



Exploring the effectiveness of a framework using e-Portfolio-type learning activities to develop teamwork skills in student engineers

Anna Dai, Nicoleta Maynard, Veronica Halupka and Misol Kim

Monash University, Australia

Corresponding Author Email: nicoleta.maynard@monash.edu

ABSTRACT

CONTEXT

Graduate engineers are expected to possess strong teamwork, communication and interpersonal skills in addition to their capabilities in the technical domain. e-Portfolios are integrated online learning, development and content delivery platforms that are becoming increasingly relevant for developing professional skills in engineering education. e-Portfolio activities, such as goal setting, peer feedback and reflection, have the capacity to facilitate continuous and ongoing development of such skills.

PURPOSE OR GOAL

This research aims to study how a framework using *e-Portfolio-type developmental activities* can help student engineers improve and understand the value of teamwork skills. The three main objectives of the study are: to understand how e-Portfolio type activities can help student engineers understand the value of developing teamwork skills; to investigate the effectiveness of these activities and to understand the implementation challenges.

APPROACH OR METHODOLOGY/METHODS

Based on an ethnographic framework, an exploratory mixed methods data collection was used, with 239 first-year engineering students forming the participant group of the study. They participated in a range of e-Portfolio-type teamwork development activities. The data, consisting of artefacts, peer evaluation reports and observations, was analysed using a framework methodology and thematic approach.

OUTCOMES

Initially the students stated the importance of teamwork skills in attaining good grades, but by the end of semester they placed a greater emphasis on using these skills for improving team relationships and personal growth. Most students stated that they improved their teamwork skills over the semester, a claim supported by the results of their Peer Feedback. However, students were not fully engaged in the class discussions relating to their teamwork skills development over the semester.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

This study found that peer feedback exchange and reflective activities helped students to understand how they behaved in teams and the impact of their behaviour on their teammates and project outcome. Though e-Portfolio type activities improved students' teamwork skills, the teaching support staff required more guidance in teaching and assisting students through these activities and team development.

KEYWORDS

Teamwork skills, reflective practice, peer feedback exchange, e-portfolio

1. Introduction

The disciplinary accreditation bodies and the industries that recruit our graduates expect engineering courses to produce high-calibre graduate engineers who are industry ready. Specifically, graduates are expected to possess strong teamwork, communication and interpersonal skills in addition to their capabilities in the technical domain; yet these skills are often reported as poorly developed among the graduates (Leydens, 2012). These skills cannot be assessed using traditional means, such as exams, and are difficult to implement within discrete, semester-long units, as they require continuous development throughout a degree (Heinrich et al., 2010). Over the past 20 years, e-Portfolios have emerged in engineering education due to intersecting developments in technology, pedagogical approaches and changing workplace requirements (Alam et al., 2015). As a digital platform that can be used to deliver assessments, store resources, showcase achievements, and to develop skills required for lifelong learning, e-Portfolios can successfully be used to integrate both personal development and content-specific requirements (Alam et al., 2015).

Studying how e-Portfolio *developmental activities* can be used to develop skills for teamwork effectiveness is, therefore, an emergent area of engineering education research that combines technology with theory. For the purposes of this paper, only e-Portfolio-*type* activities are studied in a framework which mimics the experience of using e-Portfolio for developmental purposes. The use of e-Portfolio software is outside the project scope.

2. Research Objectives

This paper examines the use of e-Portfolio-type activities in the development of students' teamwork skills through peer feedback, goal setting, and reflective practices in a first-year engineering unit. The problem statement is:

How can a framework using e-Portfolio-type developmental activities help first-year student engineers understand the value of, and improve their teamwork skills?

The research question identifies three gaps in the current research. Studies into e-Portfolio platforms tend to address administrative challenges of implementation, focusing on personal development holistically, rather than teamwork skills development specifically. Secondly, where e-Portfolios are implemented in a teamwork setting, the objectives are to test their technical suitability to deliver collaborative engineering assessments. Finally, though there is a significant body of engineering education research about methods to improve teamwork effectiveness, there is a lack of studies of frameworks using e-Portfolio developmental tools.

This research project had three main objectives:

- 1.To understand how e-Portfolio-type activities can help first-year student engineers understand the value of developing teamwork skills;
- 2.To investigate the effectiveness of e-Portfolio-type activities in developing student engineers' teamwork skills;
- 3.To identify and understand the challenges in implementing e-Portfolio-type activities to develop teamwork skills.

3. Literature Review

According to the Australian Council of Engineering Deans (ACED) Engineering Futures 2035 report, priorities for future engineering education programs include: an increased focus on non-technical attributes such as "EQ, resilience, creativity and interaction and engagement skills" (Burnett et al., 2019). Therefore, the Australian tertiary sector is aware of the need to integrate development of personal skills into the student curriculum (Heinrich et al., 2010).

3.1 Current e-Portfolio Implementation and Utilisation for Personal Development

The 'Australian e-Portfolio Project' (2008), commissioned by the Australian Learning and Teaching Council (ALTC), is the most comprehensive investigation into e-Portfolio integration in Australian universities to date. Results suggest that e-Portfolios are a valuable tool to aid students in developing their personal and professional identities over time; the main finding is, however, that while the tertiary sector is highly interested in e-Portfolios, integration of the platform in curriculum is shallow, inconsistent and lacks implementation on a faculty- and institution-wide basis (Hallam & Creagh, 2015). The main challenges related to e-Portfolio implementation have been identified to be of technological, administrative and educational nature (Fielder & Pick, 2014; Alam et al., 2015), suggesting that additional guidance is needed to assist students with their reflective practice, goal setting and finding value in completing these required tasks (Heinrich et al., 2010). Findings from literature indicate that e-Portfolios are not being effectively implemented as a development tool, and research examining its effectiveness is limited (Oakley et al., 2013; Roberts et al., 2016). Studies by Yang et al. (2015) and Ayala and Popescu (2018) suggest that students are unlikely to participate in activities that are ungraded, even if they provide a valuable learning experience. In contrast, although the pilot e-Portfolio study at Virginia Tech was ungraded and voluntary, most students felt that e-Portfolios assisted their learning and self-evaluation, and consequently exhibited interest in using the platform after the pilot had ended (Knott et al., 2004). However, the participant pool was biased towards students who were inclined to engage in e-Portfolio activities.

3.2 e-Portfolio Implementation in Teamwork Settings

A review of the literature indicates that research into effective use of e-Portfolios within an engineering team context is scarce, so further research opportunities are feasible. Abidin & Saleh (2011) conducted a study into testing the effectiveness of an e-Portfolio platform to deliver team assessments at a Malaysian University, examining the technical aspects of using an e-Portfolio platform and the ability of the platform to facilitate teamwork. The study, however, did not focus on whether e-Portfolio tools can develop teamwork skills per se, but whether students can work collaboratively on the platform. Only simple teamwork activities were assessed by Abidin & Saleh (2011), such as "recalling names of new members", and "participating in team discussions". Similarly, Willey & Gardner (2010) use the e-Portfolio platform 'SPARK' to deliver a group assessment in their study at Sydney University to examine how self- and peer- assessment activities within the assignment can promote student learning. The findings suggest that feedback activities added value to teamwork experience (Wiley & Gardner, 2010), however the results of the peer assessments were used to moderate project marks. Consequently, Willey & Gardner (2010) state that students perceived the feedback tasks as a way to 'deter free-riders', rather than as an opportunity to receive constructive feedback to aid in self-development. This may have diminished the effectiveness of such tasks to develop teamwork skills.

3.3 Teamwork in Engineering Education Research

Engineering education research into teamwork skills development focuses on understanding the skills required for effective teamwork, and not necessarily on developing the requisite skills in students, consequently there is a research gap regarding how e-Portfolio developmental activities can be used as a framework to effectively develop teamwork skills.

Vasquez et al. (2020), Michalaka & Golub (2016) and Boudreau & Anis (2020) have conducted studies into the importance of team formation. Vasquez et al. (2020) experiments with three different formation approaches – instructor-defined, self-selected and a mix of the two – with results suggesting that a combined approach improves team effectiveness. Boudreau & Anis (2020) argue that a structured approach to team formation is required because merely assigning group work is insufficient for developing collaborative skills. An issue which arises with optimising team dynamics to increase performance is that it decreases opportunities for students to learn how to be effective team members, nor does it actively train students to manage team-related challenges when they occur.

Project-based learning (PBL) is accepted as an effective method of instilling teamwork skills in engineering students (Du et al., 2020; Gomez Puente et al., 2020; Mostafapour & Hurst, 2020). According to Gomez Puente et al. (2020), the following characteristics of PBL are conducive to developing teamwork skills: they require significant interaction between members, they are open-ended and ill-defined and require multidisciplinary and diverse technical skill sets. Students, however, commonly responded by dividing the workload and completing elements of the project individually, rather than engage in collaborative processes (Hurst et al., 2016; Lindard & Barkataki, 2011). Additionally, Hurst et al. (2016) contends PBL approaches are less effective if students have not been taught the necessary interpersonal skills – such as open communication and conflict resolution – required to navigate dysfunctional team dynamics. Consequently, models to teach and facilitate teamwork in students are required in engineering education. Zou & Ko (2012) implemented a three-year study in engineering students at a Hong Kong institution with the aim of developing teamwork skills by giving explicit instructions, formative feedback and practice opportunities. The study found that students learned to effectively address team conflicts via open and constructive communication and changed their initial understanding of teamwork as a division of labour (Zou & Ko, 2012).

4. Methodology and Framework

Based on an ethnographic design, this study seeks to explore the perceptions and understandings of a group of undergraduate students in relation to their teamwork skills development. The project involved multiple exploratory methods of data collection and a framework analysis approach to student responses to developmental tasks, in addition to the researcher’s own observations (Parkinson et al., 2015). The research was conducted during the first semester of 2021 in a first-year undergraduate engineering course at an Australian university. The first-year common unit ‘Engineering Design: cleaner, safer, smarter’ was selected because one of the unit’s outcomes is to “work collaboratively and articulate practices that lead to successful teamwork in a multicultural context”. The assessment schedule included the delivery of two major chemical and electrical engineering team projects using the PBL method.

A framework using e-Portfolio-type developmental tasks was implemented in the unit. The framework involved formative peer feedback exchange in weeks 4, 8 and 11 using the ITP Metrics Peer Feedback Tool (itpmetrics.com), where students rated each other from 1-5 for the following teamwork competencies: commitment, capabilities, knowledge, focus and standards; guided goal setting in the form of an Individual Action Plan (IAP); weekly reflective discussions in weeks 7-10 class tutorials; and a graded summative 400-word ‘Teamwork Skills Development’ Reflective Essay. The framework (Figure 1) was designed to complement the assignment submission dates and allows for students to continuously practice and develop their teamwork skills via a feedback loop (Figure 2).

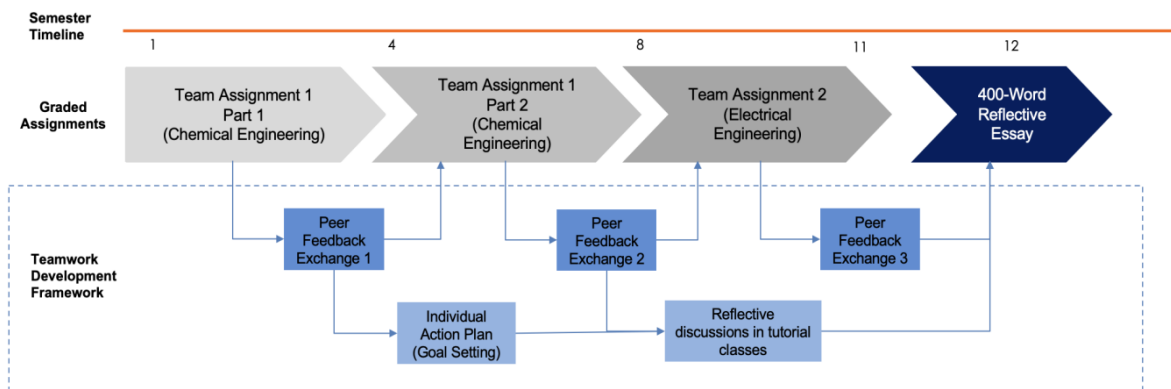


Figure 1: Diagrammatic representation of framework in relation to assignments

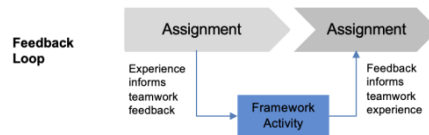


Figure 2: Framework feedback loop

The study was approved by the university’s Human Research Ethics Committee under Project ID 28198, and students were required to give consent for their data to be used in this paper. All unit students (n = 641) were invited to participate in this study, with 239 consenting students forming the participant group. Student responses to the teamwork activities formed the data sources for the project. Responses to the ITP Metrics were accessed online. Students uploaded their IAP to a Google Drive after selecting a semester-long teamwork goal based on their week 4 ITP Metrics results. The main researcher attended class reflective discussions to observe tutorial dynamics and recorded the sessions for transcription. The Reflective Essays were submitted to the university’s ‘Moodle’ portal. To analyse the data, a framework and thematic approach was used due to the volume of available qualitative data. Framework analysis (Parkinson et al., 2015) offers a rigorous and flexible approach to understanding a large volume of qualitative data and is suitable for analysing evaluative investigations. The thematic evaluation of the reflective essays for this paper was separate to the graded evaluation that contributed to students’ final grades. The Reflective Essays were graded by teaching assistants and assessed students’ reflection on their teamwork skills development and the challenges associated with goal setting and achievement. They were not used to assess the proposed e-Portfolio type activities or the unit coordinator role. In addition, the main researcher was not involved in either the design of the teamwork skills development framework implemented in the unit, or the delivery of such activities or marking.

5. Findings

5.1 Individual Action Plan (IAP) Findings

Seven themes emerged from a keyword analysis of the IAP responses, summarised in Table 1 and 2. ‘Outcomes’ and ‘Teamwork Processes’ were the most frequent themes used by students in discussing why their selected teamwork goal was important for their personal development and for their engineering career.

Table 1: Summary of keyword themes found in IAP responses

Themes – Theme Definition	Keywords
Outcomes – consequences of teamwork	Outcomes, grades, marks, standard, quality, performance, completing work, complete tasks, goals, achievement
Teamwork Processes – actions and processes involved in conducting teamwork	Communication, teamwork, collaboration, consensus, contribution, group projects, delegation, fairness, workload distribution, cooperation, leadership, dedication, sharing ideas, engagement
Time Management – actions and consequences related to timely task organisation	Procrastination, efficiency, organisation, deadlines, up to date, rushing, on track, get things done, time management, timely, delay, last minute, productiveness
Relationships – interpersonal aspects of teamwork and interactions between team members	Relationships, understanding, helping others, conflict management, encouragement, feedback, learning from another, trust, influence, support, care, valuing others, respect, openness, different backgrounds, social skills, morale, getting to know each other
Career – consequences, relevance and application of teamwork in professional setting	Career, employability, being a better employee, workplace, clients, money, cost, stakeholders, professionalism, workforce
Personal Growth – development of individual habits, mindset, and attitudes	Personal growth, improvement, learning, strengths and weaknesses, motivation, confidence, capability, effort, ITP metrics, pride, progress, striving, habits, accountability, progression, attitude

Wellbeing – impact of teamwork experience on personal health and enjoyment	Stress, mental health, balance, leisure, extracurricular activities, hobbies
---	--

Table 2: Frequency of keyword themes and illustrative examples in IAP

Themes	Occurrence	Examples
Outcomes	145	<i>My whole life depends on grades, and it is the only way to prove myself – Student E18.1</i>
Teamwork Processes	123	<i>Team members should understand each other's capabilities, so they can divide the work up to work more efficiently – Student Z14.3</i>
Time Management	106	<i>Focus is required to reduce procrastination, ensure deadlines are met and that work is completed in an efficient manner – Student C25.3</i>
Relationships	94	<i>Forming good relationships with team member is important...with little focus, the team can quickly become dysfunctional – Student C25.3</i>
Career	83	<i>If I wish to work at the places which I deem desirable, obtaining and improving my personal and technical skills will make me the best engineer I can be – Student D2.3</i>
Personal Growth	82	<i>Student engineers should identify their strengths and weaknesses so that engineers can enhance and work on them – Student Z14.3</i>
Wellbeing	33	<i>I feel a lot of stress if work is done at the last minute – Student A3.1</i>

5.2 Teaching assistant (TA) Engagement

All TAs were instructed to provide feedback for the IAPs. However, only 4 out of 18 TAs provided feedback to their students, with only 61 out of 239 students receiving feedback for their IAPs. TAs were also tasked with leading reflective discussions in tutorial classes to facilitate student discussions about their teamwork skills development. Although TAs were provided with guidelines for a 30-minute session, discussion topics and lengths were inconsistent across discussions, impacting student engagement. Findings pertaining to the twelve observed tutorial sessions are summarised in Table 3.

Table 3: Engagement levels in teamwork skills development tutorial discussions

Engagement Level	Low	Medium	High
Class Discussion Length	2 – 5 minutes	6-9 minutes	10 + minutes
TA Behaviour	TA calls on students in quick succession without providing feedback.	TA engages with students by asking simple follow-up questions	TA asks multiple-follow up questions and gives targeted guidance
Student Behaviour	Students are unprepared for discussion and unwilling to volunteer. Students use generic examples.	Students are prepared for discussion and use specific and personal examples. Students do not engage in reflection.	Students actively volunteer, evidence of reflection, self-awareness, engages with feedback
No. Classes	6	3	3

5.3 Peer Feedback (ITP Metrics) Findings

The collective average of the participant group's ITP scores did not vary across weeks 4, 8 and 11 ITP Metrics results. The peer-rated ITP scores remained within a range of ± 0.04 for all competences: Communication: 4.44-4.47; Capabilities: 4.48-4.50; Commitment: 4.51-4.54; Standards: 4.43-4.45; Focus: 4.34-4.38. Students rated their teamwork competencies more accurately as the semester progressed, reducing the difference between their peer- and self-rated scores (Figure 3). 37% of students in week 11 gave themselves a rating that was equal to that given by their teammates, compared to 4% in week 4.

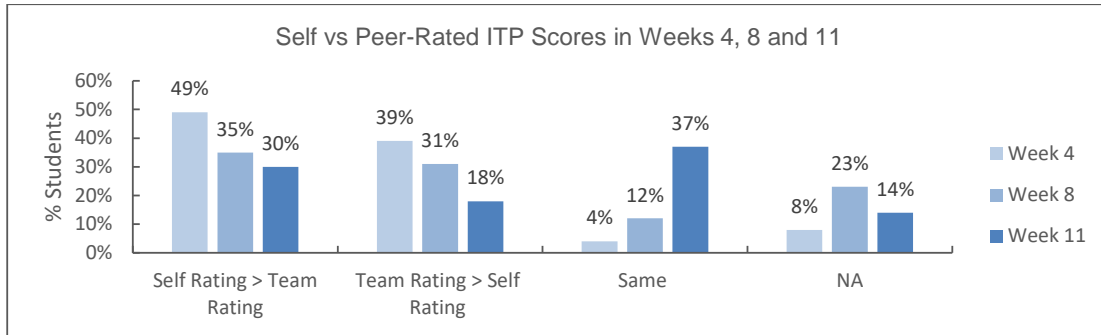


Figure 3: Comparison of self- and peer- ratings for weeks 4, 8 and 11, n = 239

Overall, students improved their goal competency score more than their overall teamwork score. Figure 4 shows the proportion of students whose overall ITP and individual goal competency scores increased, decreased, or stayed the same between weeks 4 and 11. Students who fell into the 'NA' category did not complete their survey, or specified a goal that was not one of the five competencies. A smaller proportion of students received a lower week 11 goal score (21%) compared to the proportion of students who received a lower overall score (41%).

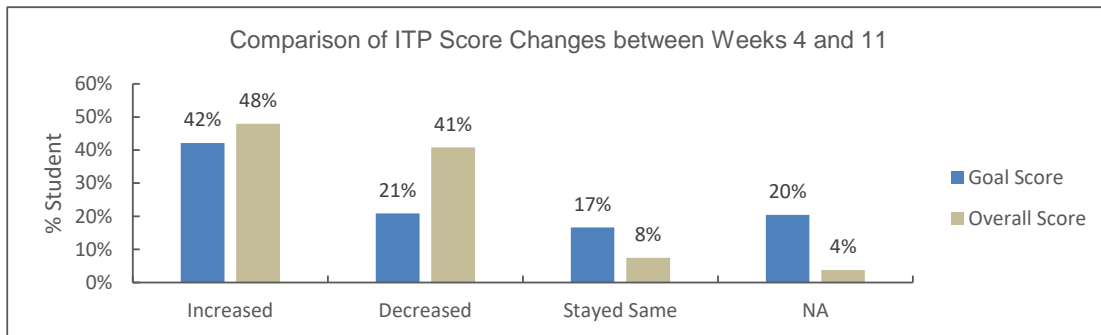


Figure 4: Goal and overall ITP score changes between weeks 4 and 11, n = 239

5.4 Reflective Assignment Findings

Similar to the IAP responses, keyword analysis of the Week 12 Reflective Essays yielded seven themes related to teamwork and skills development, summarised in Table 4.

Table 4: Frequency of keyword themes and illustrative examples in Reflective Essays

Themes	Occurrence	Examples
Personal Growth	345	<i>[The project] has allowed me to grow my teamwork skills and motivate myself without the need of external pressures – Student A1.3</i>
Relationships	280	<i>One of my goals was to establish and maintain a respective relationship between the team, being able to seek help from each other. I felt like I managed to achieve that...it felt like we were fostering our friendship – Student Z14.3</i>
Teamwork	180	<i>If I had actively engaged with group members and had clearer communication with them to express my commitment, I believe that may have improved the group dynamic – Student B13.2</i>
Time Management	150	<i>I perceive time management to be an invaluable skill not only for work at university but also in engineering and other workplaces as there will always be deadlines and time pressure – Student B13.3</i>
Outcomes	120	<i>I made it a goal to get try my best for my team as by only working towards my goal in a unit where teamwork is key was selfish- Student D12.1</i>

Health and Wellbeing	95	<i>I was able to learn the importance of delegating work and trusting my teammates such that none of us was working towards stress burns outs – Student Z8.2</i>
Career	50	<i>We would get caught in the inequivalent distribution of the work required. By week 11, rather than being irked by the uneven workload, I started to embrace it – taking it as an experience to prepare myself for the rest of my engineering career – Student Z8.2</i>

A second level of framework analysis was undertaken, with a focus on understanding how students used the e-Portfolio-type developmental activities (ITP Metrics and IAP) to improve their teamwork skills over the semester, results are summarised in Table 5.

Table 5: Use of development tools and examples from Reflective Essays

Tool	Use	Examples
ITP Metrics	Bench-marking tool	<i>The feedback I received over the 3 ITP Metrics helped me to understand my strengths and the areas that I need to improve – Student D4.2</i>
	Feedback tool	<i>I paid attention to the written feedback in each review. My teammates were kind and helped to highlight my strengths. This helps me realise there are people who notice the things I do to help – Student C21.2</i>
	Catalyst for change	<i>Although I had set my goal, in the period from week 4 to week 8 I had not actively taken any action to work towards fulfilling it. This is evident from my week 8 ITP metrics report...however, this plateau acted as a much-needed reminder of my Individual Action Plan – Student E3.2</i>
	Teamwork attribute framework	<i>ITP Metrics highlighted areas in which I needed to improve team skills and provided a platform for in depth analysis and improvement of beneficial team skills and attributes</i>
	Catalyst for reflection	<i>It should also be noted that much of my self-ratings had been highly biased as I had given myself perfect ratings even when not deserved. Therefore, I intend to continually improve on peer feedback throughout the coming units and beyond – Student B26.1</i>
IAP	Goal Identification	<i>Setting goals enabled me to better my focus in not just this unit, but across all of my studies, which will moreover aid in the development of my career - Student E21.1</i>
	Future Actions	<i>It was insufficient to only set goals, the tracking of progress and the making of appropriate alteration was more important to achieve impactful effects. Goal setting presented the first step of self-awareness in my professional development as an engineer – Student Z15.1</i>

6. Discussion

6.1 Developing student understanding of the value of teamwork skills

Initially, students struggled to articulate why teamwork skills are important to their personal growth and their engineering career. Keyword analysis of IAP responses suggests that students value teamwork skills because it can improve grades. For example, Student E18.1 emphasises grades as the most important factor for success – “*my whole life depends on it, and it is the only way to prove myself*”. In total, ‘outcome’-related keywords appeared 145 times, which was more frequently than for any other keyword theme. Only a small proportion of student IAP responses explained why teamwork skills are important for building and managing relationships, personal growth, and career development. These responses framed the student’s teamwork competency goal as an attribute they wished to improve because of its intrinsic value, and not only because it can improve their grades. For example, Student Z05.1 states that “*I hope to improve myself so I can do more, communicate with my peers better and assist them in areas they are confused about*”. It is likely that students initially struggled with explaining why and how teamwork skills were important for their personal development as the participant pool consists of engineering students in the first semester of

their degree, and, therefore, lack experience working in an engineering-related team. Students cannot speak to what they do not know. Indeed, Engineers Australia's attainment indicators for the teamwork competency are for students who have *completed* their degree (Engineers Australia, n.d.). At this starting point in their engineering education, the students are not expected to have developed a full awareness of the value of teamwork skills.

Thematic analysis of students' Reflective Essay responses – submitted *after* the students have gained experience working in engineering teams – indicate a shift away from an outcome-based understanding of teamwork and towards an experience-based understanding, with an emphasis on personal development and interpersonal experiences. In contrast to the IAP, the most prevalent keyword themes in the Reflective Essays are 'Personal Growth' and 'Relationships'. Students measured teamwork success based on whether they developed a good relationship with their team members and whether they enjoyed their experience, rather than with their project outcomes. This is evidenced by Student Z17.2, who states that "*the first step in effective communication is to see the other party as an individual rather than a pawn to further grades. I'm proud to say I consider my teammates my friends*". In addition, where students did discuss 'outcomes' in their reflective responses, the emphasis shifted away from personal success (i.e., "*my grades*") and towards the team's collective goal. An illustrative example is Student D12.1's reflection that "*only working towards my goal in a unit where teamwork is key was selfish*". A large proportion of students explicitly attribute their greater appreciation for the value of teamwork skills to the e-Portfolio-type developmental tasks (unprompted), which complimented their lived experience of working in teams. Based on the Reflective Essays, the ITP Metrics tool was instrumental in improving student understanding in three ways – as a framework to understand how specific teamwork competencies contribute towards teamwork, as a feedback tool to understand how behaviour impacted teammates, and as a catalyst for reflection (particularly when students' peer ratings differed significantly from expectations). In essence, the peer-feedback exchange helped students develop greater empathy. This is evidenced by Student C21.2, who stated that positive feedback from teammates "*helped me realise that there are people who notice the things I do to help the team...the feedback motivates me to keep up my good habits*". Conversely, Student Z14.3 realised that activities could negatively impact their teammates, stating that "*after our week 4 ITP feedback came, my team and I organised a meeting to discuss our grades. Through the meeting I discovered the problem lies within my very awkward work schedule.*"

6.2 Assessing the effectiveness of a framework using e-Portfolio-type tasks

In their Reflective Essays, most students evaluated their teamwork skills to have improved. Indeed, students were more successful in developing their goal teamwork skills compared to their overall teamwork skills. Students explicitly attributed their teamwork skills development to both the ITP Metrics tool and the IAP. Peer feedback exchange helped students improve their skills in two ways – as a benchmark for their progress over the course of the semester, and as a catalyst for improvement (particularly when students received poor feedback from their teammates). For example, Student D5.2 stated that their peer feedback results "*came as an initial shock, but the drop in score acted as a wake-up call to myself*". Similarly, Student E3.2 stated that "*although I had set my goal...I had not actively taken any action towards fulfilling it. This is evident from my week 8 ITP metrics report...However this plateau acted as a much-needed reminder of my Individual Action Plan*". For many students, the IAP worked in tandem with peer feedback exchange – the ITP Metrics was used to monitor and motivate progress, while the IAP aided with the practical development of teamwork skills. Students found goal setting to be an important 'first hurdle', with Student E21.1 stating that "*setting goals enabled me to better my focus in not just this unit, but across all of my studies*". This suggests that a framework using e-Portfolio-type developmental activities is effective in improving teamwork skills in student engineers.

In addition, students became more accurate at assessing the level of their teamwork competencies. Accurate self-assessment is an important step in the developmental process – it is likely that students who perceive their skills to be more advanced would be less motivated

to develop them to a higher standard. This is evidenced by Student B26.1, who stated that “*my self-ratings had been highly biased as I had given myself perfect ratings even when not deserved. Therefore, I intend to continually improve on peer feedback throughout the coming units and beyond*”. This suggests that ITP metrics (or other peer-feedback tools) can be effective in helping students to assess their strengths and weaknesses and illuminate personal ‘blind spots’. This contrasts with Willey & Gardner’s study (2010), where peer assessment is determined to be less effective for learning and developmental purposes, as most students predominantly used them to ‘deter free-riders’. Significantly, the weeks 4 and 8 ITP results in this study were not used as a moderating tool, therefore shifting the focus of its use away from ‘punishing’ poor teammates to informing personal development. In addition, while the week 11 ITP results were used to moderate assignment grades, there was no evidence that students assessed their peers, or themselves, any differently. Indeed, many students who had received low peer-ratings in their week 11 ITP results commented in their Reflective Essays that it was a fair assessment based on their performance.

6.3 Challenges in implementing e-Portfolio-type developmental tasks

There were two challenges in implementing e-Portfolio-type tasks to develop teamwork skills. The first is the low rate and varying quality of TA engagement, specifically in providing feedback to students and directing tutorial discussions. The second challenge is the lack of ongoing student engagement with some of the developmental tasks.

Only four TAs out of eighteen left comments on their students’ IAPs, resulting in 61 students (out of 239) receiving feedback. TAs who did not provide feedback may have not done so for a variety of reasons. They may have had a high marking workload (other unit assignments), may have been uncertain as to how best to provide feedback for these ‘non-traditional’ assessments, or saw little value in the tasks themselves. This is consistent with the findings of Mostafapour & Hurst (2020), whose interviews with instructors suggest that while they valued teamwork and project management skills, many were not confident in ‘teaching’ such skills. Varying levels of engagement are also reflected in the length of the guided reflective tutorial discussions – none of the twelve tutorial discussions reached the 20 minutes allocated for teamwork development, with four sessions lasting under five minutes. Although each class contained approximately twenty students, only two to three students in these tutorials had an opportunity to share. Furthermore, these four short discussions lacked a conversational back-and-forth, with TAs directing the conversation by merely moving from one group to the next (“ok, next team?”) without providing any guidance. Additionally, the level of student engagement in tutorial discussions positively correlated with the TA’s engagement, and discussions that showed genuine reflection occurred when TAs asked multiple follow-up questions and gave targeted guidance. This is consistent with the observation by Hurst et al. (2016) that students look to their lecturers and TAs as important sources of knowledge for their engineering development – therefore, TA attitude towards such activities is important.

Overall, the completion rate for the e-Portfolio-type developmental tasks was high (i.e., 87% of the cohort wrote an IAP, and nearly all completed their 3 ITP Metrics surveys). This compares favourably to studies by Roberts et al. (2016) – where completion rate was 20% – and Yang et al (2015). In previous studies, participation in e-Portfolio developmental activities was voluntary (e.g., in Roberts et al. (2016)) or graded and therefore mandatory (Ayala & Popescu (2018)). In this study, developmental tasks were delivered in a ‘hybrid’ manner, where student learnings from unassessed activities such as ITPs, IAPs and class discussions contributed to the summative graded 300-word reflective essay. Additionally, the graded reflective essay was only worth 4% – not a significant proportion of the student’s overall unit mark. It is likely that a high number of students completed the tasks because they were integrated with the unit’s two PBL-teamwork assessments and reinforced regularly in tutorial discussions. The high participation rate suggests that this project’s ‘hybrid’ approach balances the need to develop teamwork skills in students and enforce participation by allocating marks for their effort, with the need to develop their intrinsic motivation so that students can then independently improve these skills. Active and ongoing student engagement, however, was

an issue in this study, evidenced by the lack of responsiveness to TA feedback and in-class discussions. It was observed that students were also largely unprepared for reflective discussions. This is consistent with findings by Du et al. (2020) and Hirsch & McKenna (2008), which states that engineering students are generally unfamiliar with and unaccustomed to reflective practice.

7. Recommendations and Limitations

There are two practical recommendations that can be introduced to improve the effectiveness of teamwork developmental tasks for future cohorts. Firstly, TAs require greater professional development training to standardise the amount and type of feedback they are providing their students in the developmental tasks. Increasing TA engagement is not necessarily effective, however, if students themselves do not reciprocate or respond to suggestions and comments. As a result, it is recommended that students be instructed to treat their IAPs as a living document, so they can update it to reflect their progress over the semester. An additional reminder to guide students through the reflective process would enable students to feel prepared for class discussions and engage more constructively with their TA.

While this study drew upon a range of data to assess the effectiveness of e-Portfolio tasks in developing and understanding teamwork skills among engineering students, the study is limited as it lacks a first-person perspective about the experience of undertaking the tasks. Such data would give insight into participants' feelings and beliefs about teamwork skills, as well as an understanding of what they found effective and challenging about completing the developmental tasks. Currently, the study has inferred these insights from the results of the tasks themselves. It is recommended that future exploratory studies include semi-structured interviews or open-ended surveys to allow participants to share their experience and thoughts about the activities. Other limitations include – lack of a comparison group (i.e., a cohort of students who did not participate in e-Portfolio-type developmental tasks) to assess the extent to which e-Portfolio-type tasks aided in teamwork skills development, and an inherent bias in the analysis of the qualitative data (as the framework was largely constructed by a limited number of researchers).

8. Conclusion

This study examined the potential for e-Portfolio learning activities to be used in a framework to develop teamwork skills in student engineers. It found that peer feedback exchange and reflective activities helped students to understand how they behaved in teams and analyse the impacts on their teammates. As a result, students developed a greater appreciation for the importance of teamwork skills in fostering healthy working relationships and personal growth, compared to the initial perceptions that teamwork was important to achieve good grades. This study also found that while e-Portfolio type activities – such as peer feedback exchange, goal setting and reflective practice – improved the teamwork capabilities of students, TAs require more guidance to teach and develop teamwork skills in students in order to increase the effectiveness of e-Portfolio learning activities. The project's findings can be used to enhance content delivery for future cohorts and more broadly, be used to inform an integrated e-Portfolio framework to develop teamwork skills in engineering students over the length of their degree.

9. References

- Abidin, A., & Saleh, F. (2011). Team-Based Electronic Portfolio. Paper presented at the 2011 3rd International Congress on Engineering Education (ICEED), Malaysia.
- Alam, F., Chowdhury, H., Kootsookos, A. & Hadgraft, R. (2015). Scoping e-portfolios to engineering and ICT education. *Procedia Engineering*, 105, 852-857.
- Australian ePortfolio Project (2008). Retrieved 1 June, 2011, from <http://www.eportfolioppractice.qut.edu.au/symposium>.

- Ayala, O., & Popescu, O., (2018). Lessons from Two Years of ePortfolio Implementation in Engineering Technology Courses. Paper presented at the 2018 ASEE Annual Conference & Exposition, Salt Lake City, UT.
- Boudreau, J., & Anis, H. (2020). Effect of Personality Traits in Team Dynamics and Project Outcomes in Engineering Design. *International Journal of Engineering Education*, 36(1B), 420-435.
- Burnett, I., Foley, B., Goldfinch, T., Hargreaves, D., Kind., R., Lamborn., J., Symes, M., & Wilson, J. (2019). *Engineering Futures 2035: A Scoping Study*. Australian Council of Engineering Deans.
- Du, X., Naji, K., Sabah, S., & Ebead, U. (2020). Engineering Students' Conceptions of Collaboration, Group-Based Strategy Use, and Perceptions of Assessment in PBL: A Case Study in Qatar. *International Journal of Engineering Education*, 36(1B), 296-308.
- Engineersaustralia.org.au. 2021. Retrieved March 21, 2021, from https://www.engineersaustralia.org.au/sites/default/files/2019-11/Stage1_Competency_Standards.pdf.
- Fiedler, R., & Pick, D. (2004). Adopting an Electronic Portfolio System: Key Considerations for Decision Makers. Paper presented at the Association for Educational Communications and Technology (AECT) International Conference Proceedings, Chicago, IL.
- Gomez Puente S.M., can Eijck, M., & Jochems, W. (2013). A sampled literature review of design-based learning approaches: a search for key characteristics. *Int J. Technol Des. Education*, 23, 717-732.
- Hallam, G., Creagh, T. (2015). E-Portfolio use by university students in Australia: A review of the Australian ePortfolio Project. *Higher Education Research and Development*, 29(2), 179-193.
- Han, J. (2020). Development of a Teamwork Skill Scale for Engineering Students. *International Journal of Engineering Education*, 36(1B), 483-490.
- Han, J., & Bang, J. (2011). Development of the Elements of Teamwork Skill for Engineering students. *Journal of Engineering Education Research*, 14(5), 1-29.
- Heinrich, E., Milne, J., & Lys, I. (2010). Integrating E-Portfolios: Guiding Questions and Experiences. *Journal of Open, Flexible, and Distance Learning*, 14 (1), 47-61.
- Hirsch, P.L., & McKenna, A.F., (2008). Using reflection to promote teamwork understanding in engineering design education. *International Journal of Engineering Education*, 24(2). 377.
- Hurst, A., Jobidon, E., Prier, A., Khaniyev, T., Rennick, C, Al-Hammound, T., Hulls, C., & Grove, J. (2016). *Towards a Multidisciplinary Teamwork Training Series for Undergraduate Engineering*
- Knott, T., Lohani, V., Griffin, O., Loganathan, G., Adel, G., & Wildman, T., (2004). Bridges for Engineering Education: Exploring ePortfolios in Engineering Education at Virginia Tech. Paper presented at the 2004 ASEE Annual Conference & Exposition, Salt Lake City, UT.
- Leydens, J. A. (2012). Sociotechnical communication in engineering: An exploration and unveiling of common myths. *Engineering Studies* 4(1), 1-9.
- Lindard, R. & Barkataki, S. (2011). Teaching Teamwork in Engineering and Computer Science. Paper presented at Frontiers in Education Conference, Rapid City, SD.
- Michalaka, D., & Golub, M. (2016). Effective Building and Development of Student Teamwork Using Personality Types in Engineering Courses. Paper presented at the 2016 ASEE Annual Conference & Exposition, New Orleans, LA.
- Mostafapour, M., & Hurst, A. (2020). An Exploratory Study of Teamwork Processes and Perceived Team Effectiveness in Engineering Capstone Design Teams. *International Journal of Engineering Education*, 36(1B), 436-449.
- Oakley, G., Pegrum, M., & Johnson, D. (2013). Introducing e-portfolios to pre-service teachers as tools for reflection and growth: lessons learnt. *Asia-Pacific Journal of Teacher Education*, 42(1) 36-50, 2013.
- Parkinson, S., Eatough, V., Holmes, J., Stapley, E., & Midgley, N. (2015). Framework analysis: a worked example of a study exploring young people's experiences of depression. *Qualitative Research in Psychology*, 13(2), 109-129.

- Roberts, P., Maor, D., & Herrington, J. (2016). E-Portfolio-Based Learning Environments: Recommendations for Effective Scaffolding of Reflective Thinking in Higher Education. *Educational Technology & Society*, 19(4), 22-33.
- Students: Development and Assessment of Two First-year Workshops. Paper presented at the 2016 ASEE Annual Conference & Exposition, New Orleans, LA.
- Vasquez, E., DeWitt, M., West, Z., & Elsass, M. (2020). Impact of Team Formation Approach on Teamwork Effectiveness and Performance in an Upper-level Undergraduate Chemical Engineering Laboratory Course. *International Journal of Engineering Education*, 36(1B), 491-501. Willey, K.,
- Gardner, A. (2010). Investigating the capacity of self and peer assessment activities to engage students and promote learning. *European Journal of Engineering Education*, 35(4). 429-443.
- Yang, M., Tai, M., & Lim, C. (2015). The role of e-portfolios in supporting productive learning. *British Journal of Educational Technology*, 47(6), 1276-1286.
- Zou, T., & Ko, E. (2012). Teamwork development across the curriculum for chemical engineering students in Hong Kong: Processes, outcomes and lessons learned. *Education for Chemical Engineers*, 7(3), e105-e117.

Copyright statement

Copyright © 2021 Anna Dai, Nicoleta Maynard, Veronica Halupka, Misol Kim: The authors assign to the Research in Engineering Education Network (REEN) and the Australasian Association for Engineering Education (AAEE) and educational non-profit institutions a non-exclusive licence to use this document for personal use and in courses of instruction provided that the article is used in full and this copyright statement is reproduced. The authors also grant a non-exclusive licence to REEN and AAEE to publish this document in full on the World Wide Web (prime sites and mirrors), on Memory Sticks, and in printed form within the REEN AAEE 2021 proceedings. Any other usage is prohibited without the express permission of the authors.