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BOARD # 27: Work in progress: Multiple submissions for technical writing assignments improve students' self-efficacy and reduce anxiety

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Work in progress: Multiple submissions for technical writing assignments improve students' self-efficacy and reduce anxiety

Introduction

The engineering education community has long understood that one of the core engineering skills is technical writing, as shown in several works [1], [2], [3] and highlighted in the most recent version of the ABET Criteria for Accrediting Engineering Programs [4]. Organizing one's thoughts in a written format helps solidify theoretical and practical concepts covered in the classroom. Additionally, strong communication skills are highly sought after by employers. Despite these benefits, many traditional engineering courses fail to give students the space to reflect upon and improve their writing. Time constraints and lack of grading incentives also dissuade students from continuing to engage in the writing process, indicating a need to move beyond one-off writing assessments [5]. The subjective nature of evaluation further complicates the challenge of efficiently teaching technical writing. Extensive work has been done to create more informative rubrics and improve transparency in grading [6], [7], [8], but consistency remains an ongoing issue, particularly in courses where the grading is divided amongst instructors and/or teaching assistants. Many studies have shown that targeted feedback elucidates deficiencies and gives students a clearer roadmap to improvement [5], [9], [10].

This work posits that allowing students to resubmit assignments to improve their grade encourages students to view technical writing as an iterative process that goes beyond the first received grade. By pairing targeted feedback with an opportunity to act upon it for an improved grade, the proposed grading policy may provide students incentive to remain engaged in the writing process and further solidify both technical and communication skills; this strategy draws upon similar concepts in other alternative grading strategies [11], [12], [13]. A key distinction of this intervention is the opportunity for students to recoup 100% of points lost. By engaging students in the writing process with reduced grading penalties, such a policy may also improve students' self-efficacy and reduce anxiety through dissolving the popular "one shot" methodology of grading. This work seeks to build upon existing studies by quantifying these effects with modified, validated instruments.

Methods

The proposed intervention, henceforth referred to as the resubmission policy, was presented to students as an opportunity to resubmit any writing assignment within one week of the feedback being returned, for up to 100% of points back. These writing assignments included weekly lab reports with statistics-based analysis, weekly technical memos of concepts and devices tested during lab, and final reports for long-term projects. Assignments were only disqualified from resubmission if they did not meet a predetermined grade minimum, which varied by course level. There was no maximum number of assignments students could resubmit, but students were allowed only one resubmission attempt per assignment. The courses evaluated in this study were laboratory courses where technical writing assignments comprised over 80% of the final grade. Two courses with a combined total of 53 students were evaluated: one at the sophomore level and another at the senior level. The grading rubrics used for these writing assignments are

shown in Appendix Tables 1 and 2. Through these rubrics, students were given specific feedback to address deficiencies; example comments include: “increase font size to improve readability,” “support conclusions with quantitative results," and "cut redundant sentences for succinctness.”

To assess the efficacy of the resubmission policy, as well as its effects on students’ self-efficacy and anxiety, a course survey was given at the start and end of the semester. Students evaluated statements directly related to the policy, as well as additional statements related to self-efficacy and anxiety, on a 5-point Likert scale. The statements related to self-efficacy and anxiety were modified from existing validated instruments to fit the structure and content of the evaluated courses [14], [15]. The statements related to anxiety were further parsed into a series of statements corresponding to tasks aligning with low and high levels of Bloom’s Taxonomy [16] The relevant survey questions are shown in Appendix Table 3. Pre- and post-course survey results were paired by individual student, anonymized, and filtered for completed surveys (n = 22). These survey methods were reviewed and approved by an institutional review board at Rice University (IRB-FY2023-239). Using the Kruskal-Wallis test for ranked non-parametric data [17], the results were analyzed for any differences between pre- and post-course scores in two types of statements: (1) self-efficacy statements and (2) anxiety-related statements.

Preliminary results

Preliminary results indicate that students found great value in the resubmission policy, with nearly every response related to their improvement in technical understanding and writing communication being “strongly agree,” and every response being at least “somewhat agree” (Appendix Fig. 1). In one qualitative response, a student remarked that, “*…it was really helpful to have the resubmission policy to learn what we could improve in future assignments. I noticed that my figures and formatting improved significantly after the first few resubmission rounds.*” Though self-reported, these responses affirm that student perceive a benefit to the resubmission policy and attribute improvements in their skills to the resubmission policy.

In assessing self-efficacy statements, such as “I am confident I understand topics [in this course]” and “I believe I can master skills [in this course]”, a significant positive difference was seen in the post-course scores ($p < 0.001$). This difference was not seen in self-efficacy statements general to the field of bioengineering ($p = 0.65$), suggesting that changes in self-efficacy were limited to the scope of the courses that used the resubmission policy. The rank differences are shown in Appendix Fig. 2.

A reduction in anxiety-related scores was found for low- and high-complexity course-specific tasks ($p < 0.001$ and $p = 0.003$, respectively). The rank differences are shown in Appendix Fig. 3. Low-complexity tasks included tasks related to the *Remember* and *Understand* levels of Bloom’s Taxonomy, while high-complexity tasks included tasks related to the *Evaluate* and *Create* levels. In one qualitative response, a student pointed out, “*[the resubmission policy] reduced so much stress because we now actually have a chance to improve/learn*.” These findings suggest the resubmission policy is effective in quelling concerns at all cognitive levels.

It must be noted that all the courses evaluated required students to perform tasks across all levels, not just the lowest levels. With that in mind, practice of high-complexity tasks, and associated

technical writing related to these tasks, may be necessary to see the reduction in anxiety seen in this study. In other words, the resubmission policy by itself does not generate the wide-ranging effect seen here.

Discussion and conclusions

The results seen in this preliminary study match those found in recent work within bioengineering education. Adkins et al. reported that students found in-person, one-on-one feedback from an instructor or teaching assistant to the most valuable resource in improving their writing, compared to peer review and online resources [10]. In two studies, Gammon-Pitman and Nocera evaluated lab report resubmissions and found improvements in early resubmissions and that a great majority of students self-reported improvements in technical writing skills and confidence [6], [18]. The preliminary analysis in this work affirms these previous findings, and the analysis of anxiety-related statements suggests there are additional benefits to allowing students to act upon their mistakes and be rewarded for it, even if it creates more work overall. In fact, 100% of students in this preliminary study opted to do a resubmission when it was possible, i.e. they did not receive a perfect score on the first submission and they reached the grade minimum. This was true even for high scores (> 95%) in the initial submission.

This first implementation of the resubmission policy was limited by the fact that there was no penalty to submitting poor quality work in the initial submission, outside of the minimum grade requirement. Thus, it was unclear if students were putting forth their best efforts in the initial submission. Additionally, the rubrics used in this study could be improved by referencing previously evaluated rubrics and feedback techniques [7], [8]. Pairing greater incentive for higher quality work with clearer expectations may amplify the positive benefits to student outcomes. Future work in this study will assess more courses to confirm if the findings from this preliminary study can be extended to a broader range of topics. With a larger set of data, it may then be possible to parse the effects of grade improvements on the degree of improvements in self-efficacy and anxiety. The effect of the resubmission policy on underrepresented groups in engineering may also be evaluated to see if this policy improves classroom equity.

Another limitation is the increased workload on instructors implementing this policy. For this work, the instructor graded all initial submissions and resubmissions to ensure consistency. Deadlines were set such that students had at least one week to revise submissions, and the instructor had three days to grade resubmissions on final assignments before university deadlines at the end of the term. Future implementations will require a detailed rubric and guidelines for granting points back. Then, grading can be delegated to teaching assistants to scale up to more typical course sizes for greater efficiency and more relaxed end-of-term deadlines. Exploration into alternative strategies to reduce grading load, such as limiting the number of resubmission assignments or granting points back only in specific areas, may also be warranted. Future work will also explore extending this intervention to non-lab courses and non-technical writing assignments. In observing assignments beyond writing assignments, it may be possible to make more definitive conclusions regarding the impact of reduced grading penalties.

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Appendix

Appendix Table 1: Grading rubric for lab reports

Point values in parenthesis

Content area (40 total points)	**Evaluation statements**
Technical content (30)	• Abstract provides a concise overview of the work. (5) • Relevant background is accurately described. (6) • Methods are well-explained. (5) • Results are presented with appropriate figures and detail. (7) • Results and ensuring implications are discussed. (7)
Presentation (10)	• Figures, tables, and equations are clearly labeled and described. (5) • Professional standards for formatting, grammar, and spelling are used. (5)

Appendix Table 2: Grading rubric for technical memos

Point values in parenthesis

Content area (40 total points)	**Evaluation statements**
Technical content (30)	• Abstract provides a concise overview of the work (5) • Technology is accurately described (10) • Function of the technology is appropriately justified. (10) • Implications of technology are discussed (5)
Presentation (10)	• Figures, tables, and equations are clearly labeled and described. (5) • Professional standards for formatting, grammar, and spelling are used. (5)

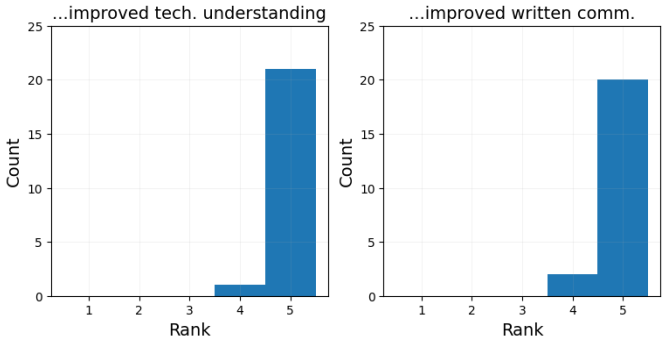
Appendix Table 3: Relevant survey questions

Additional details not provided to students but shown for the reader are in *italics*.

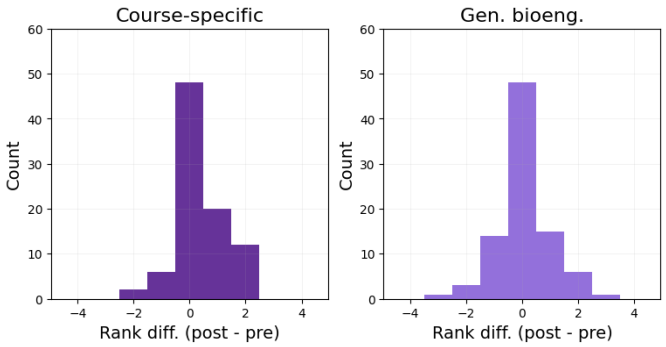
Question	**Response options (rank order in paren.)**
(*Fig. 1, post-course survey only*) Rate the extent to which you agree or disagree with the following statements: • The resubmission policy improved my technical understanding and skills. • The resubmission policy improved my written communication skills.	• Strongly disagree (1) • Somewhat disagree (2) • Neither agree nor disagree (3) • Somewhat agree (4) • Strongly agree (5)
(*Fig. 2*) Rate the extent to which you agree or disagree with the following statements concerning learning and grading **in this course**: • I am confident I will understand topics in this course. • I believe I can master skills in this course. • My grade in this course will reflect my effort. • My grade in this course will reflect my understanding.	• Strongly disagree (1) • Somewhat disagree (2) • Neither agree nor disagree (3) • Somewhat agree (4) • Strongly agree (5)
(*Fig. 2*) Rate the extent to which you agree or disagree with the following statements concerning learning and grading **in bioengineering courses other than this course**: • I am confident I will understand topics in other bioengineering courses. • I believe I can master skills in other bioengineering courses. • The grades I earn in other bioengineering courses will reflect my effort. • The grades I earn in other bioengineering courses will reflect my understanding.	• Strongly disagree (1) • Somewhat disagree (2) • Neither agree nor disagree (3) • Somewhat agree (4) • Strongly agree (5)

Appendix Table 3, cont.

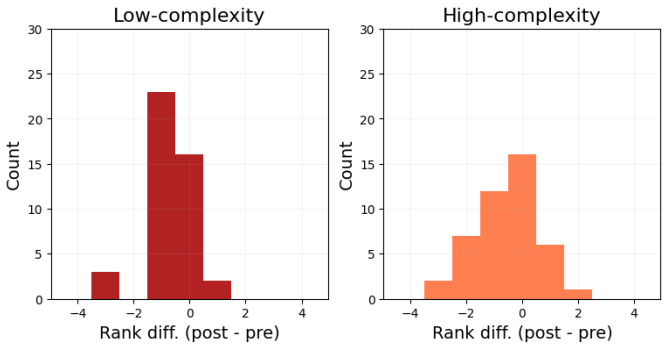
(*Fig. 3*) Rate the extent to which you are frightened or anxious of the following tasks related to this course: (Remember *level of Bloom's Taxonomy, depending on course, one of the following*): • Recalling the appropriate p-value for an experiment. • Memorizing the formula to calculate the cut-off frequency of a filter. • Memorizing the appropriate Git command to push changes to a repository. (Understand *level of Bloom's Taxonomy, depending on course, one of the following*): • Identifying parts of a heartbeat from a graph. • Reading a circuit diagram to understand its purpose. • Identifying the data type for a variable in Arduino. (Evaluate *level of Bloom's Taxonomy, depending on course, one of the following*): • Interpreting the results of an analysis of variance (ANOVA) to give a statistical conclusion. • Improving an existing circuit to record higher quality data • Improving existing Arduino code to make a device run faster. (Create *level of Bloom's Taxonomy, depending on course, one of the following*): • Designing an experiment to measure the difference in lung capacity between healthy and diseased patients. • Designing and building a device to record signals from the body. • Designing a device to detect temperature and communicate it to a smartphone.	• Not at all (1) • A little (2) • A fair amount (3) • Much (4) • Very much (5)



Appendix Figure 1: Rank scores in statements related to the resubmission policy. Ranks of 1 and 5 indicate “strongly disagree” and “strongly agree,” respectively. For each plot, 1 statement per student was queried, for a total of 22 statements.



Appendix Figure 2: Rank differences in course-specific self-efficacy statements (left) and general bioengineering self-efficacy statements (right). Positive differences indicate improvements in self-efficacy over the course. For each group, 4 statements per students were queried, for a total of 88 statements.



Appendix Figure 3: Rank differences in statements regarding anxiety in low-complexity course tasks (left) and high-complexity course tasks (right). Negative differences indicate a reduction in anxiety over the course. For each group, 2 statements per students were queried, for a total of 44 statements.