Using Self Assessment to Integrate Graduate Attribute Development with Discipline Content Delivery

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Abstract
Professionals, in addition to being technically competent, require skills of collaboration, communication and the ability to work in teams [1,2]. There is a reported competency gap between these skills required by employers and those developed by students during their undergraduate courses [3,4]. In response to this gap Universities have introduced graduate attributes which their students should develop during the course of their degree. Some of these attributes are discipline specific, others are generic to all professions. Generic attributes include teamwork skills, being able to think both critically and independently, being able to critically appraise their work and the work of others, and an appreciation of the need and value of critical reflection in one's academic, personal, and professional life. The development of all these attributes can be promoted by employing self and peer assessment. Thoughtful use provides opportunities to practise, develop, assess and provide feedback on these attributes and develop students' judgement [5] even within subjects where traditional discipline content is taught. Our research involves using two assessment metrics produced from confidential student self and peer evaluations. These metrics are shared between all group members in structured feedback sessions several times a semester. This allows students to identify their individual strengths and weaknesses and address any competency gaps in their development. These metrics also allow progress to be assessed not only within a single subject but throughout an entire degree program.

Keywords—self and peer assessment, graduate attributes, teamwork, online tools, SPARK®.

1. INTRODUCTION

Professionals, in addition to being technically competent, require skills including collaboration, communication and the ability to work in teams [1,2,6,7]. However, there is a reported competency gap between the skills required by employers and those developed by students during their undergraduate courses [3,4]. In response to this, universities both in Australia and internationally [8] have introduced attributes which their students should develop during their degree.

Generic attributes are typically required in the practice of all professions. For example attributes shared by most disciplines include teamwork skills, being able to think both critically and independently, being able to critically appraise one's work and the work of others, and an appreciation of the need and value of critical reflection in one's academic, personal, and professional life. The development of all these attributes can be promoted by using self and peer assessment. Used appropriately it provides opportunities to practise, develop and assess these professional skills and develop students' judgement [5] within subjects where traditional discipline content is taught.

Similarly these attributes are generally required by professional organisations to obtain degree program accreditation or for their members to obtain professional accreditation. For example Engineers Australia Accreditation Policy [9] lists attributes divided into three Units of Competency:

- Unit 1: Knowledge Base

- Unit 2: Engineering Ability
- Unit 3: Professional Attributes

The well targeted use of self and peer assessment can not only be used to guide students to learn and develop outcomes within these categories, but also to monitor and track this development. In addition, the use of self and peer assessment can assist institutions in demonstrating their compliance to achieve professional association accreditation.

Some instructors have a simplistic view of knowledge transfer that considers that the skills and learning required by students are achieved as a series of discrete steps or competencies which are required or built on one by one [10]. Once acquired it is assumed that these skills can be simply transferred by students to diverse situations. This is not the case and is one reason why rote learners who have not deeply engaged with material can not then use it in a different context. Hagar [10] suggests that knowledge transfer can be seen as a contribution to facilitating ongoing learning, as an expansion of previous knowledge via the experience of dealing with new situations in new settings.

Similarly, Generic Attributes are often thought of as discrete skills, while some could be described as skills most are really the development of attitudes and dispositions. Generic attribute development is an ongoing and highly contextual process. Generic graduate attributes in some sense could be considered as the maturity or ability to apply previous knowledge to new contexts achieving new learning and knowledge [10]. Thus to effectively develop graduate attributes in students throughout their degree program subjects should be designed such as to provide opportunities for these attributes to be continually developed and assessed in various contexts. Failure to address the development of these generic skills may leave students underdeveloped in their ability to apply discipline-specific skills in different contexts.

As educators we are trying to assist students to move from novices to experts in the way they apply learnt material in different contexts. An essential component of any learning process should include students receiving feedback on their development. Feedback is often provided long after the assessable work has been completed, at which time students may no longer be interested. Hence for feedback to be productive and useful for student reflection, it must be both timely and focused. The thoughtful use of online self and peer assessment processes can not only be used to provide this feedback efficiently, even in large classes, but to promote, monitor and assess the development of most graduate attributes.

1.1 Self and Peer Assessment

The use of self and peer assessment has been widely reported in the literature [5,11,12,13]. While its' use for summative assessment has proved effective in discouraging group free riders and promoting collaboration, our research has found that using it to produce formative learning-oriented feedback to complete the learning cycle significantly improved students' learning outcomes [14]. In addition to promoting academic honesty, it encouraged the ongoing development of skills and improvement in the quality of subsequent contributions. Furthermore we use assessment metrics to allow graduate attribute development to be both assessed and tracked throughout a subject or a whole degree program.

Incorporating self and peer assessment, especially in large classes, is impractical without the assistance of online tools. However the success of such tools in improving students' learning and attribute development depends critically on how academics implement them within their subjects [15]. In this paper we discuss our use of an online tool called SPARK® (Self and Peer Assessment Resource Kit [15]) to integrate the development of graduate attributes within engineering discipline subjects.

2. EXAMPLE OF SPARK® IMPLEMENTATION

SPARK® is an online tool that facilitates the collection of confidential self and peer evaluations. Usually SPARK® is used to assess and provide feedback regarding a team member's contribution to a group project, however the authors have also used it to provide assessment and feedback to students on individual projects assessed by themselves and their peers. In this paper we will restrict our discussion to the assessment of group work.

Feedback and assessment can be either aggregate (assessment of the students' overall contribution to the project) or category based where the assessment and feedback is reported over a number of different categories or attributes. SPARK® automatically generates both a performance and feedback assessment factor based on the work of Goldfinch [11,12]. The Self and Peer Assessment or SPA factor (see Equation (1)) is a weighting factor that can be used to determine an individual's contribution to a team project as indicated in Equation (2). A SPA factor of 1 indicates a student's contribution was equal to the average contribution of their team.

$$\text{SPA Factor} = \sqrt{\frac{\text{Total ratings for individual team member}}{\text{Average of total ratings for all team members}}} \quad (1)$$

$$\text{Individual mark} = \text{team mark} * \text{Individual's SPA} \quad (2)$$

The second factor calculated is the Self Assessment to Peer Assessment or SAPA factor as shown by Equation (3). It is the

ratio of a participant's own rating of themselves compared to the average rating of their contribution by their peers. Used appropriately this has strong feedback value for a participant's ongoing development. For example, a SAPA factor greater than 1 means that a student has rated their own performance higher than they were rated by their peers. Conversely, a SAPA factor less than 1 means that a student has rated their own performance lower than they were rated by their peers.

$$\text{SAPA Factor} = \sqrt{\frac{\text{Self ratings for individual team member}}{\text{Average of ratings for individual by peer team members}}} \quad (3)$$

These metrics are used to facilitate the provision of feedback, enabling students to identify their strengths, weaknesses and any competency gaps to focus their effort into improving performance.

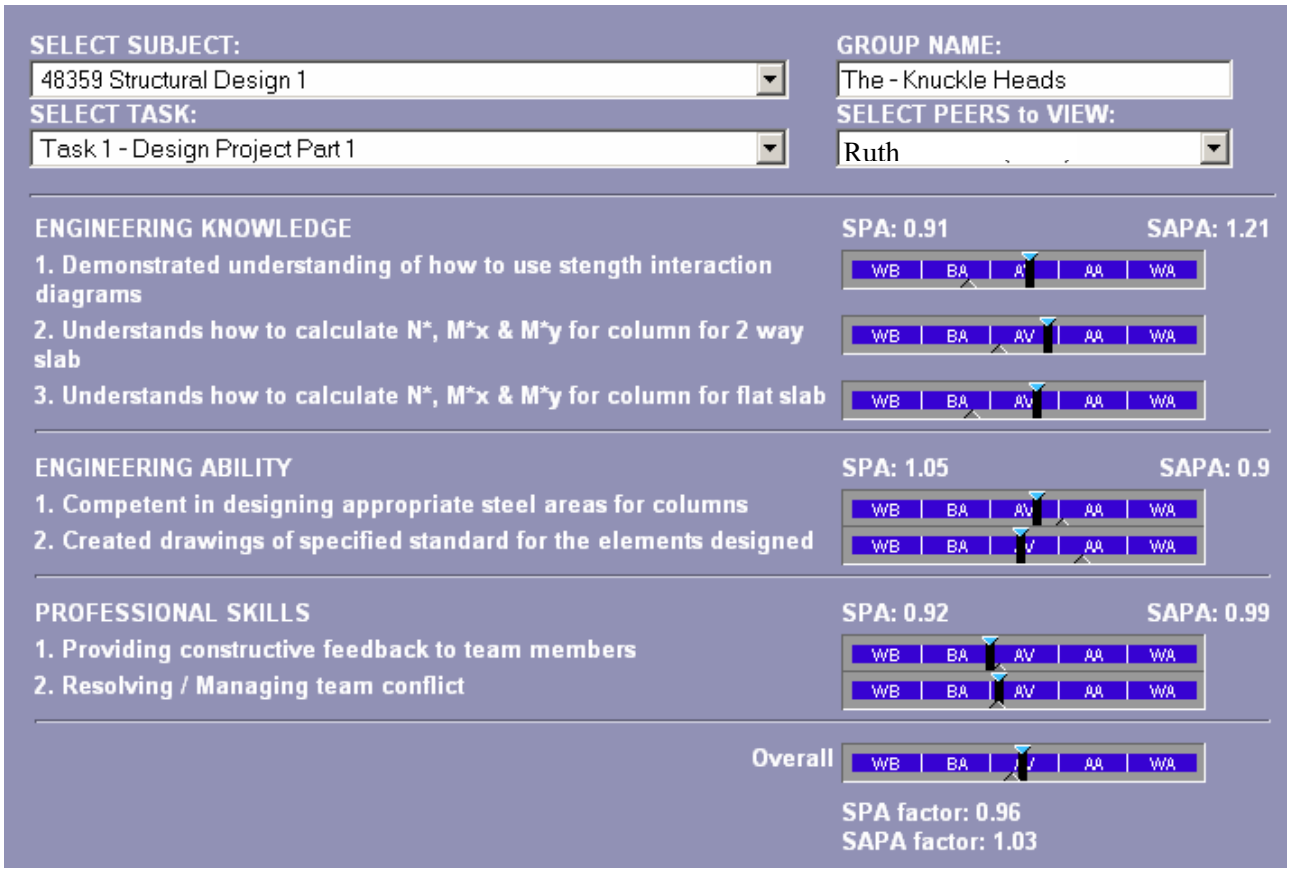

FIGURE 1. Feedback and performance factors for student named Ruth (the criteria shown are a subset of the criteria used in the subject Structural Design1) . Note this screen shot is from SPARK® version 2 currently being developed by the University of Technology, Sydney and The University of Sydney.

Let us assume that Figure 1 reports the feedback and performance factors for a student named Ruth. Referring to the figure it can be seen that the aggregate performance factor (0.96) indicates that Ruth is performing well, contributing only slightly lower than the average performance of her team peers. There is no indication as to what areas if any Ruth may need to improve her performance. The formative feedback or SAPA factor of 1.03 indicates that Ruth's opinion of her own performance is approximately the same as the average opinion of her performance by her team peers. However, further insight is gained by looking at the individual factors for each attribute. These report that:

Engineering Knowledge: Ruth's contribution to the team's required Engineering Knowledge is below the average of her team peers (SPA = 0.91). Furthermore and perhaps more importantly the SAPA factor of 1.21 indicates that Ruth is unaware that her peers feel she is underperforming in this area. Ruth feels she has made a much greater contribution.

Engineering Ability: Ruth's Engineering Ability contribution to the team is above the average of her team peers (SPA = 1.05). Furthermore the SAPA factor of 0.9 indicates that Ruth underrates the significance of this contribution to the team and may not be aware that her team peers highly regard her contribution.

Professional skills: Ruth's contribution to the team using her professional skills is below the average of her team peers (SPA = 0.92). Furthermore the SAPA factor of 0.99 indicates that Ruth is aware that her contribution was below average in this area.

In summary, analysis of the individual factors indicates that Ruth's strength is this project was her Engineering Ability. That is, her ability to apply and utilise her knowledge to solve engineering problems. Her weaker areas of contribution to this team project were her Engineering Knowledge and Professional Skills. Furthermore prior to receiving this feedback Ruth may have been unaware that she was underperforming in her Engineering Knowledge contribution and did not appreciate how highly the team rated her Engineering Ability.

This feedback allows Ruth to build on her strengths and address her weaknesses. In addition, being able to identify individual strengths and weaknesses helps academics to provide specific coaching to students where required.

The fact that SPARK® is a criteria-based tool allows academics the flexibility to choose or create specifically targeted criteria to allow any task, including the development of generic and discipline-specific attributes, to be assessed. In addition, using common categories (like the three described above) throughout a degree program, to which academics link their chosen criteria, allows the results to be recorded, for example in an e-portfolio, providing a means for both academics and students to monitor and track a student's attribute development as they progress through their degree. While we acknowledge that these assessments, being subjective assessments by team members, may not in all instances accurately reflect the actual level of a student's attribute development, they do provide useful guides and indeed mirror the professional situation where an individual's contribution and performance are judged by his or her peers. In addition, if multiple peers are used (eg teams of size 4 to 8) in the evaluation process, any bias from a single member of the evaluation group tends to be averaged out.

Our aim has been to use self and peer assessment to facilitate measured improvement within a single semester while simultaneously developing skills that will help to generate a positive attitude to lifelong learning. To achieve this we have found it necessary to use self and peer assessment multiple times during a semester to not only improve student learning, but to facilitate specific, targeted feedback from both academics and team peers. Using an online tool makes multiple uses possible, even in large classes, without an unmanageable administrative burden. The metrics are shared between all group members in feedback sessions several times a semester to assist learning. Students are guided on how to both reflect on their own performance and learning, and to give constructive feedback to their team peers [16]. The process focuses on improving students' judgement and moving them to be more expert in their ability to engage with subject learning outcomes. The use of regular formative feedback allows students to reflect on their performance and identify their strengths and weaknesses in regard to their skill development. They are then able to put into practice what they have learned to improve their future performance and overall grade.

Self and peer assessment using SPARK® is currently implemented in a number of subjects throughout the engineering degree offered by UTS. In this paper we report on its use in two subjects where specific engineering discipline content is taught.

2.1 Subject Implementations

In this paper we discuss two subjects, Design Fundamentals and Structural Design 1, in which self and peer assessment is used to assess, assign marks and provide feedback on a combination of both discipline and generic professional attributes with which students must engage as part of a major group project. Table 1 provides a brief outline of each subject including the main subject aims, group work tasks and how self and peer assessment is used.

The first subject Design Fundamentals is a second year subject taken by all engineering students. The subject's primary aim is to develop students' understanding of the engineering design process and to provide them with the skills to develop a small engineering project from initial concept through the design stages of requirements analysis, system design, and detailed design to the development of an alpha prototype and then planning for further development and product production. A secondary but just as important aim of the subject is to build on students' skill and generic attribute development begun in the first year of their degree. Students are required to work in teams to produce a prototype product, two written reports (requirements specification and design documentation) and make an oral presentation.

The second subject Structural Design 1 is a third year (or later) subject taken by all civil, civil and environmental, and construction engineering students. The subject's primary aims are to develop students' understanding of the behaviour of reinforced concrete structural elements such as beams, slabs and columns, and to develop competence in using and interpreting the Australian Standard for Structural Design Actions [17] and for Concrete Structures [18]. This subject introduces students to the fundamentals of the structural design process and the philosophy of limit state design. Students participate in a project to design beam, slab and column elements for one storey of a low-rise reinforced concrete building. The design project consists of three staged submissions: 1. Loading and Beam Design, 2. Floor System Design, and 3. Column Design, where students submit their design calculations, decisions and drawings.

To promote the development of both discipline-specific and generic professional skills, as well as academic honesty, a process of self and peer assessment is used in both subjects. The results of these assessments are used to provide constructive feedback to students on their engineering knowledge, ability and professional skills including how they are contributing to their teams, as well as to determine individual assignment marks by appropriate adjustments of group marks.

In each subject the coordinating academic chooses a number of criteria to be used in each self and peer assessment exercise. These criteria are in turn categorised as belonging to either engineering knowledge, engineering ability or professional skills. For example a subset of the criteria used in Structural Design 1 is shown in Figure 1. Categorising the criteria in this way allows students to receive individual feedback on their performance in each category as well as their overall performance ratings as previously described. While the subjects have different criteria associated with the engineering knowledge and ability categories most of the professional skills category criteria are the same. These include criteria assessing a student's teamwork, critical evaluation, feedback and communication skills.

Subject	Design Fundamentals	Structural Design 1
Subject aim	• Develop students' understanding of the engineering design process • Develop students' skills to build a small engineering project from initial concept to prototype production. • Promote the development of professional skills including teamwork, critical evaluation, feedback, communication skills and academic honesty.	• Develop students' understanding of the behaviour of reinforced concrete structural elements such as beams, slabs and columns, • Develop competence in using and interpreting the Australian Standard for Structural Design Actions and for Concrete Structures. • Continue the development of team work skills and engineering judgement.
Cohort size	260	65
Tutorial size	32	65
Small group size	4	3-4
Groupwork task	• team delivery and management of multistage engineering project, prototype production, written reports and oral presentation	• team management and multistage submission of design calculations & drawings of reinforced concrete elements of one storey of a low-rise building.
Level of understanding of self and peer assessment	• developing	• competent
Subject runs in	• semester 3 or 4	• semester 5, 6 or 7
Number of times self and peer assessment is used during semester	3	3
Why self and peer assessment is used.	• provide constructive feedback to students on their teamwork skills and how they are contributing to their teams • allow students the opportunity to learn from this feedback to improve subsequent performance. • determine individual assignment marks by appropriate adjustment of group marks • Discourage free-riding	• provide constructive feedback to students on their technical as well as their teamwork skills • allow students the opportunity to learn from this feedback to improve subsequent performance. • determine individual assignment marks by appropriate adjustment of group marks • Discourage free-riding
Marks awarded from SPARK® exercises	• 2.5 marks awarded for completing each self and peer assessment exercise and participating in feedback sessions. • moderation of marks for each stage of the group work project	• moderation of each stage of the group project
Support provided	• tutor facilitated feedback sessions • Structured feedback process • Appeal mechanism	• Some tutor facilitation of feedback sessions • structured feedback process

TABLE 1. Outline of the two subjects used in the trials reported in this paper including a description of how and why self and peer assessment is used.

3. RESULTS

In this paper we will present results from the post-subject survey for both Design Fundamentals and Structural Design 1. Most of the survey questions were written in 5-point Likert format. The results of these surveys are summarised in Table 2. The first figure reports the combined percentage of the two positive response options with the percentage of neutral responses shown in brackets. A blank box means that this question was not asked in the survey for that subject.

Subject	Design Fundamentals	Structural Design 1
Cohort	220 (excluding students who were exempt from part of the project)	63
Respondents	95	41
Survey	Online	Online
Respondents who had previous experience using self and peer assessment	37%	84%
Compared to my previous experience with group work, the use of self and peer assessment facilitated by SPARK has made group work fairer	58% (26%)	32% (34%)
The use of self and peer assessment encouraged **me** to put more consistent effort into my assigned work for the project.	54% (32%)	24% (29%)
Multiple uses of self and peer assessment and the associated feedback sessions improved **my** ability to both assess my work and the work of others.	67% (18%)	34% (29%)
The formative feedback I received from my tutor helped me to improve my performance in the subject.	63% (25%)	
My tutor provided useful formative feedback in the feedback sessions		54% (17%)
The formative feedback I received from my group helped me to improve my performance in the subject.	48% (38%)	37% (29%)
The formative feedback I received from my group will help me to improve my performance in future subjects.	58% (38%)	34% (39%)
Using self and peer assessment facilitated by SPARK improved my group work experience	54% (28%)	32% (24%)
Overall the project has enabled me to develop skills necessary for working as part of a team.	78% (14%)	56% (22%)

TABLE 2. Post self and peer assessment survey results for Design Fundamentals and Structural Design 1

4. DISCUSSION

4.1 Design Fundamentals

This was the third semester in which self and peer assessment had been used in Design Fundamentals. The subject has been specifically designed to simultaneously develop disciplinary skills in engineering design while promoting the development of students' professional skills including teamwork. Self and peer assessment has proved an effective tool in achieving this.

The subject typically involves the use of eight tutors. Some staff, while happy to use self and peer assessment as a means of detecting and punishing group free riders, felt uneasy helping students to develop their professional skills. In most cases this was due to inexperience with self and peer assessment processes and a lack of practice at facilitating small group discussions on non-analytical skills. Prior experience has shown that most tutors need to participate in the subject for at least one semester before feeling comfortable with facilitating the feedback sessions and in particular helping students to interpret their feedback factors.

Students were given 2.5 marks for completing each self and peer assessment exercise and participating in the facilitated feedback sessions. This ensures a high participation rate typically >95%. To receive the marks students must demonstrate that they have engaged with the learning outcomes. This is assessed in a number of ways including tutors asking each group questions in relation to their teamwork and team contribution during the feedback sessions. In addition, students who were found attempting to sabotage the process by submitting dishonest assessments received zero marks. Suspected sabotage is initially identified by academics through the comparison of students' feedback factors (typically a combination of low SPA factor eg <0.90 and high SAPA factor eg >1.1, note these limits vary in accordance with the particular self and peer assessment exercise and the experience of the students) and by students through a formal review process.

4.2 Structural Design 1

The implementation reported here is the first time that self and peer assessment has been used in Structural Design 1. The assessment tasks were re-designed to accommodate group work and the self and peer assessment process. The project was specifically developed to involve too much work for one student operating alone so that students were forced to work collaboratively to complete the assessment tasks. Students were required to both explain and justify their design providing good preparation and practise for when they will have to explain their work to a supervisor or client in the workplace. The project also required students to make a design recommendation ie use their engineering judgement, eg they were required to complete two designs for the floor system, the first as a two-way slab and the second as a flat slab. Each group then had to recommend one of these floor systems for their project, justifying their recommendation.

In this subject there was only one staff member involved in lecturing, tutoring and facilitating the feedback sessions. This staff member had some experience as a tutor in using the self and peer assessment process and facilitating the feedback sessions, but this was the first time they had been responsible for implementing it into a subject. It was assumed that since most students (84%) had previously used self and peer assessment in earlier subjects they would need less guidance in the feedback sessions. As a result each feedback session contained approximately twice as many groups (16 groups) as the sessions held in Design Fundamentals (8 groups).

4.3 Comparison

In both subjects we found that providing all team members with the SAPA (formative feedback) factor encouraged more realistic and honest self assessments, as participants who inflate their self ratings are typically exposed by a high SAPA factor. Providing feedback multiple times during a semester affords students an opportunity to reflect and modify their group behaviour, effort or approach to the remaining parts of the project. Hence they have an opportunity to practise and test what they have learnt. Many teams who perform poorly in the first part of their project, respond positively to this feedback, significantly improving their performance in the remaining stages of the project.

Overall the results from the Design Fundamentals (DF) trial were more positive than those from Structural Design 1 (SD1), with over 50% of respondents reporting that the process had made group work fairer (58% DF, 32% SD1), encourage them to put more effort into their work (54% DF, 24% SD1) and improved their group work experience (56% DF, 32% SD1). It is not entirely clear why there was such a difference between the results for each subject, however comments from students suggest there are a number of contributing factors including that:

- It was the first time that self and peer assessment processes had been used in Structural Design 1 compared to Design Fundamentals where the processes had been refined over a number of semesters. There was a strong feeling among approximately 18% of the Structural Design 1 students that self and peer assessment should not be used in such a discipline-specific subject. These students felt that the time spent conducting the three feedback sessions should have been spent on solving more Structural Design tutorial problems.
- The Feedback Sessions in Structural Design 1 involved nearly twice as many students compared to those run in Design Fundamentals. Hence the coordinating academic was unable to contribute as much time to facilitating group discussions. This allowed some students to take a shallow approach to these feedback sessions reducing the overall benefit.

The most encouraging result was that a significant number (at least 30%) of respondents in both subjects reported that the formative feedback they received from their group peers helped them not only to improve their performance in the subject (48% in DF & 37% in SD1) but also expected it to help them improve their performance in future subjects (58% in DF & 34% in SD1). While more students reported that they received beneficial feedback from the tutor (63% in DF & 54% in SD1), we suggest that without the use of the self and peer assessment processes this amount of beneficial formative peer feedback, a significant contribution to ongoing learning, would not have occurred.

It is impossible to ignore the negative responses, the most significant being that 44% of the Structural Design 1 respondents (only 18% in DF) disagreed with the statement *"Using self and peer assessment facilitated by SPARK improved my group work experience"*. While SPARK® is an extremely useful piece of software it is not hands off tool. Academics are still required to think critically about how it is applied and ensure that students understand the SPARK® process before the team task begins [15]. Upon reflection we may have tried to achieve too much, in too little time and subsequently not paid enough attention to how these changes would impact upon both students' expectations and engagement.

Freeman and McKenzie [15] report that SPARK® works best when students can see valid reasons for having a team task in a subject. Furthermore they identified a number of characteristics of successful implementations including:

- The assessment criteria be available from the beginning of the team task.
- Academics help students to gain a clear understanding of why self and peer assessment using SPARK® has been introduced
- That the system is reliable and accessible throughout the semester.

We are currently running a second series of trials in the same subjects. This time we have used the new version of SPARK®, depicted in Figure 1, that provides more feedback to students (the trials reported in this paper were conducted using the old version of SPARK®, which contains a number of bugs that students found to be annoying). In addition, in Structural Design 1 we have specifically set aside time to explain the reasons for including self and peer assessment into the subject and introduced students to some of the research reporting the importance of developing professional skills (this was already included in the Design Fundamentals implementation). Furthermore, we have taken considerable steps in both subjects to improve the feedback processes to promote student engagement and increase the benefits from using self and peer assessment processes [16].

Finally, we also intend to improve our research method, asking less ambiguous and more precise questions in conjunction with running focus groups, to help provide a more accurate interpretation of student responses. Whether these changes will prove effective in increasing the benefit that students receive from using self and peer assessment processes remains to be seen, however, our initial trials have been positive.

5. CONCLUSION

In this paper we have demonstrated how the targeted use and thoughtful implementation of self and peer assessment processes can be used to promote, monitor, assess and provide feedback on the development of students' graduate attributes even in subjects where specific discipline content is taught. The self and peer assessment process was an integrated strand of the subject design. In both Design Fundamentals and Structural Design 1 this process was strongly linked to the subject's assessment tasks with criteria that addressed the specific learning outcomes of that subject. The feedback sessions played a significant role in engaging each student with both the technical and more generic learning outcomes. While the trials proved effective in promoting peer feedback to improve subsequent contributions and learning not all the outcomes were positive. We are currently implementing changes to both our procedures and process to increase the effectiveness of our implementation.

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