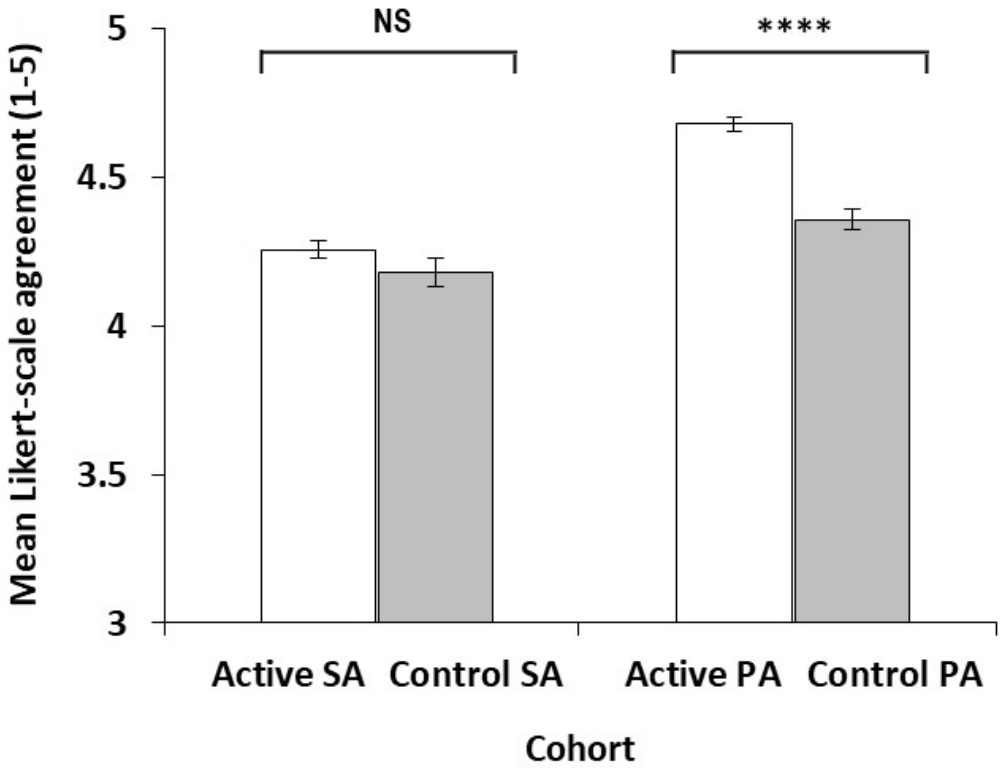

Figure 3. Comparison of Active and Control students' self-assessment (SA) and peer-assessment (PA) of their teamwork self-efficacy. Cohorts are as indicated (all values are means +/- SEM). **** denotes p<0.0001; NS denotes no significant difference between means.

TeamQ individual teamwork domains

Self assessment (SA) cohort

When assessing their own abilities, active students rated a greater self-efficacy compared to control students for two of the 13 teamwork aspects: (i) ensuring consistency between words, tone, facial expression and body language (Cons), and (ii) expressing positivity and optimism about team members and the project (Pos). Both aspects belonged to the teamwork domain of fostering a team climate (Fig. 4a).

Peer assessment (PA) cohort

In contrast to self assessment, for students' perceptions of their peers' teamwork abilities, there were significant differences between the active and control cohorts for almost all of the teamwork aspects (ten out of thirteen total; Fig. 4b) and all five teamwork domains. There were no significant differences between the active and control cohorts' ratings of their peers' contributions to participation and workload balance (Part-share), reporting to other team members on individual project progress (Rep), and provision of timely constructive feedback between group members (TCF).

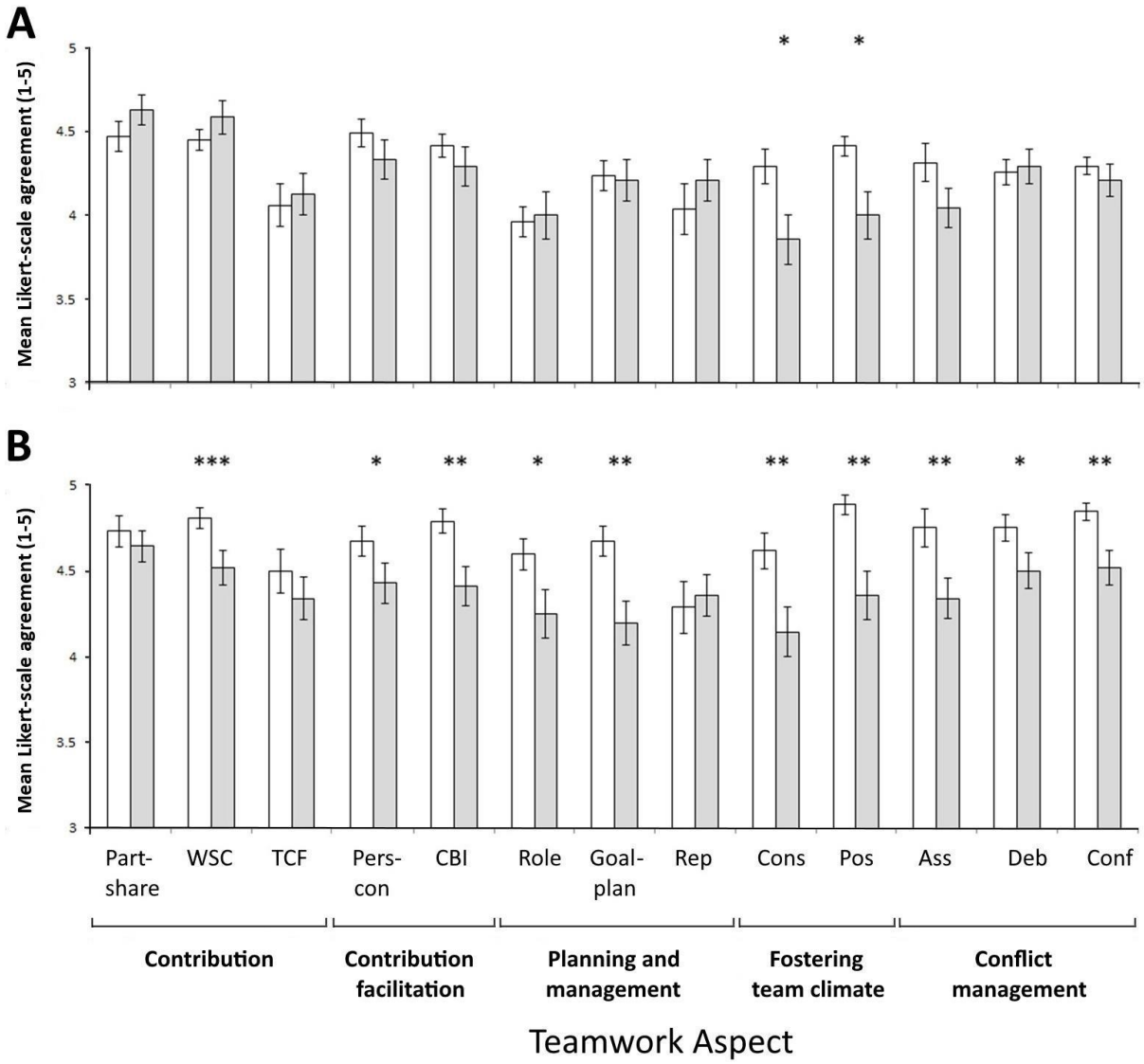

Figure 4. Students' self-assessment (A) and peer-assessment (B) of teamwork aspects.

White and grey columns denote active and control students respectively. Part-share: Participate actively, accept a share of group work; WSC: Work skilfully and complete assigned tasks on time; TCF: Give timely, constructive feedback to team members; Pers-con: Encourage all perspectives to be considered and acknowledge contributions of others; CBI: Constructively build on the contributions of others, integrate your own work and the work of others; Role: Take on an appropriate role in the group; Goal-plan: Clarify goals, plan the project; Rep: Report to the team on your progress; Cons: Ensure consistency between words, tone, facial expression and body language; Pos: Express positivity and optimism about team members and project; Ass: Display appropriate assertiveness: Deb: Contribute appropriately to healthy debate; Conf: Respond to and manage direct/indirect conflict constructively and effectively. Domains for aspects are as indicated; * denotes $p<0.05$, ** $p<0.01$, and *** $p<0.001$

Focus groups

An aggregate of 83 comments were obtained from the focus groups. Teamwork skills (SK-TW) was the highest cited theme, with communication skills (SK-COMM) ranked as second-most important (Fig 5). Other themes and subthemes identified during the interviews were: commercial awareness (SK-COMAWARE) and independent learning (SK-IND) skills, the

benefits of the reflection task (BEN-Aware), any associated negative aspects (NEG), suggestions for improvement (IMPR-WIL), and other assorted issues (OTHER-Misc) (Fig 5).

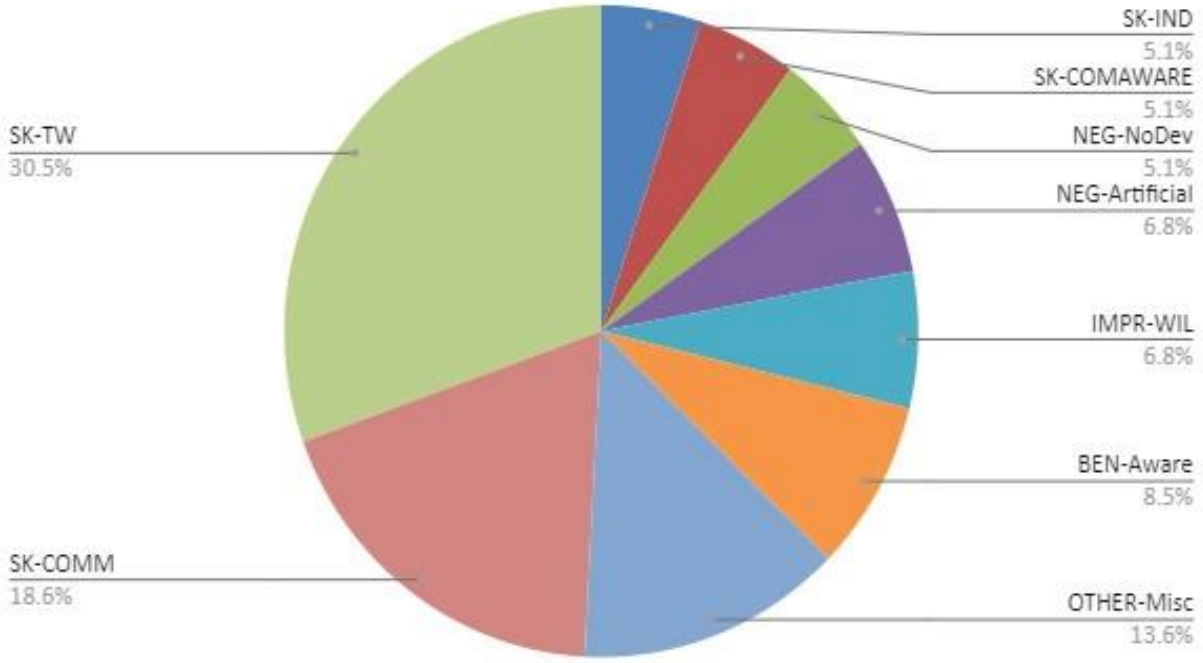

Figure 5. Skills and other issues perceived to be important in focus groups.

Themes and subthemes are as follows: SK-TW: Teamwork, SK-COMM: Communication, science communication; SK-IND: Independent learning, independence; SK-COMAWARE: Commercial awareness, industry awareness; NEG-Artificial: Felt forced, artificial, pointless, 'tell them what they want to hear', make up something; NEG-NoDev: Skills aren't being significantly improved or developed, we already have them; IMPR-WIL: Improvements in work-integrated learning; BEN-Aware: Increased awareness, acknowledgement, thinking about skills developed; OTHER-Misc: Miscellaneous.

Discussion

Student perceptions of key teamwork skills

Our study participants' identification of five key teamwork skills is consistent with previous research. For example, in a nursing context, Xyrichis and Ream (2008) identified evaluating and planning for patient care (thinking and problem-solving), open communication (oral communication), and decision-making (management & organisation) as vital teamwork components. Levin (2004) also identified the importance of communication, negotiation, mediation, managerial awareness, and a readiness to take responsibility for enhancing teamwork. Our results support the apparent commonality of certain teamwork skills across a range of disciplines (Salas, Reyes, & McDaniel, 2018). Students' identification of 'leadership' and 'communication' from the focus groups reinforce such research. Students' identification of adaptability as a key element of effective teamwork is consistent with research of its importance, in particular from the employer perspective (Stokes, 2013).

Teamwork self-efficacy

The significant increase in active students' self-efficacy of their oral communication skill, out of the six assessed teamwork skills, may have been due to their engagement in the reflective exercise. Potential artefacts include the composition of the pre- and post-reflective exercise surveys, and the possible confounding effect of tutor feedback. However, the latter can be largely discounted given that tutor feedback was general in nature and related to organisation of team-based roles, choice of presentation format and time management. Our finding is consistent with Sterling et al. (2016), who reported that self-reflection bolstered STEM students' oral communication skills. Given employers regard graduates' oral communication skills to be a high-value employability skill (Sarkar et al., 2016), our finding reinforces the value of providing opportunities for written reflection to enhance this skill. Since our study did not investigate differences between students' self-efficacy and their actual efficacy in oral communication, this is an area for further study (e.g. Rayner & Papakonstantinou, 2018), as is research into the possible effects of scaffolding and iteration of self-reflection on such skills. This would likely reduce any potential gap between self-perceived and actual ability (vis-à-vis the Dunning-Kruger effect; Kruger & Dunning, 1999).

The lack of significant differences in active students' pre- and post-reflective exercise ratings for the other teamwork skills may have been due to a lack of clear sign-posting, both before and during the written reflection task. In regard specifically to written communication skills, while it might be expected that writing a reflective diary would generate an increase in students' self-efficacy of this skill (e.g. Fritson et al., 2013), the aim of the reflective exercise related to teamwork rather than actual writing skill. Thus, while reflective writing might provide value in terms of 'free thinking' (McGuire et al., 2009), the absence of any structure or purpose in students' writing "does not explicitly prepare the learner with the analytical skills necessary for practice in a complex world" (p. 94). Additionally, tutors' feedback on students' reflective diaries provided guidance about their written teamwork experiences, rather than feedback about the quality of the writing. Thus, students were not instructed to refine their writing skill, in particular the quality of their prose, punctuation, structure, syntax and grammar, which might also have contributed to the lack of any visible effect conferred by the reflective exercise.

TeamQ teamwork assessment

The lack of an effect of written reflection on students' self-efficacy, compared to their perceptions of their peers' abilities, might result from a tendency for students to be overly-generous in their assessment of others, often to their own detriment (Goldfinch, 1994). The generosity of peer assessment is often correlated with the academic performance of the assessor, which although unknown in the context of this study, might be a possible explanation for the observed self-assessment findings.

TeamQ individual teamwork domains

That 'fostering a team climate' was the only teamwork domain for which active students' self-efficacy was significantly greater compared to control students, was most likely due to the reflective exercise. This difference may relate to the value of reflection in shaping personal perceptions relating to the dynamics of language (words and tone), nonverbal communication (facial expression and body language), and optimism about teamwork, as was described for social work students by Walter and Shenaar-Golan (2018). If correct, this suggests that there may be a link between self-reflection and these aspects of communication that collectively contribute to fostering a team climate. Paulus and Brown (2007) stated that fostering a team climate requires "some type of "bridge" that binds the group members together" (p. 256). Such undergraduate teamwork "bridges" have included icebreakers (Fleischmann, 2015), social

interactions (Carew, Ho, & Brookes, 2020) and structured mentoring (Detweiler-Bedell & Detweiler-Bedell, 2019). It is possible that the written reflection on their team interactions (goal settings, communication strategies, etc.) provided a "bridge" for our students, which then established and maintained the team climate.

That the reflective exercise conferred an effect on students' self-efficacy for only one of the teamwork domains, but all five domains in the peer-assessed results, might be explained by our participants' inability to recognise their own existing or improved ability using TeamQ. If true, this could result from participants' inherent criticism of their own abilities compared to their peers. Additionally, although used successfully for both self- and peer-assessment studies in contexts such as arts/drama (Britton et al., 2017) and engineering (Miner, Ilgu, Shane, & Madson, 2021), this study redresses to some extent the apparent gap in the literature in applying TeamQ to an undergraduate science discipline.

Focus groups

Our finding that a very high proportion of focus group comments related specifically to themes of teamwork and communication, is consistent with scholarship regarding the use of authentically-structured team-based projects in refining students' perceptions of the value of such employability skills (Sarkar, Overton, Thompson, & Rayner, 2017). This aligns strongly with Qualtrics and TeamQ data, in terms of the importance of teamwork and communication skills in underpinning the cohesion and productivity of team dynamics - vis-à-vis the fostering of a team climate, as described above. Team-based projects have been shown to be of considerable value in enhancing students' communication skills (Mayne, 2012), which is consistent with our findings. These findings are reinforced by what students themselves said in response to a question about the importance of such employability skills to their future career ambitions, for example:

> *"...teamwork, and the ability to work with others. But also to build a relationship with others that can really help to provide rapport, and stability is really important."*
>
> Student #1

In regard specifically to the value of communication, which is identified consistently throughout the study, one student observed that in terms of employability:

> *"...I think communication skills, written and verbal. So, the ability to listen to others and understand what they're saying, and also being able to deliver back a message so that other people understand what you're trying to say."*
>
> Student #2

Limitations

One limitation of the study is that active participants' instruction in using reflective practice was delivered in one, short session at the commencement of semester. As Sterling et al. (2016) contend, effective use of self-reflection is a time-consuming and iterative process, and its scaffolding is likely to require more than a solitary session. Therefore, while the results demonstrate the value of written reflection in development of students' teamwork skills, the quality and outcomes of reflective practice may be more finely nuanced through enhanced onboarding of students and targeted training in reflection and reflective practice.

Conclusions and implications for further research

Students' perceptions of five identified key teamwork skills remained consistent over the course of this study, and the value undergraduates ascribe to their employability skills is consistent with previous research. Additionally, students' use of written reflection regarding teamwork interactions conferred a significant increase in self-efficacy in their oral communication skill. Reflection also appeared to shape students' perceptions about the domain of fostering a team climate, in terms of their own self-efficacy and that of their peers (team members). Our findings reinforce the value of reflective practice in undergraduate science education, for inculcating key employability skills. Our study also identified the need for further research into the use of TeamQ to measure the potential impact of reflection in enhancing science students' own and their peers' teamwork-related abilities. A potential gap in the literature, and therefore a future research opportunity, exists around the link between written reflection and development of students' actual teamwork skills, their self-efficacy of such and potential for enhancing related employability skills.

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Declaration of conflicting interests

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