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360 degree peer assessment to train engineering students in giving good quality feedback

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ABSTRACT

Engineering degrees need to incorporate activities to develop the students' skills and confidence in constructing quality feedback, and ability to critically analyse someone else's work. These skills are highly linked with what industry expects from graduates, and implicit requirements to gain accreditation from UK professional bodies such as The Institution of Engineering and Technology. This paper reports how a novel method of peer assessment called *360 degrees peer assessment (360PA)* was used to train students to give good and insightful feedback to a piece of work, while addressing some of the traditional peer assessment limitations. 360PA was successfully applied to a variety of typical engineering assignments (technical reports, research dissertations, presentations and mathematical problems). Students and staff's quantitative and qualitative feedback were collected. Our experience suggests that the incorporation of various 360PA assignments during the degree is beneficial. Staff praise the method, students feel that 360PA has better prepared

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them to construct feedback (score 4.0/5), and the quality of the feedback provided by the students is consistently high (~85 ± 5%). Recommendations for practice are given. Our approach is scalable and should appeal to anyone interested in improving students' engagement with their feedback, or in helping students to develop such critical skills, regardless of class size.

Conference Key Areas: Engineering skills, Continuing Engineering Education and Lifelong Learning, Engineering Education Research.

Keywords: critical thinking, feedback, peer assessment, research based education.

INTRODUCTION

Engineering employers expect graduates to have a good technical knowledge, but also other important engineering skills such as a strong ability to critically analyse their own and others' work and articulate meaningful and constructive feedback [1,2]. Peer assessment has been increasingly applied in Engineering degrees because it enhances students' learning and development of professional skills [3,4,5,6], promotes self-reflection [7], encourages students to engage in constructing feedback, and helps learners to understand expectations and standards [8]. This provides students with lifelong skills, preparing them for continuing professional development throughout their careers as engineers. In addition, peer assessment facilitates prompt feedback in large classes [9]. The peer assessment approach is also increasingly used in industry as part of the performance measurement of their workforce [10], e.g. HSBC, PepsiCo, and Exxon.

Despite the strong benefits of peer assessment within engineering education, its use raises various concerns. On one hand, some engineering students feel unprepared to make fair and critical judgements of technical work [11,12], but this just highlights the need to train them in preparation for their future career. On the other hand, students might lack motivation or engagement with peer marking, feeling that they could spend their time more productively elsewhere [6,13]. We have tackled these concerns by introducing a 360-degree peer-assessment method (360PA) [5]. In this approach, which we have run successfully for the past 3 years in engineering, students are peer assessed not only on their work, but also on the quality of feedback that they provide. This ensures that students make a greater effort in critically analysing their peers' work, generates feedback that is more reliable and of higher quality, and engages students with the feedback received [14].

This paper describes how we have incorporated 360PA in a variety of assessments during an engineering programme of study, from year 1 to a research skills course in the final year. This trains and aids the development of engineering students' skills for constructing good feedback. The strengths and limitations of the approach will be shared, as well as instances when it may be beneficial to include 360PA in the curricula. Evidence was obtained from teacher observations and discussion with students.

1 PROJECT METHOD

1.1 What is 360PA?

The 360° peer assessment (360PA) was developed by UCL Medical Physics & Biomedical Engineering Dept and the UCL Institute of Education to address various challenges that traditional peer marking present as found in the literature [5], such as poor student engagement and consequently poor quality feedback provided to peers.

Traditional peer marking requires students to give formative (and often summative) feedback to a piece of work done by their peers, and that is the end of the process. The 360PA method is more advanced; it first runs the traditional peer marking, and then adds two extra layers to encourage engagement and address students' perception on mark reliability. The whole process is anonymous and as follows:

1) The students peer mark a piece of work, giving relevant summative and formative feedback.
2) The students receive the feedback provided by their peers, and then read and assess the quality of this feedback. At this point, students might raise any concerns they have about the mark they were given for their work.
3) The tutor moderates students' marks both for their assignment and the quality of feedback provided when required.

Therefore, when using the 360PA the students are assessed both for the piece of work submitted, and on the feedback they provide to their peers. This has various pedagogical advantages. However the research of this paper focuses on how this system motivates and trains students to assess their peers thoroughly and provide good and relevant feedback as now this is peer marked in return by the recipient – hence the 360° aspect.

1.2 Overview of 360PA incorporated within the programme

A range of activities assessed via 360PA were incorporated within the Biomedical Engineering BEng programme (BME) (https://goo.gl/pfMTPa), part of the Integrated Engineering Program at UCL, UK. These were progressively introduced starting in the 2014/15 academic year, and span a wide range of different assessments as described below. Note that modules 1-2 and 3-4 are equivalent to 7.5 and 15 European Credit Transfer and Accumulation System (ECTS) credits respectively.

(A) In-class lab report in Module 1: This is the first instance when students are assessed using the 360PA, early in term 1 of year 1, and it is used to introduce this new method. It carries little weight towards the module mark, and it is done entirely in-class except for the tutor moderation which is done later. Full guidance and support from the tutor and other members of staff is provided, both in terms of understanding the marking criteria and solving technical problems with the electronic system. At the end of the activity, the students have completed their first peer assessment, but most importantly, they are aware of the process and what it entails. This was done in academic years 2014/15, 2015/16 and 2016/17, and it follows the typical 70 and 30% mark allocation for product and feedback respectively.

(B) Lab report in Module 1: This is the first meaningful instance when students are assessed using the 360PA. This takes place in year 1, term 1, and it carries 20% of the total module mark. Students complete a practical activity and generate a lab report. After submission, the marking criteria are discussed in class, and then the students carried out the 360PA in their own time. This was done in academic years

2014/15, 2015/16 and 2016/17, and it follows the typical 70 and 30% mark allocation for product and feedback respectively.

(C) Mathematical coursework in Module 2: This takes place in year 1, term 1, and it carries 10% mark of the module. Students complete maths coursework which includes traditional analytical calculations, and the development of some Matlab code and data presentation. Students scan (if hand-written) and submit their work, and proceed with the 360PA in their own time. This was done in academic years 2014/15 (for two assignments) and 2016/17 (one assignment), and it follows the typical 70 and 30% mark allocation for product and feedback respectively.

(D) Small section of the 3rd year research/design project dissertation in Modules 3-4: This takes place in year 3, term 1. All 3rd year students in the department are required to undertake a *research skills course (RSC)* as part of their research/design project carrying a total of 10% of the final mark. This course aims to support students in the development of the necessary skills for a successful completion of their projects. One of the covered topics is *scientific writing*, which looks both at the macrostructure of a written piece, but also at the microstructure such that the text is coherent, engaging, and ideas well linked throughout. The assignment for this topic (20% of the RSC) consists of the 360PA of a small written piece related to their respective projects, hence encouraging them to start their project writing and providing them with relevant feedback. In this instance, emphasis is given to the quality of feedback provided, i.e. only formative assessment is done for the work while formative and summative assessment is done for the feedback, with the latter providing 100% of the mark. Submission is required for completion.

(E) Draft of final project presentation in Modules 3-4: This takes place in year 3, late term 2, as part of the previous *research skills course*. The 360PA assignment is done under the topic *presentation*, and it is worth 20% of the RSC. Students submit a draft of the pdf or ppt presentation they intend to present for formal tutor assessment and perform the 360PA. This encourages students to plan their presentation in advance (about 10 days before the actual event), gauge their presentations against their peers, and allow them to get relevant feedback in time to implement changes for the final deadline. As in the case above, 100% of the mark is allocated based on the quality of the formative feedback provided to the work, although submission is required for completion.

1.3 Research question and data collection

The research questions are:

(i) Are students capable of providing good quality feedback to their peers?

(ii) Does the 360PA in particular engage students into providing good quality peer feedback?

Data was collected and analysed from three fronts, covering quantitative and qualitative analysis from third year students and staff.

(i) Student quantitative assessment via anonymous questionnaires.

(ii) The quality of feedback as assessed by students in 2016/17 for the described assignments is presented, i.e. the marks that each student obtained for the feedback provided. The original marks given by the students quantify how they felt about the feedback they received, if they found it useful and accurate. Those cases where concerns were raised by the students were moderated by the staff,

who adjusted both the mark for the work and the mark for the feedback accordingly. Marks are presented both before and after moderation.

(iii) Student and staff qualitative analysis/point of view via quotes.

Modules 1-2 and 3-4 had 23 and 33 students respectively. A total of 5 members of staff were involved.

2 RESULTS

Students' feedback via questionnaires is presented in *Table 1*. The average peer feedback quality as assessed by students for various activities taking place in the academic year 2016/17 is presented in *Fig. 1* along with the marks after tutor moderations for the same assignments. The number and depth of the moderations differ among the assignments, but in most cases the final average marks do not differ significantly. A sample of students and staff point of view on peer assessment is given within the discussion.

Table 1. Students' responses to questionnaire (N=9 final BME students).
Scale: 1- not at all, 2- not very, 3- fairly, 4- significantly, 5-very.

Question	Vote /5 Mean (SD)
How confident are you on your ability to construct feedback for peers and junior students?	3.9 (0.6)
Since you started your degree, have you developed or improved your ability to construct feedback for peers and junior students?	*4.2 (0.8)*
Has peer assessment helped you to develop your ability to construct feedback?	*4.0 (0.7)*

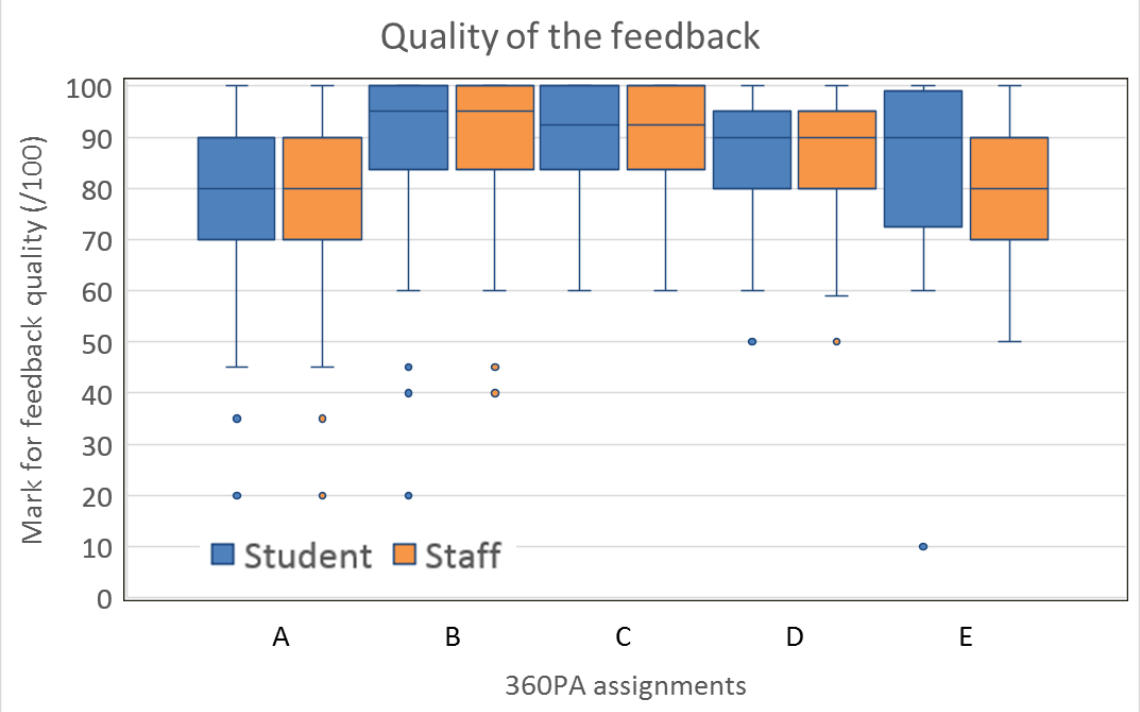

Fig. 1. Peer feedback as asssessed by students and after partial moderation by staff
N_{A-C} = 23 students, N_{D-E} = 33 students

3 DISCUSSION

We first look at whether students are capable of providing good quality feedback when participating in the 360PA. Staff seems to be in a general agreement that this is the case, which is supported by the high scores that students give when rating the feedback received (86 ± 4%), and the feedback marks after tutor moderation (85 ± 6)% across the reported assignments. Students also say that by the end of their 3rd year, they feel confident on constructing feedback (score 3.9/5), improving since they started they degree (score 4.2/5).

Lecturer 1: "The effort expended by the majority of students on the feedback was impressive, and quality of the written feedback itself was generally very good".

We questioned if the 360PA helped students to gain the ability to construct feedback. The responses from the students via the questionnaire were positive (score 4.0/5) while the students' quotes show that opinions are varied (note quotes by student 1 and student 2). Some students believe that it was a helpful exercise, improving not just their ability to write feedback but also to critically analyse someone else's work and to engage with feedback; while others thought that it did not contribute much and might see it as the job of the tutors which clearly needs clarifying. A common comment is that peer assessment adds to their workload, which is already significant. One student thought that s/he was not prepared to give feedback even though s/he is known to be academically successful and peers found her/his feedback useful, so there is room to improve the confidence of students in performing such tasks.

Student 1: "Peer assessment helped me learn how to critically analyse someone else's work and ensure I give good feedback, as well at utilising the feedback I was given."

Student 2: "Peer assessment is helpful but is also time consuming so make this as simple as possible otherwise students will not engage with the activity properly."

The 360PA compared with traditional peer assessment is more successful in that it engages engineering students more in the construction of good quality feedback (note quote by lecturer 2). It increases slightly (<10%) the workload compared to traditional peer assessment as students need to read the feedback received and score it. However, this (i) engages students into reading the feedback received which otherwise they do not do as commonly as lecturers would wish; and (ii) allows students to raise any concerns over their marks as a part of the normal procedure, making it less stressful and subjected to the student's character. The quality of the feedback is comparable across the modules, even though the assignments are of different difficulty and require of different knowledge and skills. It is even suitable for mathematical type assignments (note quote by lecturer 3). It is important to note that most of the students taking assignments D and E had not done peer assessment before, and this might account for the greater variability. Finally, tutor moderations were done to different levels depending on the assignment (at the choice of the lecturer) but in all cases, there were no student complaints after the moderation had taken place.

Lecturer 2: "I think the 360PA was a good incentive for students to focus on trying to provide good quality feedback.".

Lecturer 3: "The online and text based format may not have been the most suitable methods for correcting some of the most formula heavy questions, but this did not significantly impact the detail of their responses".

The use of the 360PA method to mark some of the assignments is overall beneficial to engineering students, supports the development of skills required by employers,

and addresses some of the skills development and assessment required by accrediting bodies such as IET in order grant accreditation to the degree [15].

Recommendations of practice

Our practice suggests that it is beneficial to integrate assignments assessed using 360 degrees peer assessment in engineering programmes. This improves the quality of the feedback provided by the students and their engagement with the feedback received. It also improves the students' experience as requests for moderation are possible within the standard procedure, which improves the students' confidence in the accuracy of the marks.

The 360PA seems to work with a variety of typical engineering assignments (reports, presentations, mathematical problems). Therefore, it is believed to be suitable for a wide range of contexts and degrees that incorporate elements such as written reports or discussions of a wide nature, presentations, technical calculations, etc. Even when students do not feel comfortable criticizing someone else's work (such as perhaps in Asian's cultures) this brings a good opportunity for students to develop the necessary skills on pieces of work that were written to their similar level of knowledge. Although there are advantages in exposing students to a range of peer assessed assignments, students and some staff believe that it might be more relevant in assignments with less prescriptive solutions (hence it should not be used with straight mathematical questions with only one possible method to reach the correct solution).

The added workload for students when using such method should be considered, perhaps decreasing the workload elsewhere. The 360PA can be used to assess soft students' skills such as ability to construct feedback, which are often required by engineering employers and professional bodies.

4 CONCLUSION

We have showed how the 360 degrees peer assessment method can be specifically applied and how it can benefit an engineering programme. Students have assessed engineering technical reports, sections of research dissertations, presentations, and mathematics coursework using this method. This has helped them to progressively build up their skills and confidence in constructing feedback, and ability to critically analyse someone else's work. These are directly related to the engineering professional skills which are necessary for accreditation, and expectations from industry.

Our approach is scalable and should appeal to anyone in engineering interested in improving students' engagement with their feedback, or in helping students to develop such critical skills, regardless of class size.

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