2023

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Recommended Citation

Cole, R. (2023). The Use Of Peer Assessment And Group Peer Moderation To Develop 'Soft' Skills In Engineering Students Researching Sustainable Energy. European Society for Engineering Education (SEFI). DOI: 10.21427/65GD-BR02

The use of Peer Assessment and Group Peer moderation to develop 'soft' skills in Engineering students researching Sustainable Energy

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Conference Key Areas*: Embedding Sustainability and Ethics in the Curriculum; Engineering Skills and Competences, Lifelong Learning for a more sustainable world*
Keywords*: Peer assessment, peer moderation, communications skills, sustainable energy*

ABSTRACT

Since the change to an outcomes-based approach in Engineers Ireland's accreditation criteria almost 20 years ago there has been an emphasis placed on 'soft' skills such as teamwork and ensuring graduate engineers are not only well versed in their chosen discipline, but that they can communicate their knowledge – to other Engineers and also non-Engineers. Energy Management is a module taught to 4th year Mechanical Engineers, and the learning outcomes are best assessed by how students can communicate the energy topics they are researching. As an individual they will research an area that interests them and write a paper at the end of semester but leading up to this there are two 'patchwork' assessments from which they receive feedback and can use to formulate the introduction to their final paper. The second of these is peer assessed using the same Rubric as for the first assessment, and they must also review their own writing following this. Feedback has shown that this develops a greater understanding of their writing and what constitutes a good technical writing style. Teamwork is developed in this module through a 35% sustainable energy group project which involves a presentation and a written group report. On completion the students submit a peer moderation form online which allows the grade to be moderated if the work was not evenly shared. The approach taken for each element has evolved over 15 years and will be explored as part of this practice paper.

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1 INTRODUCTION

The importance of communications skills and teamwork for Engineering graduates was emphasised with the introduction of outcomes-based criteria for Accreditation of Engineering programmes in Ireland in 2004, prior to this the criteria to accredit programmes was input-based. Successive updates to the criteria continue to stress the importance of these 'softer skills', with the latest version also introducing outcome criteria around Engineering Management and Sustainability (Engineers Ireland, 2021). It is simply not enough for an engineer to be technically competent; they need to be able to communicate their engineering solutions to other engineers, and also to non-engineers. In 2007 I took over the delivery of a 4th year Mechanical Engineering module – Energy Management. The syllabus covers global and national energy usage and policies, energy and the environment, an introduction to renewable energy, and Combined Heat and Power (CHP). It also covers the thermodynamics behind increasing the efficiency of fossil fuel-based energy production. In the first year, I assessed it as had been done previously, 70% terminal exam and 30% coursework, however it was clear to me that there was a very shallow learning involved in the energy topics, with students typically answering the exam questions with short, bullet like responses. At this time, I was also undertaking an MA in Academic Practice, where I first engaged properly with pedagogy. Biggs (2003) constructive alignment resonated with me, helping me to construct learning by aligning my teaching and developing more active learning to move students away from the tendency to rote learn for terminal exams.

To encourage deeper learning and develop critical understanding and writing skills I endeavoured to change part of the assessment to Patchwork Text to allow for both formative and summative assessment of their ability to write critically (Winter, 2003). This evolution will be detailed in this practice paper, including the incorporation of Peer Assessment of writing as part of the patchwork text. As a practice paper this cannot be generalised for all engineering disciplines, however as writing is a skill relevant to all, the approach is one that can be adapted by other disciplines.

The original coursework involved a group project on a sustainable energy topic. Teamworking skills are valued by employers (and accreditation bodies), so this important element is still part of the module. However, students can have concerns regarding equal workload and effort by team members, and how this affects their grade (Gunning *et al*., 2022). To overcome this group meetings are scaffolded during class time and at the end of the project there is peer moderation of the grades, which will also be discussed. The incorporation of these peer elements is key in developing graduates' responsibility for their own learning, and the evolution of this approach will be outlined in Section 2.

2 METHODOLOGY

It is widely accepted in higher education that assessment plays a large role in student learning (Fischer *et al*., 2023). Assessment for learning is a key feature of my teaching philosophy building on the use of formative assessment with detailed feedback for the students to reflect on (Nicol & MacFarlane-Dick, 2006). The methodology I developed over the years is outined in this section, firstly describing the module assessment, moving from summative to formative assessment (2.1),

then looking at this development of formative assessment using patchwork text and peer assessment (2.2), and then use of peer moderation of group project grades (2.3).

2.1 Module Assessment

The module Energy Management is taught in Autumn to 4th year Mechanical Engineers, it is a 15-week semester: 12 teaching weeks, 1 reading week and 2 exam weeks. The initial Assessment involved a 30% group research project on an energy topic, and a 70% terminal assessment, as outlined in Table 1. The second time I taught this module, this was flipped to 70% continuous assessment and 30% Terminal exam. The terminal exam is solely based on the thermodynamics part of the module, using numerical type exam questions.

The continuous assessment included the group research project as before, now focussed on sustainable energy generation, and the introduction of technical writing assignments; the evolution of which will be discussed in Section 2.2. From 2011 to 2018 an in-class or online mid-term assessment was also used, and the Coursework mark increased to 80% with only 20% for the terminal exam. As shown in Table 1, briefly the Terminal exam increased to 30% in 2019, and has returned to 20%, highlighting how I continuously adapt delivery and assessment of the module. During the Pandemic, when teaching moved online, this assessment mode translated well as it already had a small terminal exam component which was then switched to on online exam.

Table 1 Evolution of Assessment mode 2007-2022

Year	Student Numbers	Continuous Assessment				Terminal Exam
		Group Project	Short Reviews	Final Review	In-class or online MCQ	
2007	74	30%				70%
2010	32	30%	10% (5x2%)	30%		30%
2011	46	30%	15% (3x5%)	30%	5% in-class	20%
2012	46	30%	15% (3x5%)	30%	5% in-class	20%
2014	46	30%	15% (3x5%)	30%	5% in-class	20%
2015	48	30%	15% (3x5%)	30%	5% in-class	20%
2016†	42	30%	15% (3x5%)	30%	5% online	20%
2018	67	30%	10% (2x5%)	30%	10% online	20%
2019	74	30%	15% (2x5%) +5% Peer	25%		30%
2020	68	35%	15% (2x5%) +5%Peer	30%		20% (online)
2021	69	35%	15% (2x5%) +5%Peer	30%		20% (online)
2022	74	35%	15% (2x5%) +5%Peer	30%		20%

*2008, 2009, 2013 on leave, 2017 seconded to Athena SWAN team
† Rubrics introduced

From 2020 there was a slight increase to the Group project mark, which corresponds with the introduction of Peer moderation (as discussed in Section 2.3), and following a brief increase to 30% terminal exam, the overall distribution of 80% continuous assessment was returned to.

For all the written elements Turnitin Feedback Studio (previously known as Turnitin Grademark) is used to provide feedback. Up to 2015 the students received marks under several headings using a detailed gradings scheme, with Table 2 showing the scheme for the 5% Short Technical Review. From 2016 this was developed into a set of rubrics for each element (Short Review, Final Review, Group report). This helps scaffold the students' preparation for the given element. Table 3 presents the current rubric for the Short Technical Review, with the marks awarded similar to those presented in Table 2.

Table 2 2015 Grading scheme for Short Technical review (5% but marked out of 20)

	Excellent	**Good**	**Acceptable**	**Poor**	**Dreadful**
Language style (technical, not colloquial, no rhetorical questions, punctuation, spelling)	4	3	2	1	0
Technical Content	8	6	4	2	0
Introduction, Conclusion (each)	3	2	1.5	1	0
Referencing	2	1.5	1	0.5	0

Table 3 2022 Rubic for Short Technical Review

	Exceptional	**Good**	**Acceptable**	**Poor**	**Inadequate**
Introduction	Excellent context given Argument/Case to be made is clearly 'signposted'	Good context given Argument/Case to be made is 'signposted'	Acceptable context given Argument/Case to be made is somewhat apparent; Too long/short	Poor context given Argument/Case to be made is not apparent ; Too short	No context provided Argument/Case to be made is not apparent
Language style (technical, not colloquial, no rhetorical questions, punctuation, spelling)	Excellent technical language used, with no colloquialisms, no rhetorical questions. Correct punctuation and spelling throughout	Good technical language used, A *small* number of colloquialisms or rhetorical questions, or punctuation mistakes, or spelling mistakes	Acceptable technical language used; A number of colloquialisms or rhetorical questions, or punctuation mistakes, or spelling mistakes	Poor technical language used; A *significant* number of colloquialisms or rhetorical questions, or punctuation mistakes, or spelling mistakes	Language used is not appropriate for technical report
Technical Content	Excellent breadth of content (appropriate for the length). Clear argument made or position outlined. Excellent support provided for the argument made	Good breadth of content (appropriate for the length). Argument made or position outlined is not fully clear *Or* more support required for the argument made	Acceptable breadth of content (appropriate for the length). Argument made or position outlined is not fully clear *And* more support required for the argument made	Poor breadth of content (not appropriate for the length). Argument made or point is unclear *And* more support required for the argument made	No real content. No argument made or position outlined is not fully clear
Conclusion	Excellent conclusion on the review. Appropriate length for the length of the review. Points made are synthesized well into a conclusion, linking back to the argument signposted.	Good conclusion on the review. Appropriate length for the length of the review. Points made are synthesized into a conclusion, and may link back to the argument signposted.	Acceptable conclusion on the review. Maybe too short. Points made are may not be synthesised into a conclusion, and may not link back to the argument signposted.	Poor conclusion on the review. Too short. Points made are not synthesized into a conclusion, *or* not linked back to the argument signposted.	No real conclusion or conclusion missing. Too short
Referencing	References complete and properly laid out.	Some gaps in references but Reference section properly laid out. *Or* References complete but gaps in reference section layout	Some gaps in references and/or reference layout.	Major gaps in references and/or reference layout.	No references or sources identified for information.

2.2 Patchwork Text

In transforming the module's assessment, I wanted to promote deeper engagement with the topics while also giving the students the opportunity to get feedback on their technical writing skills in advance of writing their Final Year Project report. Patchwork text involves a number of smaller assessments that can be 'stitched together' to give a final piece (Akister *et al*., 2003; Winter, 2003). The first time I undertook this in 2010 I had the students write five short essays, approx. 250 words each, for which they received marks (a small 2% max) and more importantly feedback, and they could choose whether to use these as part of their final essay. The grading load involved was too high, so from 2011-2016 this was changed to three 5% pieces. The students submitted their first essay early in semester, this is graded using the rubric and returned to them before they prepare the second one, and same then for the third; with the aim that these short essays, once reworked based on the feedback, would form the Introduction to the final essay.

Due to engineering student resistance to writing 'essays' the assignment was retitled to *Technical Review*, and the expectation is the writing style is that of a Literature Review. Regardless of what it was called, it was clear from the improvement in the quality of work submitted, and grades attained, that student engagement with the topics increased – leading to deeper learning, as also evidenced by Trevelyan and Wilson (2012). The students' ability to think and write critically was scaffolded by the use of the short reviews and the feedback they received, to help them prepare the longer Technical Review. Their appreciation of this approach has been noted in module feedback, and also in end of year feedback to External Examiners. The introduction of rubrics in 2016, as discussed in the last section further aided in the development of these critical writing skills, as they know before they write what is expected at all levels for all categories under which the piece will be graded.

In 2018 the class size increased by over 40% as shown in Table 1, which meant that the grading workload was too onerous again. Initially in 2018 the short reviews were cut from three to two per student. In 2019 to try ease the workload issues, but also to try develop better critical thinking skills in the students, I decided to involve the students in the grading (Moloney *et al*., 2019). Peer assessment has been shown to robust and is supported as a formative method (Double *et al*., 2020).

The practice since 2019 involves the students each anonymously reading and grading two other reviews using the rubric, after which they must do a self-review. A limitation to this approach is that it is dependent on students engaging with the peer-assessment. To encourage them to do this, they get up to 5% for giving these reviews. Better engagement will get the full 5%, and while this may seem like an 'easy' 5%, feedback from the students in module evaluations and in their self-reviews shows that they find it very useful to see exemplars of their peer's writing. From their reflective self-reviews students have indicated that they find the peer-review very useful in helping them understand how to correctly frame a review – from language style to forming a cohesive argument. Students may distrust peer assessment (Planas Lladó *et al*., 2014), so it is imperative to discuss their responsibilities in advance of the peer assessment. The reliability and validity of the peer assessment is monitored to ensure the marks and comments are appropriate.

While this is a relatively smaller cohort, averaging 70 students, Power and Tanner (2023) have suggested peer assessment is appropriate to use with even larger cohorts with suitable use of a Virtual Learning Environment (VLE) to assure anonymity.

2.3 Group Project - Peer moderation

The group research project has been a key assessment tool in this module, since before I started teaching it. Initially each tutorial group had 15 students per hour, and in five project groups of three students they researched an energy topic of interest over the first 3-4 weeks of semester and then over the following weeks they took turns to give a 30 min presentation. In 2007 for many it was their first time giving a formal presentation, which has since changed with curriculum development. The group research project was timed so that the group presentation took place early in the semester in advance of Final Year project Interim presentations. As there were different dates for presenting, each group then had two weeks to submit the written report. As detailed in Section 2.1 from the start Turnitin Grademark has been used to allow detailed feedback on the report. With VLE enhancements regarding group submissions this has become more straightforward in the last five years. These research projects serve to significantly improve their knowledge in a particular area of sustainable energy and also develop their awareness of other topics, though attendance at the presentations.

Overall this structure has worked very well and there have only been a few changes over the years. As noted, the grading workload is quite substantial, and due to increasing class size in 2020 the groups were increased from three to five students to reduce the number of projects to be graded, with 30 students in 2-hours, allowing six groups of five. In 2021 & 2022, instead of being spread from weeks 4-8, more time was given to project scaffolding in the tutorials, with all presentations occurring between Week 7 & 8, and the Final report due for all in Week 9.

There are student and academic concerns regarding group work and ensuring that those who do the work are rewarded accordingly (Gunning *et al*., 2022). Especially in 4th year, students can worry that their grades and final awards will be impacted, yet the ability to work in a team is a key Programme Outcome for Engineer's Ireland accreditation. Initially for this module each group had to declare how the final mark would be allocated, and when the groups were smaller it was easier to distinguish if the group mark needed to be moderated to reflect the individual workloads. With increased numbers in each group, managing these dynamics became more difficult. In 2021 I introduced the use of an individual online form (using MS Forms) based on a small subset of WebPA criteria (Loddington *et al.*; 2009) where each student rates themselves and their group colleagues under five personal effectiveness criteria, as described in Table 4. If work was shared equally amongst the group, then they are asked to choose 'about average for this group' for all, including themself. The scores for each student under each criterion are averaged, and this has led to more robust peer moderation of the group grade. If any group feels the moderation does not fully reflect the workload, then they are free to discuss this, but as of yet there have not been any issues. Again, module feedback has shown that students value this way of being able distinguish those that have do more work to make up for others.

Table 4 Peer moderation of individual effectiveness (adapted from (WebPA, 2019)*)*

Criteria	Description
Co-operation	attendance at meetings, contribution to meetings, carrying out of designated tasks, dealing with problems.
Communication	effectiveness in meetings, clarity of work submitted to the group, negotiation with the group, communication between meetings and providing feedback.
Enthusiasm	motivation, creativity and initiative during the project
Organisation	Self-organisation and the ability to organise others, including planning, setting targets, establishing ground rules and keeping to deadlines.
Contribution	Overall effort put in by an individual during the Project (Weeks 1-9)

3 SUMMARY

The pivot to online teaching and learning in 2020 and 2021 highlighted that terminal assessment is flawed, especially when the assessment is online and not proctored. In the return to on-campus teaching it is important not to lose the best practices of using increased Continuous Assessment. Taking an 'Assessment for Learning' approach, a number of different strategies are used in this module.

- The use of Patchwork Text develops the student's critical writing skills, though use of timely feedback that can then be used to write their final review.
- Including an element of Peer review in this Patchwork Text structure has been shown, through module feedback and student self-review comments, to also accentuate their understanding of good technical writing, as they see other people's writing (good or bad) and it obliges them to engage with the rubrics that are used for the assessment.
- Acknowledging the concerns that students have with group project work, the use of peer moderation forms allows for them to acknowledge how the workload was shared, and again from student feedback this has been welcomed.

This paper is intended as a practice paper, to show how my practice has evolved and how I attempt to develop deeper learning and utilise peer elements to foster graduates' responsibility for their own learning. Over the last two years, following the staged return to on-campus teaching there has been a noticeable change to the level of student engagement. Methods such as these – patchwork text and peer assessment, group work and peer moderation – can assist in motivating a responsibility for their own learning. While the methods are not applicable to all, there may be elements that can be adapted for other's teaching.

A principal factor of my approach is to move away from the standard high stake terminal exam, that is used by many as it is an efficient way to assess. The approaches I have discussed show a way that a Module Leader can sustainably move to more continuous assessment. This is applicable for all engineering studies, not only the 'softer skills'. A limitation of this study is that the feedback is all based on module feedback and student self-review, therefore further structured research of student perceptions is planned.

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