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Attitudes of tertiary students towards a group project in a science unit

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Summary

Collaborative learning tasks produce positive outcomes in student learning, including the development of teamwork skills; a key attribute sought by employers of chemistry graduates. The literature in this area focuses on factors influencing group effectiveness and the processes involved in completing an activity of this nature. There is a gap in the literature focusing on students' attitudes towards these types of tasks. This paper describes an original study focusing on the attitude of tertiary students, in a science discipline, towards completing collaborative learning tasks. Two samples of students, enrolled in different units across different tertiary institutions, were considered. A mixed methods approach was used to collect attitudinal data from students via pre- and post- surveys. Data collected was interpreted within the context of six key factors related to collaborative learning tasks, drawn from the literature. Responses to open questions were used to reach overall conclusions about the effectiveness of this type of task at a tertiary level from a student perspective.

Keywords

Collaborative learning, small groups, student attitudes, undergraduate chemistry, service teaching, non-chemistry majors, applications of chemistry, teamwork skills.

Introduction

A key factor sought by industry when hiring scientists is their ability to work as part of a team. It is essential that scientists are able to work in collaboration with a diverse range of people across multidisciplinary fields, both within their organization and the wider community. The ACS Committee on Professional Training published results from an industrial roundtable indicating that in addition to technical skills, team problem solving is one of the key skills industry seeks in graduate employees (Towns, 1998; 2000). This is in agreement with the results of a more recent survey of employers of chemistry graduates in

Australia, where 90 % of respondents indicated they regard the attribute of working in groups as a highly valuable professional skill (Lawrie *et al.*, 2010).

Collaborative learning tasks provide opportunity for students' to develop interpersonal and team work skills; skills most important to a scientist's employability, productivity and career success (Towns, 1998). The term 'collaborative learning' refers to small groups of students at various performance levels working together on a task or towards a common goal (Gokhale, 1995). The positive benefits of collaborative learning tasks have been well published in the literature, and their use has been demonstrated to promote active learning, enhance engagement, improve performance and, depending on the nature of the task, provide the students' with a more authentic learning experience (Kuh, 2003; Prince & Felder, 2006; van den Bossche *et al.*, 2006; Lawrie *et al.*, 2010). In addition, collaborative learning environments foster mutual knowledge construction and provide opportunity for students' to develop shared understanding of concepts (van den Bossche et al., 2006; Kagan, 1992; Johnson *et al.*, 1998; Smith *et al.*, 2005). Sharing of knowledge in this manner encourages deep learning and can improve retention of learned material (Johnson *et al.*, 1990; Johnson *et al.*, 1991; Webb 1984a; Webb 1984b; Webb 1989; Webb 1991).

Although the use of collaborative learning tasks can offer many advantages, it is acknowledged that these small groups are social constructs and consequently the effectiveness of the group in completing the task is dependent on several factors (Gillespie *et al.*, 2006; van den Bossche *et al.*, 2006). Stamovlasis *et al.* (2006) summarized these factors into four key points:

1. Individual differences of the group members
2. The nature of the task
3. The process itself
4. Prior training in group skills

There are numerous studies reporting examples of collaborative learning tasks that have been successfully incorporated into a science curriculum. The effectiveness of these have all been measured as a function of one of the above factors (Appleton, 1997; Bowen, 2000; Lazarowitz *et al.*, 1994; Lazarowitz *et al.*, 1998; Shachar & Fisher, 2004; Stamovlasis *et al.*, 2006; Zady *et al.*, 2002). The findings from these studies should encourage the use of collaborative learning tasks at a tertiary level, to allow students' to develop important graduate attributes, such as interpersonal skills, whilst simultaneously learning the subject matter. Despite this, many undergraduate chemistry programs do not specifically incorporate these types of tasks and limited literature exists on the use of small group-based activities in chemistry curriculum at a tertiary level (Huddle, 2000; Wimpfheimer, 2004; van Ryswyk, 2005; Yeung *et al.*, 2006; Mills *et al.*, 2000; Bartle *et al.*, 2010; Lawrie *et al.*, 2010).

Huddle (2000), Wimpfheimer (2004) and Mills *et al.* (2000) present collaborative learning tasks where students are required to work in small groups to prepare posters on a given chemistry topic, which they then present to their peers. The focus of their research around these tasks is on student engagement and retention in tertiary chemistry courses. Other published studies give examples of alternative small group-based activities in chemistry that involve new media, multimedia projects and extensive writing tasks (Bartle *et al.*, 2010; van Ryswyk, 2005; Oliver-Hoyo, 2003; Whelan and Zare, 2003; Magner *et al.*, 2002; Nakhleh, 1993). Research around these also focuses on student engagement and issues of surface versus deep learning. Lawrie *et al.* (2010) gives an example of interdisciplinary scenario-inquiry tasks, focusing on the role of team formation in collaborative learning tasks.

Although a large amount of literature exists on the pedagogical benefits of small group-based activities at a tertiary level, there is a gap in the literature focusing on students' attitudes towards these types of tasks (Stamovlasis *et al.*, 2006; Hillyard *et al.*, 2010; Towns, 2000; Patton, 1990). Springer *et al.* (1997) published quantitative results from a survey of college students in science, mathematics, engineering and technology which found that collaborative learning tasks were effective in promoting positive attitudes towards learning and increasing retention in these programs. As emphasised by Towns (2000), although quantitative studies provide insight into why these collaborative learning tasks lead to positive outcomes, such as enhanced engagement with the subject material, qualitative studies that include the voices of the students are also needed to develop a deeper understanding in this area.

This study considered the attitudes of tertiary students' towards collaborative learning tasks, using both quantitative and qualitative research methods. Two samples of students enrolled in different units were considered. First year students enrolled in a non-major chemistry unit were required to work in small groups to produce an information poster on an allocated chemistry topic. Students enrolled in a science communication unit were required to work in small groups to produce a short iMovie on a science topic of their choice. The teamwork and interpersonal skills developed by the student's completing these activities are all essential skills for scientists in the workplace.

The students were surveyed to ascertain their feelings about completing a small group-based activity task. Using a scale of agreement, they were asked questions on their level of interest in the project, thoughts on working in a group, strategies used to complete the task, challenges completing the assignment, information and skills learned through collaborative learning, group dynamics and any suggestions for change. They were also asked to provide comment on whether they thought overall that additional interpersonal skills learned during the collaborative learning task were of use and importance. The collected data were analysed to examine student attitudes towards the different processes related to group work and draw overall conclusions about the effectiveness of this type of activity at a tertiary level from a student perspective.

Background

Science Communication Talking (COMM2209) is a science communication unit offered at The University of Western Australia, designed to teach students how to communicate science orally to a range of audiences. The unit is a semester in duration and is taught by academic staff with expertise in science communication. Students enrolled in the unit were given the task of producing a two minute digital iMovie, based on a scientific topic of their choice and pitched at a level understandable to a general audience. These students were completing various degree programs; however a proportion were enrolled in a chemistry major and consequently chose topics with a chemistry focus, such as green chemistry. The multimedia project was assigned as a small group-based activity and accounted for 40 % of the student's semester mark.

The groups were required to follow a series of steps to complete the task. Through discussion with other group members they had to select a science topic of their choice, either a general science topic or a current topical issue related to science. They were then required to produce a hand-drawn storyboard detailing the structure of their iMovie. After attending a tutorial on how to use the digital cameras and iMovie software, the groups then had to film the necessary segments for their iMovie, transfer footage to the computers for editing and produce a finished movie.

Chemistry 141 is a non-major unit offered at Curtin University, designed to provide an introduction to fundamental concepts of chemistry for students with limited or no background chemistry knowledge. The unit is a semester in duration and covers general chemistry topics at an introductory level, such as mole concept, stoichiometry, acids and bases, equilibrium, gas laws and basic organic chemistry. Lectures for the unit are given by academic staff within the Department of Chemistry at Curtin University and the laboratory sessions are run by sessional academics, comprising a mixture of chemistry PhD and honours students. The scientific poster project was assigned as a small group-based activity and accounted for approximately 20 % of the laboratory mark for the unit. The students were required to work in a group of no more than three people to produce an A2 information poster on a chemistry topic, specifically related to the science of their major.

The groups were required to select a science topic from a given list to research, focusing on the associated chemistry and links between concepts. The subset of topics provided to students to choose from was based on the major they were enrolled in, providing them opportunity to apply chemistry in the context of their chosen degree. For example, pharmacy students were given the option to explain the chemistry of common drugs such as aspirin and antacid, whereas viticulture students could choose to research acidity and pH with respect to wine quality. They were then required to synthesise and summarise the information onto an A2 cardboard sheet, producing a poster that was both informative and visually appealing. The posters were peer-assessed (50 % of the final mark) and assessed by the tutor (50 % of the final mark) using a marking rubric with criteria based on both the accuracy of chemistry content and presentation.

Student participants

Sample one: iMovie project

Twenty students were enrolled in COMM2209 and had formed into seven different groups to complete the iMovie project assignment. Students were allowed to form their own groups, and there was no input from teaching staff during the group selection process. As a result, the composition of the different groups, with regards to achievement level and relevant skills, varied greatly. This collaborative learning task was given towards the start of the teaching semester when the enrolled students were not very familiar with each other. Hence the student's selection of their group members was not based on peer friendships.

All twenty students were invited to be involved in the study and informed that participation was voluntary. All the students (11 female and 9 male) agreed to participate. 16 of the students were in the 18-25 year old age category, three were in the 26-40 year old category and one participant was in the 41-60 year old category. The participants were studying a range of different science majors and were all at different stages of their undergraduate degree program. COMM2209 was a core unit in the degree program for five of the participants, and the other 15 students had enrolled in the unit as an elective.

Sample two: Chemistry poster project

Chemistry 141 is offered as a unit in the first semester of the teaching year. This study commenced after the Chemistry 141 teaching period had finished, however it was still thought useful to collect data from them as a comparison to sample one. All of the students who had been enrolled in the unit were contacted and invited to voluntarily participate in the study. Of the students contacted, six (four male and two female) agreed to be involved. Four of these students were in the 18-25 year old age category and the remaining two were in the 26-40 year old category.

For this collaborative learning task, students in each laboratory class were allowed to form into their own groups. The participants were all in their first year of the BSc(Viticulture and Oenology) degree program, which has a set unit structure and for which Chemistry 141 is a core unit. The group activity was also given towards the end of the teaching period, when students had a high degree of familiarity with each other. As a result, the students were very familiar with each other at the time of selecting their group members and peer friendships were a factor in choosing their groups.

Data collection methods

Data was collected using surveys as these were considered to be effective instruments for collecting attitude data from students. This study was commenced at the time students enrolled in COMM2209 were assigned their group activity and hence both pre- and post-surveys were administered to participants from this sample. Participants from sample two had already completed their group activity at the time of this study and hence only the post-survey was administered to this sample of students. All participants completed the surveys.

Data were collected using a mixed methods approach via pre- and post- surveys with Likert scale, coded and open response questions. The surveys were written in-house with the developed questions based on the key themes arising from the current literature in collaborative learning, such as group formation, student engagement and group processes employed by students' when completing a small-group based activity. Questions asked in the post-survey were similar to the pre-survey but with more of a reflective focus. Additional open response questions were also asked around specific things they had either learnt from their group members or taught their group members, challenges faced and their overall opinions on the effectiveness of small group-based activities as a teaching and learning tool.

A pre- and post-survey was used to identify if there had been any changes in attitude of the participants towards small group-based activity tasks as a result of their experience in completing one. Although participants in sample two could not be pre-surveyed, and hence any attitudinal changes could not be identified for this group, it was felt that data collected from a post-survey alone would be useful as it would allow general comparisons in attitudes between both samples. A copy of the pre- and post- survey is given in Appendix 1.

Data analysis

Numerical data collected from the surveys was extracted and imported into Microsoft Excel for analysis. This data, along with the qualitative information provided by the open response questions, was used to provide insight into the attitudes of the students' across both samples completing the collaborative learning tasks. As previously mentioned in the introduction, significant literature exists on collaborative learning tasks and the factors which influence their effectiveness as a teaching and learning tool. Stamovlasis *et al.* (2006) summarized the common themes emerging from the literature into four key factors. From these, four focus areas for this study were chosen and results were interpreted within the context of these – level of interest in the task, familiarity with other group members, level of contact (related to the assignment) for completion of the task and strategy used to complete the task. Two additional focus areas were also chosen – student's self-evaluation of their group's effectiveness, including areas for improvement, and overall opinions on the use of collaborative learning tasks in science at a tertiary level.

Results and discussion

Level of interest in the assignment

Participants were asked to rank their level of interest in the collaborative learning task in the pre-survey. A 5-point Likert scale was used, with one corresponding to 'very low' and five being ‘very high’. Both samples of students expressed a high level of interest in the small group-based activity task, with 95 % (N = 26) of the total students giving a score of three or above.

In the post-survey, the participants were asked a coded question on whether their high level of interest in the small group-based activity impacted the way they worked, and invited to give open responses to support their answer. In sample one, 14 (N = 20) of the participants responded that it did, giving explanatory comments such as;

- *“If I was not really interested in the topic or doing good work, I would have found working within a group and some technical aspects of the project difficult to overcome”*
- *“More interest brings more energy into the teamwork”*

The six participants in sample one that indicated their level of interest in the task did not influence the way they completed the small group-based activity task gave reasons like, *“I would have invested the same amount of effort and time regardless of how interested I was in the topic.”*

The data collected from sample two was significantly different from that of sample one. Only two (N = 6) of the participants indicated that their high level of interest did impact the way they worked in a group on the collaborative learning task with the other four participants indicating that it did not. The two participants that stated that it did influence the way they worked were in the 26-40 year old category and gave the reasons;

- *“keen to gain information on a topic related to the future of our course and therefore employment”*
- *“It inspired me to invest as much time as I could, knowing that it would benefit my education in this subject area”*

These attitudinal findings support the literature on collaborative learning tasks, which report that incorporating these types of activities into a tertiary curriculum enhances student engagement. A common practice in higher education research is to use student engagement as an indirect measure of student learning (Lawrie et al., 2010; Kuh, 2003; Seymour et al., 2000). Increased engagement with the task encourages deep learning of the material, leading to improved performance and increased retention of material (Towns, 1998; Towns *et al.*, 2000). Although the level of interest in a project may be independent of how efficiently a group operates in terms of dynamics and efficiency, setting small group-based activities which appeal to students helps foster and promote a working environment which is conducive to improving the group’s performance and success. It can also have a positive influence on the attitude of students towards completing a collaborative learning task.

It is also reported in the literature that students achieve at a higher level and work better when they feel they have ownership of the material and the responsibility of learning has been shifted more towards them (Wimpfheimer, 2004). The small group-based activity tasks completed by the students in each sample were consistent with this. The groups were given flexibility to select a topic of their choice, minimal structural requirements and maintained creative control over how the task was completed. This could be an external factor that influenced the way in which group members chose to operate and their attitudes towards completing the small group-based task.

The open-response comments provided by the students' in sample two demonstrate that student's value learning activities that provide an authentic learning experience and opportunity to learn subject matter in a relevant context. This is particularly important in the discipline of chemistry, where a significant proportion of first year undergraduate teaching is service teaching for non-chemistry majors. Large first year classes of this nature pose a challenge to instructors as the interests and backgrounds of the cohorts vary greatly (Lawrie *et al.*, 2010). Incorporating applied tasks, such as the poster activity discussed here, that allow students' to break into smaller groups and complete activities which require them to relate general chemistry concepts to the context of their chosen field, will lead not only to enhanced engagement with the collaborative learning task but also with the subject as a whole. This pedagogical approach is strongly supported by the literature (Lawrie *et al.*, 2010; Felder & Brent, 2001; Kagan, 1992; Johnson *et al.*, 1998; Smith *et al.*, 2005). The attitudinal comments provided by the participants support the literature, demonstrating that student's highly value being able to see the relevance of chemistry to their chosen major.

Level of familiarity with other group members

Students were asked to state how familiar they were with their other group members before commencing the assignment using a 5-point Likert scale, with one corresponding to unfamiliar and five being very familiar. The frequency of each stated response is given in Figure 1.

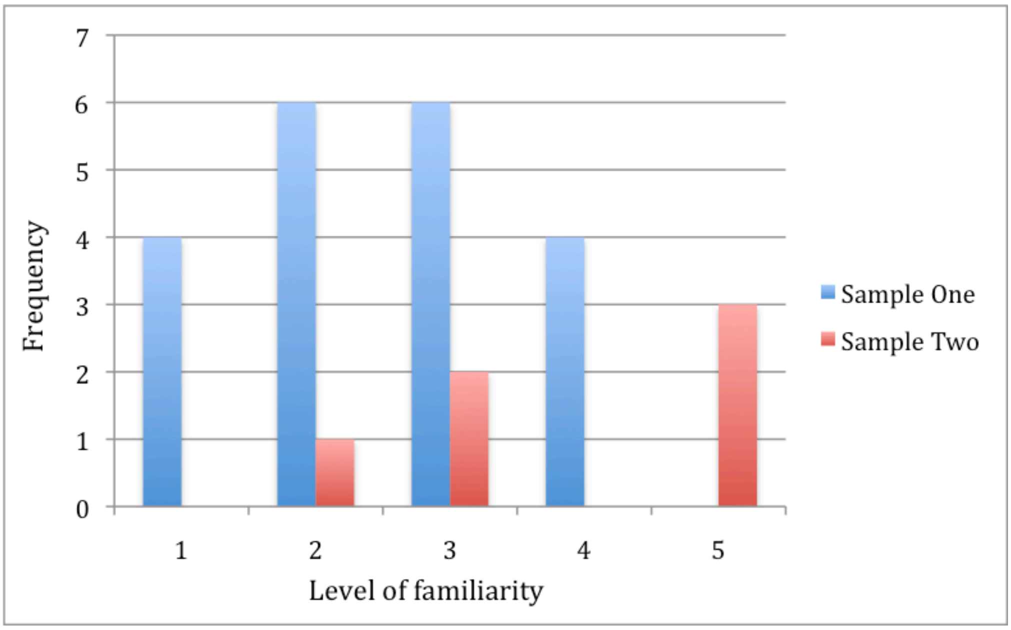

Figure 1: Frequency of each stated response given by participants with regards to their level of familiarity with other group members before commencing the collaborative learning task (1 = unfamiliar, 5 = very familiar)

There is strong evidence in the literature that the success of collaborative learning is critically dependant on group formation (Gillespie *et al.*, 2006). Kriflik (2007) summarized the frequently used approaches for allocating students to groups into four main categories as detailed in Table 1, based on various approaches to group formation reported in the literature (Piltz & Quinn, 2005; Morgan, 2002; Houldsworth & Mathews, 2000; Mahenthiran & Rouse, 2000).

Table 1: Group selection options (Source: Kriflik, 2007:15)

Method	Advantages	Considerations
Student self-selection	• students choose who to work with	• students overlooked or rejected • inequity in skill distribution • inequity in task distribution
Selective appointment (Groups formed on the basis of criteria i.e. mark aspirations, meeting times, complementary skills, specific competencies)	• students have common goals • less pressure on low achievers • student skills recognized and rewarded as being proficient	• low achievers not exposed to higher expectations • friends with shared aspirations not accepting a newcomer • less opportunity to develop new skills in

	• appreciation of diversity required in group work	unfamiliar roles
Random selection	• opportunity for students to learn from new people • opportunity to enhance communication skills	• students resent lack of choice • student concern about skills and attitudes of other students
Selection of topic choices	• students interested in topic • students working with interested others	• inequity in skill distribution • student concern about skills and attitudes of other students

As detailed in Table 1, advantages and disadvantages exist for each of the common methods of group formation. Mahenthiran and Rouse (2000) investigated whether or not the use of random group selection by the instructor had a positive impact on student performance. They argued that this method avoided students been left out for cultural, academic and social reasons and that, on average, the individual mark of all students in lecturer nominated groups using random selection were positively affected. No findings of how this method of group formation influenced student attitudes towards completing the collaborative learning task were reported. Similarly, none of the other literature surrounding the methods of group formation given in Table 1 focused on student attitudes, concentrating instead on the relationship between performance and group formation (Piltz & Quinn, 2005; Morgan, 2002; Houldsworth & Mathews, 2000; Mahenthiran & Rouse, 2000).

Lawrie *et al.* (2010) reported on student attitudes as part of their investigation into the role of group formation in collaborative learning tasks in large science classes. They concluded that the method of team formation impacted more on student learning outcomes for small group-based activities than it did on student attitudes.

The data collected from the participants in sample one on whether their level of familiarity with other group members impacted the way they worked in a group for the assessment task is consistent with the findings of Lawrie *et al.* (2010). The groups were self-chosen however over 80 % (N = 20) of these participants responded that they were unfamiliar with their other group members before commencing the activity, indicating the groups were not formed based on friendships. This could be a result of these students being enrolled in different degree programs and many completing the unit as an elective.

This unfamiliarity with other group members impacted the way 12 of the participants in sample one worked on the collaborative learning task. Written open-response comments from these participants include *“I didn’t know how the others liked to work so we had a lot of compromising to do”* and *“it meant we had to get to know each other’s strengths and weaknesses”*. These positive responses demonstrate that in addition to gaining the skills required to complete the small group-based activity, students are also inadvertently developing many of the interpersonal skills associated with working in a team. This has a positive impact on the learning outcomes of the task whilst not affecting their level of interest in the activity.

Another participant who was unfamiliar with their other group members stated that it did impact the way they worked, but *“possibly in our favour since everyone pulled their weight”*. This statement suggests that groups where students are unfamiliar with each other can still be successful as they adopt a good work ethic to avoid been seen as lazy by their peers.

The eight participants in sample one that reported that being unfamiliar with their other group members did not impact on the way their group completed the task, gave explanatory comments such as *“I could have worked the same with another group”*.

Several studies have been published concluding that allowing students to choose their own groups based on friendships results in ineffective groups as students often lack the transferable skills which the process of group work is intended to teach (Huxham, 2000; Towns, 1998; Towns *et al.*, 2000). The participants in sample two were enrolled in the non-major unit as a core unit and were all at the same stage of the same degree program. Hence, groups were chosen based on friendships, as reflected in the results for this sample, with five of the six participants stating they were familiar with the other group members before commencing the collaborative learning task.

Despite this, the data for sample two on whether the level of familiarity impacted the way they worked followed a similar trend to sample one. Half the participants stated that their high level of familiarity did impact the way they worked in a group while the other half reported that it did not. Open-response comments from participants that indicated being familiar with other group members did impact the way they worked were both positive and negative. Positive comments included *“easier to arrange work time”*, which is interesting as one of the main challenges students in both samples reported with group work was finding common times for all group members to meet. Negative comments received from participants who reported they were very familiar with other group members included *“more casual, felt like I didn’t need to pull my weight”*. Responses from participants who stated their level of familiarity did not impact the way they worked in a group included *“we were all pretty good people who got along well enough so we had no trouble completing the work given”*.

Level of contact (related to the assignment) with other group members

Participants were asked to rank how important they thought regular contact with other group members was to complete a small group-based activity task successfully on a scale of one (low) to five (very). All of the participants gave a score of four or above, demonstrating they recognize the importance of regular contact with other group members when completing small group-based activity tasks. However, only 16 participants in sample one and three participants in sample two stated that they met with other team members more than twice a week to discuss their projects. In the post-surveys, participants reported finding meeting times when all group members were available as the biggest challenge in completing the collaborative learning task, which could explain this discrepancy.

There is a general trend that suggests the greater the level of interest in the small group-based activity task the higher the level of contact with group members. The participants that stated they had a high level of interest also reported having more regular contact with their group members. It can also be linked to achievement, with these participants from sample two who met regularly receiving distinctions for their scientific posters. The marks given to students in sample one were not obtained and hence the relationship between level of contact and achievement could not be explored.

Strategy used to complete the assignment

Participants were asked to select which strategy, or combination of strategies, best described the way their group completed the assessment task. The frequency of each stated response is given in Table 2.

Table 2: Frequency of each stated response reported by student participants with regards to strategy used to complete their group assignment (participants could select more than one)

Strategy	Sample one	Sample two
1. Dividing tasks evenly between group members	7	2
2. Each group member takes charge of a key aspect	6	2
3. Group members work on all of the tasks together	6	1
4. Divide the tasks according to each member’s strengths and skills	10	1
5. Group members work individually on their tasks and only collaborate at the end	0	1
6. Group members work individually on their tasks, but meet regularly with other group members to update them and discuss progress	9	3

Participants in sample one favoured strategies four and six. The proportion of students choosing strategy six, and the nil choice for strategy five, is consistent with the data collected from them relating to how important they thought regular contact with other group members was to successfully complete the assignment. Participants that reported they used either strategies one and two, indicated these were used in combination with three and/or four. Participants that selected strategy six also chose strategies three and/or four and gave reasoning like *"any individual tasks were very small and could be done overnight before collaborating with the rest of the group"*. This demonstrates that participants believed regular contact and working on the task as a team, rather than individuals, were an important part to completing the activity successfully. Completing the collaborative learning tasks using these strategies and having regular contact with other group members also ensures that tertiary students are developing interpersonal skills, such as teamwork and cooperation, which are important in the workplace.

Strategies one, two and six were the most common strategies used by participants in sample two. This suggests that these participants preferred to complete the task more independently than student sample one. This is interesting as the participants in sample two were more familiar with their other group members than sample one, and hence it was expected they would be more willing to work as a group rather than independently. Even though they did complete the task more independently, these students performed highly in the activity, indicating the desired result of requiring the students to develop interpersonal skills was still achieved.

Participants self-ranking of the effectiveness of their group

Participants were asked to rank how effectively they believed their group worked together on the tasks using a 5-point Likert scale, with one corresponding to poorly and five corresponding to very well. They were also asked to list any challenges they experienced working in a group and any changes they felt their group could have made to improve their performance and efficiency. The frequency of each stated response reported by participants is given in Figure 2.

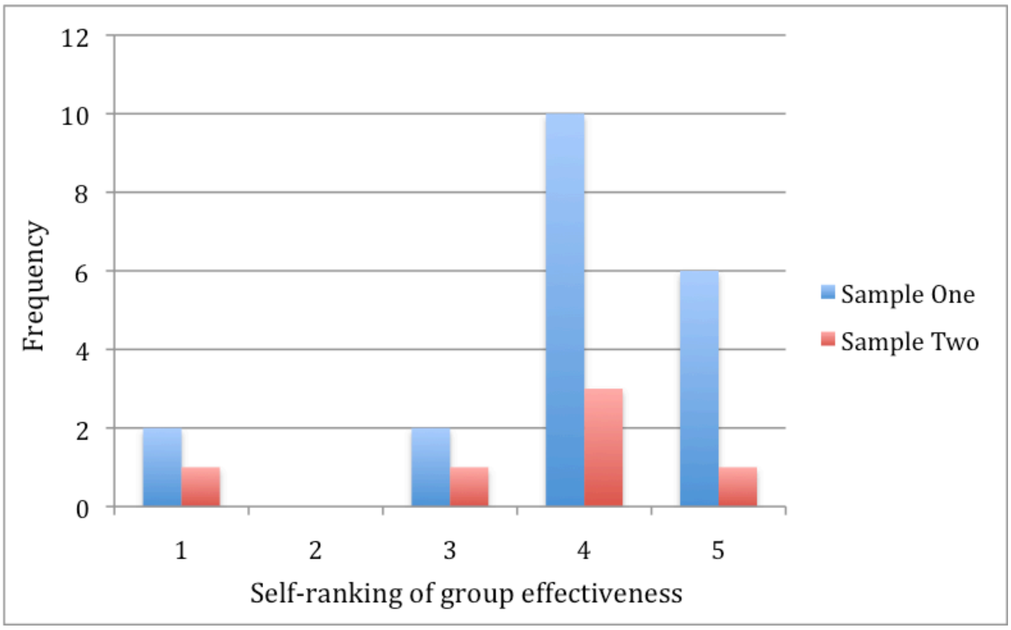

Figure 2: Frequency of each stated response given by participants with regards to their self-ranking of their group's effectiveness (1 = poorly, 5 = very well)

Of the participants from sample one, 16 thought their group worked well, giving a score of four or above on the scale. The written open-response comments from these participants on challenges and possible areas of improvement were all very positive towards group work itself and instead focused on the challenge of finding common times that their group could meet. Written answers included *"finding time everyone was available"* and *"everyone had a different schedule so it was hard to find time to meet"*.

The participant who gave their group a score of three reported that they had had serious trouble finding time when all three members were available to meet together and hence their suggestion to improve their group performance was *"work as a team rather than as a group of individuals with a common project"*.

The participant who reported their group worked very poorly could be considered an outlier, as their group had trouble with one particular member and so they operated as a partnership of two rather than a team of three. Their comments were very negative, stating that they could have improved their group's performance by *"making it clear to our slack group member that we weren't happy with their contribution earlier in the project"*. This demonstrates that they learned and now recognize the importance of communication when working in a team.

Similar data results were also obtained for sample two, with four of the participants giving their group a score of 4 or above on a 5-point Likert scale. The written open-response comments from these students on the challenges they had faced and possible areas of improvement were also all very positive with respect to group work itself and instead related more to the task. Comments included *"finding an angle on which to tackle the task was the most significant"* and *"simplifying information to convey in poster format was a challenge"*.

Overall opinions on the use of group work at a tertiary level

Participants were asked their opinions on whether group work was an effective teaching and learning tool in science at a tertiary level. The responses from participants in both samples were very positive.

In sample one, 17 of the participants agreed that group work was effective and only three were undecided. The written comments received for this question were also very positive and demonstrated that the students recognized the importance of learning not only unit content for use in future employment, but also interpersonal skills. Written comments included;

- *"reflects what it will be like with a proper job"*
- *"research is rarely done solely, it is always a group of academics, therefore, teamwork is highly important for success"*, and

- *“because it’s important to learn how to work in a team. Also relevant to learn how different teams work. Good for communication skills and interaction. There’s also greater creativity/knowledge in teams”*

Participants were asked to state whether they thought group work was an effective teaching and learning tool in both the pre- and post-surveys. Most participants gave the same response in both surveys, only one changed their response from an initial vote of ‘no’ to a ‘yes’. In the initial survey their explanation was *“the pressures of forming a new team for each assignment that can only use specific tools at a particular time is an unpleasant task to contemplate”*.

All of the participants in sample two stated that they thought the use of group work at a tertiary level was an effective teaching and learning tool in science. As with sample one, the written comments were all very positive and included;

- *“in our future workplace group work is part of the job, ability to find balance in a group is integral to future development”*
- *“it allows group members to share knowledge already known or found by other members of the group. Also different members of the group can contribute different skills to the project”*, and
- *“it is practical and the skills will be needed later in life”*

These findings correspond with the limited studies published in the literature on the attitudes of students towards collaborative learning tasks at a tertiary level in disciplines other than science. Kriflik (2007) conducted a survey of undergraduate students completing the ‘Introduction to Health Behaviour Change’ subject at the University of Woollongong, Australia. Over 85 % (67) of the survey students responded that small group-based activities within the unit had contributed to development of their teamwork and interpersonal skills. Additionally, 83 % (66) of the participants recognized that these developed skills would benefit them in their future workplace environments.

Participants in both samples were also asked to reflect on specific examples of things they had learned from their group members that they probably wouldn’t have learned working alone or things they felt they had taught the other members of their group. The response to this was very positive and demonstrated that overall the students had found group work to be very enjoyable and beneficial. Written comments from participants in both samples demonstrating this include;

- *“I learned to be open to other people’s ideas, importance of everyone in the group being happy with the end product and different groups work differently”*
- *“I taught others how to make group work enjoyable as well as constructive”*

- *"I enjoyed mingling with other very different people that exist at university and taught other group members that people doing completely different courses have similar interests/personalities"*
- *"have faith in your peers"*

Conclusions

Numerous studies have been published demonstrating that the incorporation of collaborative learning tasks into a tertiary curriculum produces positive outcomes, such as development of teamwork skills; skills that are highly regarded by employers of Chemistry graduates in Australia. Despite this, many undergraduate chemistry programs do not incorporate these types of tasks into their curriculum. There is a gap in the literature focusing on students' attitudes towards these small group-based activities. Evidence on student attitudes' towards these tasks would supplement the existing literature around collaborative learning tasks and be used to encourage teachers of tertiary chemistry units to implement activities of this nature into their curriculum. This study investigated the attitudes of tertiary science students towards completing small group-based activity tasks and whether they felt it was beneficial to their personal and educational development.

Data collected indicates that students feel very positively about collaborative learning tasks. Written open-response comments received from the students indicates that students recognize the importance of developing strong interpersonal skills and many felt that completion of a small group-based activity had contributed to the development of these. The results from this study indicate that students' recognize that as well as technical skills and chemistry knowledge, graduate attributes are also essential to their future career development and success.

The degree of familiarity of individuals with other group members did not seem to influence how groups operated, with participants who were both very familiar and unfamiliar with their peers successfully completing the tasks. Although controlled formation of groups, rather then self-selection based on friendships, does offer some advantages such as providing opportunity for students to learn from other people, it does also introduce the challenges of group members finding common times to meet. The majority of participants in this study reported their negative experiences with group work related to the issue of finding time when all group members were available, rather than group work itself. This consideration is particularly relevant in the chemistry discipline, as a significant proportion of undergraduate chemistry teaching in Australia is service teaching for non-chemistry majors and hence the enrolled students are often completing different degree programs and hence have different class timetables.

Student engagement and retention also becomes a significant issue for chemistry educators involved with undergraduate service teaching. Catering for the diverse interests and backgrounds of these students in the traditional lecture setting can be a challenge. Incorporating small group-based activities that allow students to focus on applying general chemistry principles to their chosen major can be one way to put the chemistry into context. Results from our study support this, confirming that students' value learning activities that provide an authentic learning experience and opportunity to learn subject matter in a relevant context. People with an interest in this area of research could further investigate how student attitudes towards chemistry, and science in general, as well as their appreciation of the relevance, changed as a result of completing these types of applied activities during their tertiary studies.

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