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Implementation and Assessment of New Techniques in Technical Writing

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“Implementation and Assessment of New Techniques in Technical Writing”.

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Abstract

Teaching technical writing to engineering students is a challenging task since they are very math oriented and reluctant to recognize the importance of the topic. But communication is most definitely an engineering asset that any successful engineer must have. The goal of this research is to compare the technical writing performance of students before and after a series of changes were implemented in the university's technical writing course 'Laboratory Analysis and Reports'. These changes included providing more feedback to students, allowing them to resubmit assignments after an initial grading, reading assignments in front of the class, reading, summarizing and discussing technical papers in addition to other laboratory exercises. The results are evaluated by grading a number of student final projects from the pre and post-changes cases. The final project is an extensive report on a fictitious experiment the students have designed and supposedly executed. The idea is not to have them execute the experiment, but write effectively about it. Grading is done without the grader knowing whether the student is from a class where these changes were implemented or not. The assessment was done using six criteria that include: (a) document structure (b) objectives and conclusion, (c) grammar and spelling, (d) quality of writing, (e) depth of analysis and (f) scientific integrity. The results obtained show increases of 8% for categories (a), (c) and (d) , 14% for category (b), 7% for category (f) and a decrease of 3% for category (e). These results suggest that the changes implemented had a positive impact on the technical writing level of the students.

Introduction:

A successful engineer has to be able to gather and analyze the data obtained and communicate the results effectively to engineers and non-engineers alike. Research has shown that an engineer's performance in the workplace depends greatly on his or her ability to communicate effectively[1],[2]. This important and crucial skill is rather challenging to teach and even harder to master. Engineering students are by nature reluctant to recognize the importance of proper communication and as a result do not give it the time and effort it requires. Research has also shown that many recent graduates have less than average level of technical writing [3]. Many institutions have implemented different ways to address the topic. Some have incorporated technical writing into other courses [4],[5], some have addressed the issue early on starting with freshman classes [2],[6] while others have incorporated the engineering and communication together [7]. Unlike the traditional engineering problems where the final numerical answer could confirm the validity of the solution, the outcome of a technical document cannot be evaluated as easily, especially by the students. In addition the skill required is one that is not gained overnight but demands a lot of patience and feedback.

A course titled "Laboratory Analysis and Reports "is part of the Mechanical Engineering and the Mechanical Engineering Technology programs at a regional university. It was developed to address data analysis and technical writing for engineering students. The course includes sections on technical writing, project management, Microsoft Excel, probability, statistical analysis and error propagation. The course evolved over the years and two years ago a series of changes were implemented to improve the technical writing part. Before and after these changes were implemented, the students were required to submit a final project report on a fictitious experiment they have designed and executed. The idea is to force them to think of a particular experiment with well-defined objectives and have them write about it. This includes an introduction with a detailed section on the governing theories and equations, procedure, results, discussion and conclusion. The students will either fake the data obtained or obtain some from external sources. The purpose is not to run the experiment but rather to write effectively about it.

In order to assess the effectiveness of the changes, fifty final projects were selected from classes before the changes were implemented and fifty from after the implementation. It is important to note that all copies were re-graded by a single instructor and without him knowing where the paper came from i.e. pre or post-changes. This was done to ensure a level of uniformity when grading. The projects were selected randomly from two years' worth of classes for the pre and two from the post cases. The class averages around 30 students and is offered 4 times a year. The project can be done in groups of two although many students decided to do it on their own. This yielded a total of 174 projects from the two years of pre-changes and 155 from the post-changes case. The final project is submitted as a hard copy with a front cover page with the student (s) name and date. The instructor gathered all the pre-changes projects submitted and removed the front page so that the name and date are not known. Fifty projects are then selected randomly from the 174 available and the same is done for the post change case. In this case the fifty projects are chosen from a batch of 155. The resulting 100 projects are mixed into one stack and re-graded. While some projects might seem familiar to the instructor, in most cases it was not

possible to identify or remember what year the project was from, especially once a few reports have been graded. In order to make the grading more systematic the following topics were separately assessed for each paper.

a) General structure of the document, i.e. how well it follows the format specified, whether all required sections are present, whether figures, tables and appendices are properly labeled etc. as well as how well it ties in together.
b) Objectives and conclusions, i.e. how clear and well defined the objectives and conclusions are.
c) Grammar and spelling.
d) Quality of writing, i.e. use of run on sentences, choice of words and jargon, etc.
e) Complexity of topic, i.e. whether the topic is too simple or too complex.
f) Scientific integrity and depth of analysis, i.e. how good are the technical aspect and analysis of the project outcome.

Implementations of new techniques

The new techniques implemented in the post-changes case are based on having the students be writers, readers and reviewers while providing them as much feedback as possible. The following is a list of the changes that were applied and their justifications.

I. **Provide more feedback more often:** This is a key issue and is reflected in most of the changes implemented. Unlike most of the traditional problems in engineering where a numerical answer is often the result of the analysis and can be checked easily, the case is not so for technical writing. As a result, it is much harder for students to assess whether the document is sound or not as there are no numerical answers to refer to. Providing more feedback and the chance to rewrite the document and be re-graded allows them to understand what needs to be changed and get the opportunity to improve on it. If feedback is not provided and resubmittal not required, the students will be very reluctant to reexamine or improve their work. The resubmittal was done for the post-changes case only. In addition, the students were encouraged to take advantage of the instructor's availability outside of class for additional assistance if needed.

II. **Reading the documents in front of the class and receiving feedback**. This was done in the post-changes case for three assignments, mainly the abstract, introduction and conclusion of the final report. The students are asked to submit a version of their abstract first. They were not told that they will have to read it to the class until they submit. However they realized that they will have to do the same when they submit their introduction and conclusion next and this puts more pressure on them to perform. Feedback from the class as well as the instructor benefit all students as they tend to make the same types of mistakes. This was done during regular class time. For the pre-changes case, the students were asked to submit an abstract but without reading it in class. For both cases however, they were given the same instruction on how to write an abstract before they submit their first draft.

III. **Reading and reviewing other students' documents**. For the post-changes case, the following laboratory was created. Students are asked to build a paper airplane without providing any more details. When everyone is done, they are asked to write instructions for creating the airplane but without resolving to any figures or diagrams. The instructions are then exchanged and students are asked to use them to build the airplane. The plane created by a particular team is compared to the one built according to their instructions by another team. As part of the review process, they are asked to fix or rewrite parts of these instructions they deemed unclear. This help them realize the importance of communicating correctly and forces them to organize their thoughts. It also generates a lot of discussion on the best way of describing the different steps. Another variance of this exercise uses Erector® sets to build a vehicle instead of a paper airplane.

IV. **Reading technical documents**. Another exercise consists of reading a technical publication, summarizing and reviewing it. The objective is to read the paper and figure out what information must be included and what can be omitted in the summary. They were required at first to answer a series of questions and submit their answers. These questions include 'what was done?' 'how was it done?' 'why was it done?' and 'what are the conclusions?'. The paper is discussed in class briefly then the students are given the chance to rewrite the assignment as a single paragraph for re-grading. This exercise is done during lab and was done for the post-changes case only.

V. **Stretch work over entire quarter**. Allowing the students the entire quarter to work on their project is extremely beneficial and a much better approach than the earlier one. Initially, the instructor introduced the technical part of the course half way through the quarter after the rest of the course material has been covered. This left the students with four to five weeks but that proved to be insufficient. Instead, the students are asked to start writing the first draft of the abstract at the end of the first week of classes. They are given a week to do so, after which they are asked to submit the introduction and their conclusion at one week intervals. The students will then have until the end of the quarter to finish their project.

VI. **Provide one on one**. In order to maximize the one on one interaction with the students, the instructor encouraged all students to take advantage of office hours. Furthermore, the instructor did not hesitate to have them work on their writing during lecture and lab time. This allowed him to move around, answer questions and suggest changes on the spot. The students get instant answers and can move along much quicker. This was not done in the pre-changes case.

VII. **Identify and address common issues**. Sometimes, the same mistakes are made by a large number of students. These typically include run on sentences, improper use of abbreviations and punctuation, vague statements, improper labeling of figures and tables etc. Even though these are addressed and emphasized in class students seem to overlook

them when writing, at least for the first drafts. In order to highlight these issues, after a student reads his or her assignment, the instructor specifically asked the class if there were any of these common mistakes, and if so where and how can they be fixed. The idea is to help the students remember and identify them more easily. This was done in the post-changes case only.

VIII. **Ease them slowly into the project, force them to go one step at a time**. Instead of simply asking the students to submit the report at the end of the quarter, intermediate steps were required for the post-changes case. The abstract is required first. The students read this first draft in front of the class and make note of any valid comments or suggestions. They will then rewrite and submit a copy of the abstract to be graded as a homework. The same is done for the introduction, which includes a detailed analysis of the governing theories and equations, as well as the conclusion. Once these three documents are finalized the students are asked to finish writing the report. This includes sections such as error analysis, appendices, results and discussion. However, they always have the opportunity to ask questions and get feedback on their progress during class, laboratory or office hours.

Results:

Table 1 and Figure 1 both show the average grades for the final projects obtained for the a) thru f) criteria, for both pre and post-changes. The grade scale is shown in Table 2. This is only a rough reference as it does not directly apply to all the criteria of Table 1.

	a) General structure of the document	b)Objectives and conclusion	c)Grammar and spelling	d)Quality of writing	e)Complexity of topic	f) Scientific integrity and depth of analysis
PRE	71%	68%	70%	69%	73%	75%
POST	79%	82%	78%	77%	70%	82%

Table 1. Grades of 50 pre-changes and 50 post-changes final projects.

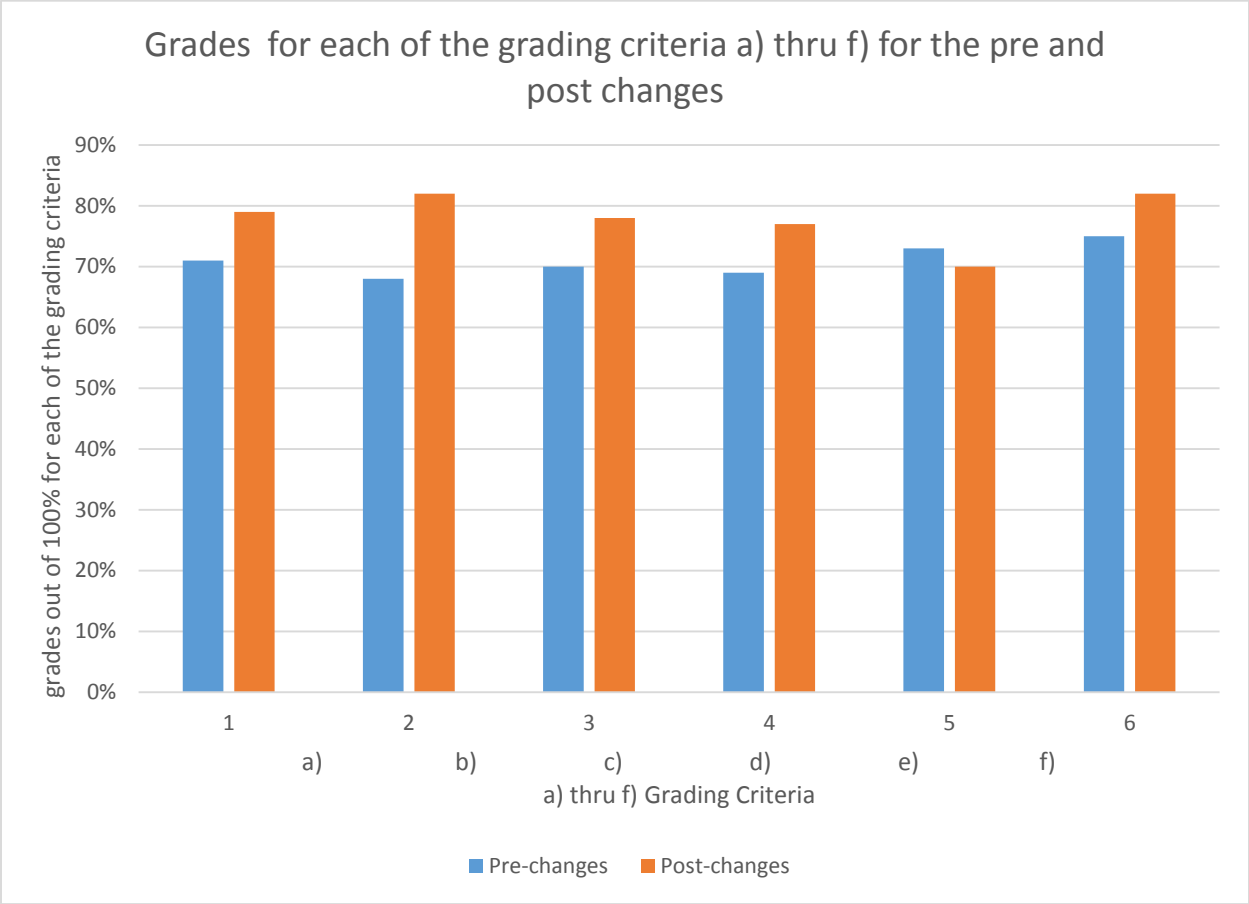

Figure 1. Results of 50 pre-changes and 50 post-changes final project grades.

Less than 60% : failing work
60% to 70% : Mediocre. Needs a lot of improvement. Multiple mistakes
70% to 80% : Average work. Needs some improvement. Many mistakes
70% to 80%: Acceptable work. Some mistakes. Could be improved.
80% to 90% : Very good work. Followed rules. Few mistakes
90% and more: Outstanding work. Free or almost free of mistakes. Clear.

Table 2. Grade scale.

Analysis of results.

a) **General structure of the document:** Post-changes data shows an increase of 8 % in the average grades. For the pre and post cases, the students were given a table of content for their project and were asked to use it as a template. This increase can be attributed to the instructor insisting more and more with each passing quarter on a proper format and highlighting some of the common mistakes and misconceptions. In addition, the instructor required a detailed table of content from the students once

their conclusion has been graded. This was done to provide the students with guidance on the general structure of the report and was implemented in the post-changes case only.

b) **Objectives and Conclusions:** With an increase of 14%, this category has the highest increase of all the ones considered. This is due to the fact that, for the post-changes case, the students were asked to read their abstract, introduction and conclusion in front of the class and then answer questions. When forced to do so, they tend to be more prepared. Even though they were not told they will be reading their abstract when they submit it in class, once they have done so, they realized that they will be doing the same for their introduction and conclusion. This was done on purpose as experience proved it an excellent motivator for students. After they read their abstracts, the instructor asks the class a few selected questions such as 'do you know what they are doing?' 'do you know why?' 'do you know how?' and ' what were their conclusions?' These basic questions generate a lot of comments and discussions in the classroom and help the students identify what should be included and what should not in their paper. The same is done when the introduction and conclusions are presented in class. The high increase could be attributed to the fact that these assignments are graded after the students read them in class and made changes, so the quality is much better. It is also beneficial for the students to be aware of the work of others and watch the progress they make. The students responded favorably and stated that they benefited greatly from this exercise.

c) Grammar and spelling: The change in this case is an increase of about 8% and is due to the fact that students have gotten the chance to rewrite their assignments for the post-changes case. For this case in particular, the abstract, introduction and conclusion were relatively free of these mistakes since they were graded after the students received feedback and gotten the chance to fix them. However, it was noticed that a few more errors were present in the remaining parts of the final project. This might be due to time constraints on the students as these parts are usually written towards the end of the quarter and are not read in class.

d) **Quality of writing:** Here again there is about 8% improvement in the quality of the writing. Weaknesses in the sentence structure and run on sentences were obvious to the students once they read it to the class. For the post-changes case, the instructor strongly recommended the assignments be read out loud in front of an audience (could be roommates or friends) before it is submitted. Students who did not do so had less than desirable results in front of the class and the risk of future embarrassment led most if not all of them to put in more effort and time into their work.

e) Complexity of topic: This is the only category where there was a decrease in the grades. However, this is not an indication of the quality of the assignment. The purpose of the paper was made clear from the beginning and that is to see if the

students can explain a topic they are already familiar with. The emphasis is not on the topic itself but on the description of it. Students were given the chance to choose a topic of their liking and this in order to make the project a bit more interesting for them. Few chose topics that were relatively complex but had to readjust half way through the project. The drop could be attributed to the fact that in the post-changes case, the students realized how complex their topics were and how challenging it was to explain the governing equations and theory effectively. This became apparent to them after they read their assignments in class. The instructor stressed quite a bit on this early on for the post-changes cases and that could also have contributed to the drop in the results.

f) Scientific integrity and depth of analysis: An increase of 7% is observed for this criteria. This dealt with how sound and complex the scientific analysis of the paper was. Keeping in mind that while the data is fake or obtained from external sources, the analysis of the results should still be comprehensive. The students were told to be smart about their results and to anticipate what these results could be so as to effectively discuss them. While it might seem odd to be discussing results that were never really obtained, here again the focus is on the interpretation of the results much more so than the actual result themselves. This was not greatly emphasized in the pre-changes case.

Conclusion: A series of changes were implemented in the technical writing course for the Mechanical Engineering and Mechanical Engineering Technology programs in order to improve the student's communication and writing skills. These changes were numerous and focused on writing, reading and reviewing technical documents. A final project consisting of a paper describing a fictitious experiment was used as the mean assessment tool. A total of 100 assignments were chosen, half of which were from pre-changes and the other half from the post-changes classes. The grading was done by one instructor without knowing what classes the assignment came from (pre or post-changes). The assessment was done according to the following six criteria: (a) document structure (b) objectives and conclusion, (c) grammar and spelling, (d) quality of writing, (e) depth of analysis and (f) scientific integrity. The results obtained showed an increase of 8% for categories (a), (c) and (d), an increase of 14% for category (b), an increase of 7% for category (f) and a decrease of 3% for category (e). These results suggest that the changes implemented had a positive impact on the technical writing level of the students.

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