Assessing Group Project for Fluids Power and Advanced Fluid Mechanics Paper

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Introduction

One of the Engineering New Zealand graduate profile attributes is to prepare our students to: **"***function effectively as an individual, and as a member or leader in diverse teams"*. This attribute is developed across three years of study in the Bachelor of Engineering Technology program. Group projects play a major role in developing and assessing this graduate profile attribute.

As the style of engineering education at Universities and polytechnics transitions away from the traditional teacher-focused delivery to more student-centric approaches, methods that put the student at the centre of learning, such as project-based learning, have become increasingly important (Trigwell, Prosser, & Taylor, 1994; Prince, 2004; Roessingh & Chambers, 2011) Projects encourage students to engage in self-directed learning to solve complex problems and develop a "mindset for problem solving" (Roessingh & Chambers, 2011, p. 60).

Project-based learning (PjBL) has a greater focus on behaviour and a more open-ended, exploratory approach that requires critical thinking, a process of inquiry, reflection and an evolution of thought (Roessingh & Chambers, 2011) which skills and processes are part of most graduate profiles. As Nordberg (2006) points out, a key job interview question is "are you a good team player?", reflecting the importance to industry that graduates be able to function effectively as members of teams. Therefore, the shift towards more project-based methods of inquiry is therefore encouraged across most tertiary institutions, including those in New Zealand and Australia. These methods, including PjBL, have been implemented to suit the practical requirements of the qualification and to produce students who are work-ready.

PjBL requires students to work in groups to find a solution to a problem by defining what they need to know and how they will acquire this knowledge (Triantafyllou & Timcenko, 2014). Effective group work should not be a matter of divide and conquer for tasks: each task should receive contribution from more than one member of the group. The process of interacting over time, mutual input of intellectual effort, and meaningful communication between team members turns the group into a high-performing team (Fink, 2004). Consequently, peer interaction and contribution is a key feature of the group project process (formation of the final product) and assessment (grading of the final product).

PjBL that occurs via group projects entails two challenges: did the project actually teach teamwork, and was it assessed "fairly"? There is a wealth of literature answering, in particular, the latter question. Methods involving peer- and self-assessments of participation are becoming increasingly sophisticated, but are still imperfect proxies for actual contribution. The lack of apparent fairness in student projects as a grading tool remains, as student complaints, and the wealth of internet memes, suggest. The alternative is to increase direct monitoring of group interactions by instructors, such as via the LMS. This method is resource-intensive.

This paper describes how to directly measure team-contribution by students in a way that does not entail peer- or self-bias. First, a non-assessed PjBL class is outlined and the method to encourage intra- and inter-team participation is described. Then a method to accurately identify team participation in a group project is presented and discussed. Where functioning effectively

as an individual and a member of a diverse team is an assessable graduate profile attribute and a learning outcome of a course, we present a way in which to develop, and then effectively and fairly assess, that attribute.

Design of the Project-Based Learning Tasks

In-class teaching and evaluation of teamwork skills.

The initial impetus for the design of this PjBL class arose from something other than a burning desire to institute PjBL into the classroom. An instructor with four hours of class in a row with the same group of students must find some way of sustaining attention during that time. It turns out such a long stretch of class is a great opportunity to engage in free investigation of the topics, and as the class was a third-year group, students were sufficiently experienced to benefit from a constructivist approach to teaching.

The following specifies the resulting group-based workshop – an ungraded "mini-project" – which we designed to optimise use of longer time-frame classes and prepare students to work on their assessed group project.

In Class Exercise: Control for a Foundry Ladle

The students were placed into four groups of three students, labelled groups A, B, C and D. Each group had 120 minutes to solve the exercises in their group. Once the solution had been sketched, each group prepared a brief PowerPoint presentation to demonstrate their solution for the other three groups. After the demonstration, the other three groups provided feedback on the presenting group's solution. The four groups presented in a random order, and the focus was on the quality and reasoning behind their solutions, not on their all obtaining the same solution.

Description of the task: The lowering of the ladle is to be effected by a push button valve (slow lowering). The lifting of the ladle is to be effected by automatic reversal (slow lifting) as shown in Figure 1.

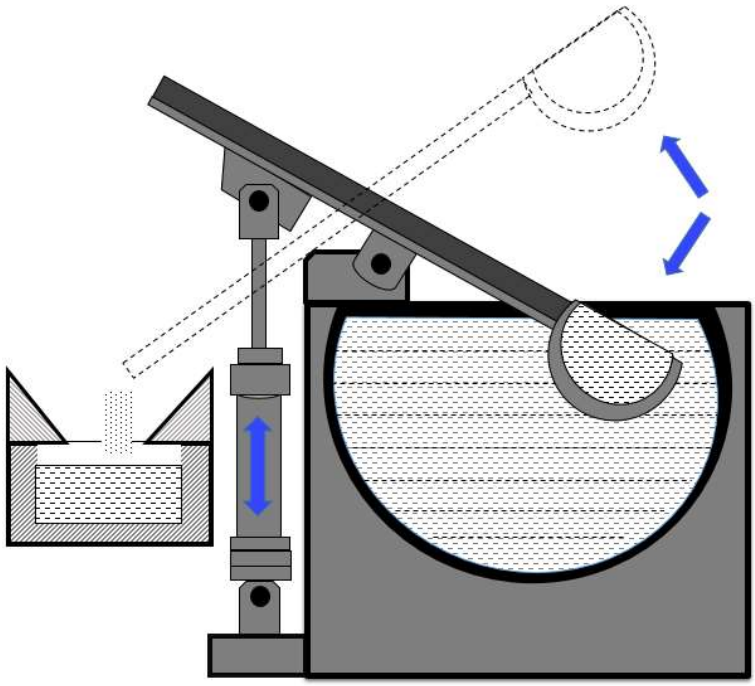

Figure 1: Foundry Ladle Source: adapted from Meixner & Kobler (1978).

The four groups investigated the task and did their own research as shown in Figure 2, which took a significant amount of time, hence the 120 minutes for the group work part of the task. They then started working on the pneumatic design and preparing the PowerPoint presentation. Students were therefore required to work together to produce an outcome in a collaborative environment (thereby demonstrating one of the learning outcomes for this course).

Figure 2: Group-work based learning.

The second two hours were spent with each group presenting their proposed design to the rest of the class. During these presentations, the lecturer and the students from each of the three other groups could ask questions and provide comments to the group who is presenting. We found that the quality of the questions and feedback were extremely good.

At the end of the session we gave the groups a chance to update their design based on comments and recommendations received from the lecturer and their classmates. They then uploaded everything into Moodle including the AutomationStudio file. After this, we presented the model answer and discussed it with them.

Overall, we found that:

1. Rather than being drained, at the end of this class we all felt energised by the mixture of activities, teaching and facilitating student-centred learning.
2. At Level 7, we could comfortably expect students to work outside the box and learn from the less teacher-directed process.
3. Informal student feedback really favoured the mini-project based workshop.

Group-project assessment of teamwork skills.

The assessed group project, worth 40% of a student's final grade, is outlined below.

The content-based aim of this project was for students to demonstrate their ability to design and choose a suitable pump for an application, working in a group of three students. The system must pump water at 80°C from a water heater to a washing system, as shown in Figure 3 below, The desired minimum flow rate is 750 L/min.

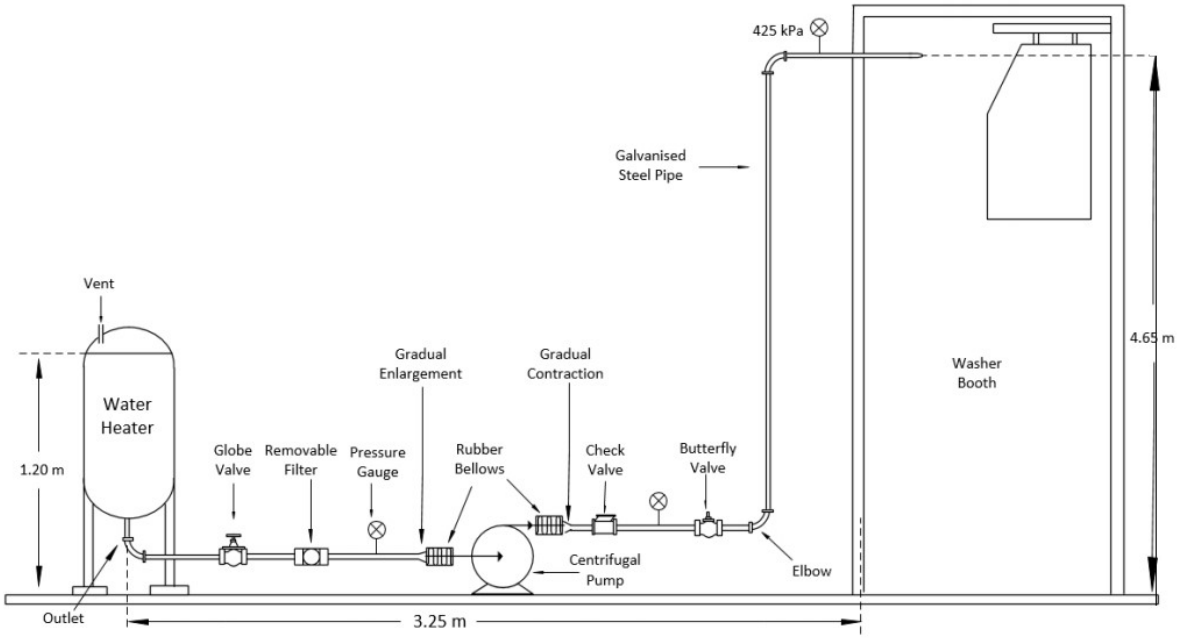

Figure 3: Pump design. Source: Adapted from Mott (2006).

The lecturer explained the project concept during class, then met each group individually. During this initial meeting, students were required to select a leader for the group and discuss the next steps for each team member. The group was informed that, during the final presentation, each member would be assessed both on their individual contribution, and their contribution as part of the team. They were aware that they would be asked questions related to their own part in the project (individual contribution) and about their teammates' work in the same project (assessing team-based contribution).

The project was conducted by 13 students divided into four groups of between three and four students. The instructor formed the groups to be diverse in terms of gender, nationality, English language ability and academic ability. Each group selected their team leader, who was responsible for facilitating their meetings, coordinating the tasks for each member and meeting separately with the lecturer to report on the group's progress. These elements reflected the graduate profile requirement that students must be able to function effectively as an individual and *as a member or leader* in a *diverse team*. In addition, if the leader was not managing their task well, then another member in the group could take a 2IC position to provide support to the leader. The instructor provided each group with weekly feedback to ensure they were on the right track and improving their time management skills.

Although the luxury to select one's leader is not realistically available at most jobs, in this assignment we let students' select their own leader based on availability, flexibility, and whether the student was keen to take the role.

Performance in the actual project (calculations and written report) was very good (mean = 25.5/30), as is often the case with group projects. However, the oral presentation was revealing. 50% of the students adequately demonstrated knowledge of their teammates' contributions to the project. The rest, however could not answer any questions about the other students' work in their groups. The mean for the presentation was 6/10. Some admitted that life and other business took them away from their studies and impacted on their contribution towards the group project. Student feedback was positive about this project; in particular, students were happy that there was greater spread in the presentation marks, even though they got the same marks for the final report.

Discussion

Project-based and team-based learning in the classroom, and group projects for assessment neatly fit with the requirement of many employers, and the Engineering New Zealand graduate profile, that graduates be able to function effectively as part of a team. However, the reason for introducing team-based approaches to learning and assessment are often workload or resource-based (Willcoxson, 2006; Nordberg, 2006).Furthermore, group projects frequently frustrate students, with many feeling they allow some students to freeload on the work of others (Willcoxson, 2006; Bushell, 2006; Cheng and Warren, 2000; Hall and Buzwell, 2013).

In recognition of the incentive to free-ride, most group projects require a component in which the group members reflect on their and their team-mates' contributions to the project. Ways to achieve this include: students assigning a grade to self and/or team-members' contributions (Conway & Kember, 1993); students ranking individuals' contributions from highest to lowest contributor (Bushell, 2006), students estimating the percentage each team member contributed towards the project (Sprague, Wilson, & McKenzie, 2019) and active monitoring of student's online communications with team-members via the LMS by staff (Clarke & Blissenden, 2013).

When announcing a group project to the class, it is tempting to respond to the collective groan by extolling the virtues of group projects: reflective of the real world, important teamwork skills for the workplace, develop critical thinking, solve real-world problems… We may point to the graduate profile, and remind students of the attribute(s) relating to teamwork and interpersonal relationships. However, in placing group work into a group project, we risk expecting students to develop a key skill that we have promised to deliver as part of the course – functioning effectively in a group – without actually teaching them how to function effectively as a group. Furthermore, we have just established that teamwork as part of a group project is notoriously difficult to accurately assess – although the methods for doing this are improving. Consequently, we are placing the burden of teaching and assessing teamwork in the hands of students.

The ever more sophisticated methods of avoiding peer pressure, or "gaming" of the peer-assessment grade suggest that this low hanging fruit is readily plucked. Where gaming is possible, students are likely to report that peer-assessment of contribution, or group projects in general, are unfair assessment tools. However, it is not merely fairness that motivates instructors to design group projects that encourage actual group work. Bearing in mind the advantages of group-based work: interactivity between students on a professional level, development of key interpersonal skills necessary for working as a team, and preparation for the workplace (Nordberg, 2006; Willcoxson, 2006), it is important that the final product, or the project, not only foster those skills, but also assess them accurately.

The advantage of using the presentation to measure project contribution is that the instructor can obtain a measure of the contribution made by each participant without any increase in instructor monitoring time. It also circumvents the ability of low contributors to exert pressure on their teammates to be accorded a higher contribution grade. Furthermore, as students are well aware that their lack of contribution in the team shows in the presentation, this provides them with an opportunity to reflect on what they can do in future to improve their grade in this respect. Therefore I recommend implementing this at lower levels, as level 7 is the final year of study. This information would be better received earlier.

As noted earlier, monitoring of LMS-based communications by instructors can encourage and support teamwork, but may be an undesirable solution due to lack of resources. We have shown how a PjBL class, or a mini-project, enables this very instructor monitoring of team behavior without any additional instructor time. We have then shown how individual and team behavior can be assessed during group project presentations – again, with no increase to instructor time – by introducing questions relating to own versus others' contributions. What this tested is the "fabric" of the team: how well a student could present on others' work

illustrated how collaborative was the team's creative process. It also identified non-contributors, as students performed very poorly on describing others' work.

Conclusion

Teamwork skills form a key expected attribute amongst engineering graduates. It is important for instructors to effectively teach and assess these skills. Project-Based Learning is one method by which these skills may be taught and assessed. However, group projects, a dominant form of PjBL, are notoriously considered unfair, both as experiences of teamwork and reflections of team-members' contributions to the final project. Methods to address this unfairness rely on student assessment of members' performance or forms of monitoring team behaviour by the instructor. The former is a proxy for team-performance and the latter is very resource intensive. This paper described a method by which team behaviour can be taught in class and assessed in a group project setting. The intensive environment of the mini-project required students to work as teams and participate as a group in order to generate some outcome. By having students report on each other's contributions to the group project during the final presentation for the assessed project, the instructor could accurately identify contributors and non-contributors even revealed themselves during this presentation. This involved no additional monitoring cost to the instructor.

References

Bushell, G. (2006). Moderation of peer assessment in group projects. *Assessment and Evaluation in Higher Education, 31*(1), 91-108.

Cheng, W., & Warren, M. (2000). Making a difference: Using peers to assess individual students' contributions to a group project. *Teaching in Higher Education, 5*(2), 243-255.

Clarke, S., & Blissenden, M. (2013). Assessing student group work: is there a right way to do it? *The Law Teacher, 47*(3), 368-381.

Conway, R., & Kember, D. (1993). Peer assessment of an individual's contribution to a group project. *Assessment and Evaluation in Higher Education, 18*(1), 45-57.

Fink, D. (2004). Beyond small groups: Harnessing the extraordinary power of learning teams. In L. Michaelsen, A. Knight, & D. Fink, *Team-Based Learning: A Transformative Use of Small Groups.* Sterling: Stylus Publishing.

Hall, D., & Buzwell, S. (2013). The problem of free-riding in group projects: Looking beyond social loafing as reason for non-contribution. *Active Learning in Higher Education, 14*(1), 37-49.

Meixner, H., & Kobler, R. (1978). *Introduction to Pneumatics.* Esslingen: Festo Didactic.

Mott, R. (2006). *Applied Fluid Mechanics* (6 ed.). Jurong: Pearson Education.

Nordberg, D. (2006). Fairness in assessing group projects: A conceptual framework for higher education. *SSRN Electronic Journal*.

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, 1-9.

Roessingh, H., & Chambers, W. (2011). Project-based learning and pedagogy in teacher preparation: Staking out the theoretical mid-ground. *International Journal of Teaching and Learning in Higher Education, 23*(1), 60-71.

Sprague, M., Wilson, K., & McKenzie, K. (2019). Evlauating the quality of peer and self evaluations as measures of student contributions to group projects. *Higher Education Research and Development, 38*(5), 1061-1074.

Triantafyllou, E., & Timcenko, O. (2014). Peer assessment in Engineering group projects: A literature survey. In Y. Cao, T. Väljataga, J. Tang, H. Leung, & M. Laanpere, *New Horizons in Web Based Learning.* Cham: Springer.

Trigwell, K., Prosser, M., & Taylor, P. (1994). Qualitative differences in approaches to teaching first year university science. *Higher Education, 27*, 75-84.

Willcoxson, L. (2006). "It's not fair!": Assessing the dynamics and resourcing of teamwork. *Journal of Management Education, 30*(6), 798-808.

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