Developing Engineering Students Writing Competence: An Intervention Based on Formative and Peer Assessment

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Abstract. The ability to communicate is recognised as an important undergraduate engineering competence. While acknowledging its importance, employers often express dissatisfaction with engineering graduates ability to communicate. In one course that the author teaches, learners are asked to document project outcomes via an engineering-style conference paper. Over the years, many learners consistently struggle to write high quality abstracts, introductions, conclusions and to apply referencing conventions appropriately. This year the author designed and implemented a writing intervention, based on formative and peer-assessment, to address this issue. This article explore the impact of this intervention. Impact was evaluated by comparing writing artifacts produced in this academic year with artifacts produced in two other years prior to the intervention. The results indicate that the intervention was impactful with the quality of these elements improving from an average score of 35% (2017 & 2018) to 70% this academic year. An implication is that specific, targeted supports are likely to be more impactful than repeated practice – especially when practice is not supported with feedback. More generally, the article adds to the extensive literature evidencing the impact of formative assessment on student learning.

Keywords: Writing · Graduate attributes · Formative assessment · Peer review

1 Introduction

Writing is important. It is one of those “generic” competences that crosses disciplines. Most employers expect that those who graduate from higher education will exhibit communication skills, including writing, to a high professional standard. Regardless of whether we agree with this neo-liberal view on the purpose of higher education, graduates that do not possess those skills are likely to be disadvantaged in a competitive labor market. In that sense we, educators, have an ethical responsibility to try and develop those skills. In addition to its importance as a graduate attribute, writing is also one of those really effective learning strategies that we should be encouraging all learners to adopt [1]. For these reasons, writing features strongly in all of the courses that I teach.

One such undergraduate engineering course, the focus of this paper, asked learners to document project outcomes in a conference style engineering paper. This task represents the main assignment within the course and has been consistently so for many
years. Over those years I have mostly used exemplars – examples of papers from past students and others – to help clarify the requirements and expectations associated with this assessment task. This, along with feedback on drafts, has had a positive impact on writing. Despite this general positive impact, year after year I see that my students struggle to write good abstracts, introductions, conclusions and their referencing practice is really poor. This paper summarizes how I attempted to address this problem and evaluates the impact of the intervention that I developed. The next section provides a more general background and justification for the approach adopted and subsequent sections document the research approach, including the intervention itself, and evaluates its impact on student’s writing performance.

2 Background and Justification for This Approach

2.1 Writing in the Engineering Curriculum

Writing is important as a professional competence within engineering, as a graduate attribute that can enhance employability and as a really effective learning strategy [1]. However, despite its importance, and indeed the regularity with which engineering undergraduates produce laboratory and other types of written reports, there is ample evidence that graduate writing skills are underdeveloped [2, 3]. One reason why writing remains underdeveloped is attributed to the lack of formal writing instruction within the engineering curricula. We (engineering educators) seem to assume that our undergraduates have been taught everything that they need to know about writing from the secondary-school curriculum and students just need more practice in order to develop writing proficiency. This is in stark contrast with our attitude to mathematics. As a specific example, on the B.Eng. in Electronic Engineering programme in my home department, there is a component of one first-year, semester 1 module that is dedicated to writing instruction. There are two mandatory 5-credit modules dedicated to mathematics in first year, second year and third year with an optional 5-credit mathematics module in four year. Hence, through our curriculum, our undergraduates can easily see that mathematics is important but that writing is something "other". This "otherness of writing practices in the engineering curriculum" is developed in [4] where the authors argue that engineering identity centres around technical knowledge (exemplified by science and maths) and that writing is not what engineers do. Undergraduate students then adopt this identity. Hence, there is a tension between the demand from employers for graduate engineers that can write and engineering curricula’s willingness to meet that demand.

As this tension is not new, different approaches have been explored to redress it. A common approach is to introduce one or more writing or communication modules into the engineering curriculum. These usually appear in the early years of the programme. The obvious advantage of this approach is that writing instruction is delivered by experts and a mandatory module that focuses on writing means that learners cannot sidestep this learning if they want to progress. On the other hand, if this writing instruction is provided by experts outside of the engineering department it can reinforce the “otherness” of engineering writing. It is also possible that the writing assignments
that are posed are less meaningful or relevant to engineering students, making engagement harder. The alternative approach, and the one that the Dept. of Electrical & Electronic Eng. at CIT has adopted in our programmes, is to integrate writing instruction and practice throughout the curriculum. This provides multiple opportunities to develop and practice the skill. Moreover, by embedding writing within technical courses that are delivered by engineering staff we may change engineering student’s perception of writing and they may come to see writing as being important to the engineering profession [4, 5]. However, it does now become possible for students to avoid this skill and successfully complete courses by just focusing on the remaining technical parts. It also, arguably, more challenging to develop an integrated curriculum as the progression of writing development from year to year needs to be defined to create a spiral curriculum [6]. Furthermore, engineering staff may need to be convinced to make the changes to individual course and then be supported as they implement those changes. Despite these challenges, our Department’s approach has been to integrate writing into the curriculum as we feel that perceptions of writing is a big part of the problem and, like any skill, providing multiple opportunities to practice and develop is an important part of the solution.

2.2 Solution Components

Within individual modules, our Department’s solution integrated a number of teaching strategies - specifically formative assessment and peer review in a blended learning environment. The assessment literature presents persistent, strong evidence that formative assessment has a positive impact on learning [7]. However, for this impact to be realized it is critical the learners engage with and apply the feedback that is provided. To enable this [8] recommend a “social constructivist” model whereby learners are encouraged to interact with the criteria and standard associated with assessment components, apply those to assessment examples and discuss both the process and outcome with their peers. Throughout this literature the use of two stage assignments that consist of drafts, an opportunity to re-work based on feedback and then the submission of a final assignment is recommended. This model naturally incorporates many of the principles of good feedback practice advocated in [9].

The second strategy that formed part of our solution was to incorporate peer-reviews of writing assignments. Traditional feedback practices are heavily criticized for encouraging learners to be heavily dependent on a more knowledgeable others for validation and feedback [10]. As a consequence, peer-reviews are gaining in currency as one strategy that enables more independent learners. The peer-review process is also advocated as a means of encouraging learners to develop the capacity to make critical and evaluative judgements [11]. With peer-reviews, learning can happen from the feedback received by peers. It is also accepted that the process of creating feedback can have a powerful learning impact. This happens because the process requires learners to actively engage with the assessment criteria, apply the criteria to examples and justify the application [12, 13]. This can result in a more explicit or concrete understanding of the assessment requirements and as a result better enable individuals to meet those requirements. Challenges associated with the implementation of peer-reviews relate to the need to provide training around the process, the need to develop a shared
understanding of the assessment criteria and students holding mixed feelings towards the strategy [14]. However, despite these challenges the potential of peer-reviews to enhance critical thinking and to develop academic writing [13, 15] convinced the author to pilot this approach.

The contribution of this article then is to describe how these strategies – formative assessment and peer-review were combined in a blended learning environment to create a writing intervention for final year engineering students in a particular module. The impact of this intervention is then analyzed by comparing the quality of written papers from two years prior to the intervention and this current academic year when the intervention was piloted. Data analytics from the Learning Management System used to host the resources will also be used to assess student engagement with the developed interventions. In the next section, the research method, including the intervention, will be described.

3 Research Method

3.1 Research Question

The research question explored in this article is what is the impact of a specific formative and peer-assessment writing intervention on the quality of specific writing components in a particular undergraduate engineering course? The specific writing components are: title, abstract, introduction, referencing and conclusion.

3.2 Problem Context

The context that this intervention is situated in is a 5 ECTS credit course that forms part of year 4 of the B.Eng. in Electronic Engineering at that author’s institution. The module timetable specifies two hours of lecture content and two hours of laboratory content per week. The laboratory content consists of a semester-long group mini-project in which learners are expected to engage in design, test and evaluation work. Content is primarily delivered through lectures that incorporate a range of individual and group-based active learning techniques. The module is assessed via coursework, which includes an individual research-style paper (worth 70%) that is typically submitted in two phases as a draft, on which learners receive instructor feedback and then a final submission. This two stage draft/feedback/final assignment has previously been shown to positively impact on learning [16]. However, because learners have limited time between the draft and final submissions there is only so much feedback that can be acted on. This often means that the focus (both mine and theirs) is on important technical aspects of the project that need to be addressed. Consequently, for a number of years final assignments have consistently displayed a range of common problems associated with weak titles, incomplete abstracts, inadequate introductions, poor or no conclusions, few if any references and poor formatting of references. One aim of the intervention was to address those issues. The second aim of the intervention was to try and spread the writing workload by requesting submissions of sections of the paper throughout the semester rather than leaving this large writing task to the busy end of the
semester. Learners then received feedback on these submissions either from their peers or the instructor.

## 3.3 The Intervention

The intervention consisted of a range of short focused writing activities to address the common problems identified in the previous subsection. So for example to address the referencing problem, learners were firstly asked to respond to a general question on what purpose(s) referencing serves and then given a paragraph of text which referenced a number of sources and these sources were then listed after the text. Common errors were deliberately built into this reference list. Learners were then asked to identify which of the sources were correctly referenced according to the IEEE referencing format. This, and all the interventions, were hosted on the institute’s Learning Management System (LMS). To enable fast, efficient feedback the activity was structured as a multiple-choice question where learners had to pick one from a range of options. Feedback was automatically built into this so once learners engaged and selected an option the feedback explained which of the references were incorrectly formatted and the formatting issue with each. For the abstract, introduction, conclusion learners were pointed to an on-line resource that discussed the purpose and nature of these elements. They were then given a previously published paper that was similar in content to their projects [17] and asked to critique these sections of the paper. With the introduction, for example, they were asked to identify the topic sentence of each paragraph in the introduction so that they would see how that was structured. They were then asked to create topic sentences for a three-paragraph introduction for their own papers. In general the format of these small interventions was similar.

a) learners were provided with a general resource on the topic
b) learners were asked to engage with a specific task e.g. critique an example
c) learners were then asked to apply that to their own paper

Over the course of the semester 10% of the course grade was assigned to these activities to encourage engagement.

## 3.4 Evaluation

The impact of this intervention on writing was evaluated by comparing the quality of reports produced at the end of this current academic year with those produced during the 2016–17 and the 2017–18 academic years. The criteria summarised in Table 1 was developed for this purpose. This criteria is quite subjective in nature. Given the authors “insider” role and personal involvement this raises concerns related to the objectivity of this evaluation and the role that biases e.g. confirmation bias might play. In an attempt to mitigate this some more objective measures were also considered. These included engagement data from the institutes LMS, word counts for the introduction, number of sources referenced in the text and the marks awarded for the quality of the writing. While the marks associated for writing are arguably a subjective judgement, over the period in question (2016–2020) the same assessment rubric has been used and these marking decisions are available for scrutiny by two external examiners. These
processes help to ensure a degree of consistency and objectivity in the grading process. Grading sheets for the academic year 2018–19 could not be located and that is the only reason for not including that year in this analysis.

### Table 1. Criteria used to evaluate the impact of the intervention

| Criteria     | Points | Explanation/Example                                                                 |
|--------------|--------|------------------------------------------------------------------------------------|
| Title        | 0      | Generic title e.g. “Report for Control Engineering Module”                          |
|              | 1      | Title describes the content of the report e.g. “Controller Design and Analysis of a Balance Beam” |
| Abstract     | 0      | Missing                                                                            |
|              | +1     | For including a specific aim or objective of the work; a description of the method; specific results/conclusion is included in the abstract. A maximum of 3 points if all three are included |
| Introduction | 1      | The aim/objective of the work and an outline of the tasks involved is described     |
|              | 2      | In addition to the criteria for (1) above some more general background context is included |
| References   | 1      | More than two sources are cited in the text                                         |
|              | 2      | More than two sources are cited plus accurately referenced                          |
|              | 3      | More than two sources are cited, referenced and used to justify an argument or support an explanation |
| Conclusion   | 0      | Missing                                                                            |
|              | 1      | Focuses on summarizing the work                                                     |
|              | 2      | Uses key results to emphasize findings and draw conclusions                         |

### 3.5 Participants

Participants were all enrolled on the same final year course. They are predominantly male. To be included in this study they must have submitted a valid paper for the final assignment. Valid in this case means that the assignment was complete, judged to represent the student’s own work, be free from plagiarism or other infringements and not be accompanied by requests for a deferral (e.g. on account of the impact of COVID-19). Table 2 lists the participant numbers by academic year.

### Table 2. Summary of participant numbers per academic year

|              | 2016–17 | 2017–18 | 2019–20 |
|--------------|---------|---------|---------|
|              | 12      | 9       | 14      |
4 Results

Report quality for each of the three academic years was evaluated using the criteria reported in Table 1. Scores for each year were then averaged and converted into a percentage of the maximum possible score (1, 2, or 3) depending on the criteria. These average percentages for each of the three years are displayed in Fig. 1. Along with these percentages, the actual grade that was assigned for the quality of the written report is also presented in Fig. 1, labelled as Writing Mark. Again the average is recorded as a percentage. This Writing Mark represents the overall quality of the written communication and the technical details are graded separately. So the Writing Mark includes things like the quality of the writing, the logical structure of the paper, the quality of graphs, tables and equations etc. in addition to the aspects (abstract, introduction, conclusion and referencing) that are the focus of this article. Comparing the 2017 and 2018 academic years the results show a small overall improvement in most of these elements and a significant jump in quality for the 2020 academic year. The five specific criteria (Title, Abstract, Introduction, Referencing, Conclusion) increased from an average grade of 31% in 2017 to 39% in 2018 to 70% in 2020. This is reflected in a modest increase in the overall writing mark which remained stable at 63% (2017) and 64% (2018) but increased to 73% in 2020.

![Fig. 1. Evaluation of report quality based on the criteria reported in Table 1.](image-url)

A more objective lens is provided by Table 3 and Table 4. Table 3 presents some quantitative data from the reports which count the average number of articles referenced in each year and also the average word count in the introduction. There is clear evidence that in both cases these numbers have increased. Table 4 presents the organization of the intervention over the semester and student engagement with the intervention. Student engagement data was extracted from the institute’s LMS. Section 3.3 outlined how learners were expected to engage or “do something” as part of each activity and in each case the “doing” was submitted to the LMS. In some cases (week 3 for example) the engagement was to answer multiple choice questions while in other cases (week 5 for example) it was to submit a draft of a section of the paper. So the engagement data records the number of learners that engaged with the requested
activity. Throughout the semester the engagement data remained high and helps to explain or justify the results presented in Fig. 1. COVID-19 did have an impact. Our institution closed to students on week 7 and the average student engagement after that is, understandably, lower than it was before. Of course, the second half of the semester is always a busier one for students so this drop in engagement may not exclusively be caused by the impact COVID-19.

Table 3. Quantitative evaluation of paper quality

|                           | 2016–17 | 2017–18 | 2019–20 |
|---------------------------|---------|---------|---------|
| Average no of references per paper | 1.3     | 2.6     | 4.6     |
| Average word count introduction | 116     | 160     | 399     |

Table 4. Engagement with formative and peer assessment activities

| Intervention or activity | Referencing | Writing an introduction | Peer review | Draft Sect. 2 | Draft Sect. 3 | Writing a conclusion | Title & abstract | Draft Sect. 4 | Peer review |
|--------------------------|-------------|-------------------------|-------------|---------------|---------------|----------------------|-----------------|---------------|-------------|
| Timing                   | Week 3      | Week 5                  | Week 6      | Week 7        | Week 11       | Week 12              | Week 13         | Week 14       |             |
| Engagement (%)           | 93          | 93                      | 93          | 86            | 79            | 64                   | 64              | 71            | 57          |

5 Discussion and Conclusion

This article has evaluated the impact of a writing intervention based on formative and peer assessment. The intervention focused on addressing specific writing issues around the quality of titles, abstracts, introductions, referencing and conclusions. These were identified as problematic from previous iterations of the course. The results indicate that the intervention was largely successful in that the quality of these elements improved, on average, from 35% (2017 & 2018) to 70% this academic year. This represents a significant and substantial impact.

Examining Fig. 1, it is evident that some of the more substantial improvements were linked to the abstracts, introductions and references. In 2017 there was on average 1.3 sources referenced per student paper and in almost all cases these references were not formatted in accordance with the recommended style (IEEE). While the number of references increased in 2018 the quality of the formatting did not. This year, the intervention was successful in increasing both the number of sources and the quality of the referencing. The most common use of these references is to identify components or software that was used, rather than using references to support an academic argument. This is perhaps a consequence of the intervention that I designed which did focus on the technical aspects of referencing rather than the more abstract purpose and use of references. A future iteration will address this. Likewise, while the quality of the abstract have improved, most abstracts still do not summarize the entire paper. They generally do not report findings or conclusions/implications. Additional emphasis on these aspects may help to develop this aspect in the future. Conclusions tend to be similarly limited and focus on summarizing in a quite generic way and not emphasize
findings by linking them to specific results. In contrast, introductions were developed to a high standard. In previous iterations of the module, the introduction was very short (Table 3) and did little more than provide an outline of the paper or the technical tasks that were completed. This intervention resulted in the development of significantly longer (Table 3) introductions that included a general background (importance of control engineering), explicitly included the aim/objective of the work in addition to an outline of the tasks that needed to be completed.

A somewhat unexpected outcome, evident from both Fig. 1 and Table 3 is that the quality of these writing elements improved somewhat between 2017 and 2018. Since then the institute has migrated to a new LMS and I no longer have access to the details of the courses as they were implemented in 2017 and 2018. Hence it is not possible to explore or explain what features of the course or cohort that might have resulted in this small improvement.

There are a number of limitations associated with this research. The small sample size in each year raises questions about the generalizability of the findings. There is also a question as to whether the intervention is feasible with large cohorts. Some components of the intervention involved individual instructor feedback and these are certainly problematic for larger groups. Other aspects involved the use of multiple choice questions and peer-reviews which should be easy to scale. A significant issue is the potential for bias to influence the outcome due to the “insider” nature of the research. As both the instructor who teaches the course and designed the intervention, I have a vested interest in the outcome. In addition, my expectation at the start is that it would be successful as the literature on formative assessment generally indicates positive outcomes [7, 8, 12]. Hence there is real potential for confirmation bias and sources to contaminate the findings. I tried to manage that by developing a simple and relatively explicit rubric to evaluate the impact of the intervention prior to evaluating the written papers themselves. Again, in an attempt to manage the subjective, qualitative nature of the evaluation, I considered some more objective measures such as the number of references and the length of introductions and student engagement with the intervention. These more objective measures generally support the qualitative evaluation.

It is not uncommon to hear academics in higher education bemoaning the generic skills levels, especially those linked to writing, mathematics and evaluation, possessed by current students. Faculty are often reluctant to address these as they believe they do not have the time or background to teach these skills [4]. An implication of this small-scale piece of research is that specific aspects of writing can be developed with no formal in-class teaching and without reducing the normal technical content of the course. In this case, the intervention was exclusively hosted on the institutes LMS and a small portion of the course grade was used to encourage learners to actively engage with this writing intervention. While the focus of this intervention was on abstracts, introductions etc., there is no reason why a similar type of intervention could not be used to develop other writing elements if they were to be found wanting. In a more general context, the article contributes to the extensive literature evidencing the impact of formative assessment on student learning.
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