Improving Students' Technical Writing Skills: Abstracts in Introductory Solid Mechanics

Kai Jun Chew, Stanford University Designing Education Lab

Kai Jun (KJ) Chew is a second year Master student majoring in Mechanical Engineering at Stanford University. Born and raised in Malaysia, KJ received his Bachelor of Science in Mechanical Engineering at the University of Southern California (USC). Though he did not have a specific concentration at his undergraduate level, he is interested in working in the field of solid mechanics and engineering education. He has been working on improving students' technical writing skills in the Designing Education Lab at Stanford University.

Ms. Autumn Turpin, Stanford University

Autumn Turpin is a junior undergraduate studying Engineering, Product Design at Stanford University. She was born and raised in the Bay Area. She has been working with the Designing Education Lab since January '14.

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Introduction

Technical writing is an important skill for students to develop by the time of graduation, and effective communication is required of the ABET 2009-10 Criterion 3. In addition to ABET requirement, the industry demand for skilled technical writers is increasing⁶. However, for many engineering students, the act of technical writing can be intimidating. This is especially true if the students are still learning about the topic in question⁶. More exposure to the subject matter is useful in making technical writing a less daunting task. Students need significant practice to become effective communicators upon completion of their degrees. Beginning this education in technical writing early allows students maximize time spent learning to communicating effectively and efficiently. Much work has been done to investigate the effect of interventions in upperclassmen capstone courses (see bibliography). Additionally, courses which integrate writing and project design instruction are becoming increasingly common^{6,8}. This interdisciplinary combination has the potential to give students an experience in technical writing and engineering design closer to that practiced outside of an academic setting⁸.

For this paper, the researchers examined the effect of instructional interventions on early engineering students, primarily freshmen and sophomores. The course in question is ENGR 14: Introduction to Solid Mechanics. This is a prerequisite course for many higher level engineering classes which combines communication, project based learning, and technical writing. . There are two longer writing assignments in the course; the assignment we have focused our research on is the second project, P2. This assignment required students to design their own statics research question, solve the problem using topics covered in Introduction to Solid Mechanics, and complete a written summary. This written summary contains an abstract, free body diagrams, final calculations, and a poster presentation. The purpose of the project is to give students experience in designing their own problem and solving it, writing a professional technical paper, and class presentation.

The questions that this research seeks to answer are:

1. How did the changes in the assignment worksheet affect student work in terms of clear technical writing?
2. What could be added or changed about the assignment to maximize student performance?
3. How will these ideas be implemented for future quarters?

This research adds new information to the existing literature because it examines the effect of instruction in technical writing through a project that is not a capstone design course nor requires students to design a working model within certain constraints.

Background

Design projects involving technical writing in engineering courses have the potential to provide a learning platform for other essential skills. For example, in Seawright's work with the Texas A&M University's Qatar site⁹, a technical writing opportunity was used to facilitate education in collaboration. Lessons learned from this particular paper include the importance of deliverables

for on-time completion as well as communication with and care for group members improves production.

As discussed in “Adventures in Paragraph Writing”⁵, the addition of writing exercises to teach communication helps the absorption of technical content. In “Putting the Horse Before the Cart,”⁷ Riddell asserts that “fitting design projects and writing assignments into an established instructional framework is an essential aspect of teaching project-based courses.” As ENGR 14 is a combination class with many scenario-based learning exercises and two main projects, it stands to benefit from structured, intense writing instruction for students.

Barriers to Inclusion

One of the most influential reasons that classes do not integrate more writing components into the engineering curriculum is lack of time. This is addressed in “Adventures in Paragraph Writing,”⁵ which mentions that many engineering programs include writing education in a “bookended” fashion - in the freshman intro and senior capstone courses. The paper’s thesis indicates that more frequent, concise writing assignments based on course material will provide students with beneficial exposure. The goal of this experiment was to provide preliminary results about implementing writing exercises in engineering courses that do not usually include communication. Meanwhile, in “Making Communication Matter,” Riddell et. al.⁸ concede the difficulty of implementation and delivery but are supportive of student gains from inclusion of communication, in both their engineering and writing skills.

From the student perspective, there are several things that make them dissatisfied or skeptical of technical writing instruction. In “Writing Like an Engineer: A Rhetorical Education”¹⁰, student opinions that were gathered include the ideas that engineers are bad writers because “their writing is often ‘boring’ and ‘ineloquent’”, that engineers deal with facts and aren’t persuasive, engineers only write to communicate ideas to other engineers, and that “relevant peers” provide an example and standard for writing. From these opinions, we can conclude that students do not seem to consider engineers good or interesting writers, and that there is no need to consider a wider audience for their writing. However, Winsor (author, “Writing Like an Engineer”) finds that engineering writing is rhetorical and that the audience matters. Including these impressions of engineering writing for students could help their understanding of the importance of technical writing and some of its subtleties.

Students are also frustrated with course materials that do not relate to real-world applications or are sometimes obsolete⁴, resulting in a non-motivational course structure. Students do respond positively to project based learning, but unfortunately at times do not find writing (specifically abstracts for homework problem solutions) to be useful². Strangely, in “A Freshmen Engineering Design Course,”⁴ when questioned “does the process of explaining to someone else how to solve a problem change or enhance your own understanding of the problem solution?”, 72% responded “frequently,” or “always.” The paper concludes, “Despite this unpopularity, there are indications that writing abstracts lead to increased student learning, as the 2012 cohort performed significantly better than the 2011 cohort which did not write homework abstracts.” While this may have been due in part to other class manipulations, the authors believe that the abstracts played a main role in this change. These results motivate the idea that although students may

think an intervention is unhelpful, the intervention is actually for the greater benefit of student education.

Motivation for Process

Several other studies have included the use of rubrics for evaluating student work^{5,6,8}. These were implemented by faculty to provide an evaluation of student work. In the case of “Making Communication Matter”⁸, students were provided with these rubrics ahead of time, as are students in ENGR14. In addition, there was not an expectation that evaluation would match exactly; rather differences were discussed for resolution. For the excerpt grading process used to evaluate ENGR 14 abstracts, this same process of blinded grading and post-evaluation for consistency was used.

In “Adventures in Paragraph Writing,”⁵ the support for the ENGR 14 rubric method came along the lines of allowing more positive comments and specific suggestions. It provided students with a framework in which to work. However, in some cases, the students did not feel as though there was enough detail contained within the rubric.

Methods

The methods utilized in this project stemmed from discussion with the primary class professors. They are also backed in the literature review. The researchers experimented with several ideas to improve the technical writing skills of students.

Figure 1 Process Map Looking at the Four Steps of the Research

This research was conducted in four steps as shown in the process chart in Figure 1. The abstracts written by the students of ENGR 14 were subjected to a preliminary analysis. Next, several steps (detailed later) were recommended as part of the intervention process to P2. After intervention, all the abstracts were examined to identify the categories, or codes, present in the abstracts. Lastly, excerpts which are categorized based on the codes were graded to evaluate quality.

Preliminary Analysis

The abstracts written by the students from Fall 2013 (F13) edition of ENGR14 were analyzed. The researchers read all the abstracts and identified a preliminary list of observations regarding the quality of the F13 abstracts. The following table lists the results of the analysis. The F13 abstracts were lacking in three main categories. These issues were a lack of brevity, unexplained free body diagrams, and results that were not mentioned or explained.. With these observations in mind, several recommendations were proposed to improve the writing of abstracts among

students. The recommendations were based on literature review, observation of common problems, and discussion with the Designing Education Lab and ENGR14 instructors.

Intervention

Several recommendations were accepted by the teaching staff and implemented in P2 of the Winter 2014 (W14) edition of ENGR14. The recommendations implemented are shown in the table below, with changes relevant to the focus of this research italicized are italicized.

Table 1: The list of intervention steps implemented in P2 in W14

Changes in the P2 Instruction Sheet	Additional Material/Steps for P2
<ul style="list-style-type: none"> • <i>Structured guidelines for writing an abstract</i> • More detailed poster instructions • Updated List of Example Problems • Adding a staff reviewing sheet (as guidelines for students) • Adding a student reviewer sheet • Adding notes for Elevator Pitch 	<ul style="list-style-type: none"> • <i>Sample abstracts provided to the students</i> • <i>Improved grading rubric (students are provided with the grading rubric)</i>

The recommendations shown in Table 2 are all the changes made to P2 in W14.

Structured Guidelines for Writing an Abstract

In the previous version of the P2 instruction sheet, there were no detailed explanations on how to write an abstract::

“The 1-page summary must contain the title of your project, an abstract of the project (a written narrative version of your post-presentation that is 300 words or less), a clear description of concepts used from E14, and a list of references used. Additional pages should contain supporting analyses and calculations.”

Based on the preliminary analysis observation that the abstracts have varying structure, the researchers decided to look into whether providing a structured guideline to writing an abstract would help the students in the writing process. A structured guideline was included in the W14 P2 instruction sheet, and can be found in Appendix A.

The guideline provided that contains specific details and explanations of each of the major categories. Most students in the class are sophomores, and are likely not familiar with the concept of writing an abstract. The detailed guideline is expected to provide the students a clear view of how to approach the writing process for an abstract. In addition, a small footnote (shown below) is included to explain the definition and importance of the abstract.

“In Project 2 you get experience with writing an abstract as a summary of your work. An abstract is more generally an important part of a paper or report. It is usually only a paragraph long, and often takes no more than one-third to one-half of a page. However, do not underestimate the power of an abstract; sometimes, it is the deal breaker on whether your paper

will be read. Keep in mind that when people are trying to find information from your paper, they will not delve straight into the contents of the paper to look for them. Instead, the first thing they do is to read the abstract and see whether your paper is relevant to their field of studies or research. This means the abstract is the very first impression you are going to make to the people. It is similar to an elevator pitch, only to be written formally on paper. Also, the abstract is usually the last part of the paper that is written, since by then you will be knowledgeable and comfortable with the materials you have researched.”

These changes were implemented with the expectation that providing more information about abstract writing could potentially improve the abstracts written.

Grading Rubric and Sample Abstracts

Two additional steps were implemented for the project in general. One was providing the students sample abstracts. Providing sample abstracts along with the structured guidelines was expected to give a complete picture of how to write an abstract. The samples given were obtained and edited from students’ work in F13 so that the sample abstracts accurately portrayed the expectations of the teaching team of student work. .

Another step introduced to P2 was providing the students with the grading rubric of the abstract (see Appendix B). The rubric was drafted based on the detailed guidelines in Table 3. The 3-level system was created to simplify the grading system and to allow the students to know how their abstracts were going to be graded. The grading rubric functions primarily as a reminder to include the important categories or codes detailed in the structured guidelines. From the literature (“Adventures in Paragraph Writing”), the adoption of a grading rubric in that specific class was due to concerns about students completing the assignment poorly or not at all. While students did not as a whole have a problem with completing the assignment in ENGR 14, including a rubric seemed promising to improve work.

Coding

Coding began after W14 edition of ENGR 14 ended, and was completed to identify the existence of each code in students’ abstracts.

Table 2: Sets of Codes and the Changes Over 2 Iterations

Preliminary Set	First Iteration	Second Iteration
Statement of Problem	Statement of Problem	Statement of Problem
Background Information and Context	Context	Discarded
Theoretical Explanations	Theoretical Explanations	Theoretical Explanations
Mention of Free Body Diagram (FBD)	FBD: Assumptions Made	FBD: Assumptions Made
	FBD: FBD Explanations	FBD: FBD Explanations
Mention of Results/Explanations of Results	Results: Mention	Results: Mention
	Results: Explaining	Results: Explaining
	Data Comparison	Discarded

	Use of Numbers and Equations	
	Mention of References	

The preliminary set of codes were based on the structured guidelines and the grading rubric. It was expected that student work would contain these codes. After the first iteration of coding was conducted, the researchers decided to split two of the main codes into subcodes, which are FBD: Assumptions Made and Explanations, and Results: Mention and Explaining. This was done to ensure the coding process captured the essence of both codes, as some of the abstracts coded only have one of them. The researchers felt that it would be not accurate to represent a brief mention of the outcome of the results by coding them as part of Explaining.

For the third iteration, only 6 codes were retained. The excerpt grading process, which will be detailed in the next part of the Method section, only focused on the 6 codes. The researchers decided to narrow the focus of the codes by only concentrating on codes that accurately represent the knowledge ENGR 14 has conveyed to the students.

Coding was done on the online software Dedoose. The researchers coded separately in which both researchers were blinded from each other's coding. To ensure consistency between the two authors, Dedoose Training feature was utilized by having both researchers take the code application test. A test was set by each researcher and both researchers take each other's test to evaluate how consistent the coding process was done with respect to each other. Multiple tests were set and done after each iteration as the researchers deliberate to ensure all the coding done was consistent. The test gives a Pooled Kappa that reflects the agreement between both researchers. The final two tests gave a Pooled Kappa of 0.67, which falls in the range of good agreement between both researchers. The relationship between Pooled Kappa and Cohen's kappa (a measure to evaluate inter-rater agreement) is that the Pooled Kappa is a global result for an inter-rater reliability test that includes more than one code, while Cohen's kappa provides a result for only one code.

With the coding done, the next step is to evaluate the quality of the abstracts written, which was evaluated through the process of Excerpt Grading.

Excerpt Grading

The excerpt grading process was completed to assess the quality of the abstracts analyzed. From the coding process, the sentences or section of an abstract that are categorized to a code are known as excerpts. This means each code contains excerpts coded from the abstracts. This is explained in the sample abstract shown below.

We chose this project because we wanted to explore FallingWater's structural integrity issues, specifically the cantilever beam failure located directly above the waterfall. The lower deck cantilever beam failed due to its deficit of steel bars inside the concrete, a mistake caused by the architect and structural engineers ignoring the reinforcement needed to counteract a negative bending moment.

Using equilibrium and maximum stress formulas learned in E14, we analyzed the mechanics of reinforced concrete in order to explain the failures integral to FallingWater's cantilever deflection. We modeled a free body diagram of the cantilever as a combination beam and calculated the maximum bending moment based on varying rebar placements within a reinforced concrete beam.

Using the Parallel Axis Theorem, we analyzed varying distances of the rebar from the center of the beam to calculate different area moments of inertia, which we then used the maximum stress formula to calculate the maximum bending moment that each steel bar can withstand. Since steel rebar has high tensile strength, the closer the steel rebar is to the top of the concrete beam, the higher bending moment the beam can withstand. Also, a larger area moment of inertia results in a higher maximum bending moment.

We concluded that using more steel reinforcement toward the top of the beam translates to higher load capacity, which is consistent with the information we found in the Mechanics of Materials textbook. Through research, we found that the FallingWater cantilever has a deficit in rebar, causing the beam to deflect downward beyond its tensile capacity. Originally, Wright planned to include eight steel bars within each beam. The structural engineers overrode this decision, noticing the high stress that would fall on each beam. They doubled the number of steel bars, but the structure was still stressed to the maximum tensile strength, which was fixed only recently with external reinforcement.

Figure 2: Sample Abstract

Table 3: Sample Excerpts

<i>Statement of Problem</i>	<i>"We chose this project because we wanted to explore FallingWater's structural integrity issues, specifically the cantilever beam failure located directly above the waterfall."</i>
<i>Assumptions Made</i>	<i>"We modeled a free body diagram of the cantilever as a combination beam"</i>
<i>Results: Mention</i>	<i>"We concluded that using more steel reinforcement toward the top of the beam translates to higher load capacity"</i>

The excerpt grading process allowed a category-by-category look on the quality of the students' work. The Excerpt Grading process was done on the final set of six codes. Similar to the coding process, both researchers were grading while blinded to each other's work. The excerpt grading scheme for each of the code was formulated and revised, and is included in Appendix C.

The excerpts from each code were graded with a level of low, medium and high. The three-level scale was used so that the analysis would not be too complicated and the results would give a general overview of how the writing of the abstracts has improved between F13 and W14 with clean statistics.

Similar to the grading standards held in the paper "Making Communication Matter: Integrating Instruction, Projects and Assignments to Teach Writing and Design,"⁸ the researchers first graded the excerpts in the bucket categories of low, medium, and high. After this grading was completed, the researchers noted any grades that did not match, then discussed and resolved any differences. This process also assisted in developing more concrete guidelines for evaluating quality of student work when later categories of excerpts were graded.

Results

Population

This research examined E14 students from F13 and W14. The total number of students in the sample is 174: 90 in F13, 84 in W14 versions of the class. Class year and major were collected from enrollment data, while gender data was gathered via Facebook profile (observed gender).

In F13, there were 57 males and 33 females. The total sample included 2 freshmen, 54 sophomores, 28 juniors and 6 seniors. As for major, 43 of them were undeclared at the time of enrollment in the course, while the remaining were students in various engineering fields (mechanical, civil, electrical, etc.) There were also 2 humanities students in the class. 44 abstracts were coded for F13. The abstract score (given by the teaching team of that quarter for the Project 2 abstract) was an average of 84.12.

In W14, there were 84 students, 48 male and 36 female. There were 44 sophomores, 33 juniors and 7 seniors in the class. 52 students were undeclared when they took the class, while the remaining students had majors in different engineering fields. The number of abstracts in W14 is 42, and the average of the abstract score for W14 was 91.45.

Effects of Changes of Assignment Worksheet to Students' Work in Technical Writing

As mentioned in the Method section, two important parameters are viewed to gauge the changes in students' work in technical writing: the existence of the codes or categories in the abstracts, and the quality level of the abstracts written. Statistical analysis was performed with the data to see whether the effects are statistically significant.

Existence of the Codes or Categories in the Abstracts

The existence of the codes or categories in the abstracts is gauged in all 86 abstracts.

Table 4: The percentage difference of each code between abstracts of F13 and W14

	F13	W14	Percent Difference
Statement of Problem	95.5	100.0	+4.5
Theoretical Explanations	90.9	97.6	+6.7
FBD: Assumptions Made	61.4	85.7	+24.3
FBD: Explanations	50.0	78.6	+28.6
Results: Mention	77.3	88.1	+10.8

From Table 6, it is seen that the codes that show the largest increase from F13 to W14 are the free body diagrams-related and results-related codes. It must be noted that in the preliminary analysis, the authors discovered the trend that F13 abstracts lacked content regarding the free body diagram and results of P2. The significant increase in both of these codes show that the

recommendations implemented in Intervention had positive effects on the students' work, which links directly to the first research question.

Quality Level of Abstracts

Statement of Problem

Figure 3 Comparison of High, Medium and Low Level of the Excerpts for Statement of Problem

From Figure 3, it can be seen that the excerpts categorized at the level “low” see a large decrease in W14 as compared to F13. There is also an increase in the number of medium and high level excerpts. The results are encouraging as it shows that intervention did have effects on how the students write abstracts in P2, a positive sign for the first research question.

Theoretical Explanations

Figure 4: Comparison of High, Medium and Low Level of the Excerpts for Theoretical Explanations

The grading results show that there is a rise in the low and high level excerpts while there is a drop in the medium level excerpts.

FBD: Assumptions Made

Figure 5: Comparison of High, Medium and Low Level of the Excerpts for FBD: Assumptions Made

Figure 5 shows an increase in the medium and high level excerpts for FBD: Assumptions Made and a drop in the low-level excerpts. Similar to the results for Statement of Problem, this is consistent with the researchers' expectations for this research as the changes in the assignment sheet are having a positive effects on the students' technical writing skills.

FBD: Explanations

Figure 6: Comparison of High, Medium and Low Level of the Excerpts for FBD: Explanations

Figure 6 shows results that send mixed signals regarding the intervention. There is an increase in the low level excerpts and medium level excerpts. This happens along with a drop of high level excerpts. The encouraging sign that the medium level excerpts increase is consistent with the

researchers' expectations, but the rise in the low level excerpts could show some parts of the Intervention might not have worked as well.

Results: Mention and Explaining

As discussed in the Method section, any of the excerpts that were coded as Mention were considered as the low level excerpts for Results. The following shows the results of the Excerpt Grading process.

Figure 7: Comparison of High, Medium and Low Level of the Excerpts for FBD: Explanations

As seen in Figure 7, the outcome of Excerpt Grading for the Results code is encouraging as it shows a similar trend that the Intervention had a positive effects on students' work in terms of technical writing.

The results shown in this section have portrayed that the changes in the assignment sheet or Intervention in general have a positive effects throughout the writing of the abstracts by the students. However, these data only provide an overall trend. To confirm whether the data is statistically significant, correlation and t-test were done with the data set for the quality level of the abstracts.

Statistical Analysis

Statistical analysis was conducted in R, and the first point examined was the correlation between excerpt quality and variables of gender, class year (freshman, sophomore, junior, senior), major, and abstract score. These results are included in a table below.

Table 5: Statistical Analysis results, pt. 1

Independent Variable	r	p-value
Gender	0.013	0.086
Class year	0.166	0.03
Major	0.030	0.69
Abstract Score	0.392	8.6e-4

Based on the p-values, the variables of gender and major do not have a significant correlation with the excerpt grading results. There is a weak correlation between class year and excerpt grades, which makes sense – an upperclassman or someone with more educational experience would be expected to be better at writing and class projects.

There is a moderate correlation of abstract scores and excerpt grades. This is encouraging as it shows two things: (1) the excerpt grading process is consistent with the teaching team grading process of the abstracts and (2) the intervention has potentially had a statistically significant effect on the quality of the abstracts written by the students.

The researchers then conducted a t-test to compare the results for the 5 codes (Statement of Problem, Theoretical Explanations, Assumptions Made, FBD Explanations and Results) of F13 and W14 to see whether the differences in both means are statistically significant. The following results are obtained:

Table 6: Statistical Analysis, pt. 2

Codes/Categories	t	p-value	Cohen's D
Statement of Problem	2.04	0.04	0.44
Theoretical Explanations	0.96	0.34	0.20
Assumptions Made	2.93	0.004	0.63
FBD Explanations	2.48	0.01	0.53
Results	0.14	0.89	0.03

It can be seen that for both assumptions made and FBD explanations, the differences between means of F13 and W14 are statistically significant. The Cohen's D analysis shows both Assumptions Made and FBD Explanations excerpts have Cohen's D of larger than 0.5, which is further justification that there is statistically significance in the differences in means. Since Cohen's D only works when there is a sufficiently large enough samples, performing Cohen's D analysis makes sense for the data set as there are 86 abstracts.

Discussion

Based on the outcome from the analysis of the existence of codes plotted in Figure 2, there is general improvement across the coding categories between F13 and W14, with significant increase in the FBD and Results categories as shown in Table 1. One of the possible reasons behind this increase is the structured guideline introduced in Intervention 1. Since in F13, there were no explicit instructions on how to write an abstract, the introduction of a guideline with specific details has shown to provide the students a clearer way to write the abstract. It must also be noted that providing the students with sample abstracts could also be a possible reason behind the improvement in terms of the existence of the codes as the students were able to refer to these sample abstracts and start planning their abstracts writing from the samples. In addition, the grading rubric provides the students a view of how their work is going to be graded, and as shown in Appendix B, the grading rubric specifically mentions the list of categories similar to the codes required for the abstract at the Level 3 of "Summary includes Appropriate Materials". All these steps provided a combined effects on the existence of the codes, as students now are aware what they are expected to include in the abstract for the project.

There are several interesting observations in the results for excerpt grading. Based on the statistical analysis done, both Assumptions Made and FBD Explanations show improvement that is statistically significant as shown by the t-tests done. This is an encouraging sign as it shows that the intervention does have a positive effect on the quality of the abstracts written by the students. Another observation is that since the structured guidelines provide information on the importance of including elements pertinent to FBD in the abstract, the improvement on FBD section of the abstract becomes significant as shown in W14 abstracts. Apart from that, the 5 graphs presented in the paper show that the low side of the excerpts graded drop significantly and the medium and high side of the excerpts increase. This is another positive sign that the intervention does have an effect on the writing of abstracts.

Possible Changes to the Assignment to Maximize Students' Performances

With the results shown above, it can be seen that the changes to the assignment shows positive effects on the students' performance in writing an abstract. From the results, the changes made listed in Table 2 managed to affect the students' performance by improving the important aspects in writing an abstract, which are the inclusion of important categories or codes and the quality of the excerpts in terms of contents and sentence structure. With the structured guidelines, grading rubric and sample abstracts provided, the results showcase a positive improvement in students' technical writing skills.

From the results, the researchers could potentially create more possible changes to future edition of P2. These include abstracts peer review, simplified structured guidelines and instructions sheet for the students. It must be noted that the outcome of the analysis for this research managed to show that changes or recommendations implemented could have an effect on the students' technical writing skills, which paves the way for more future changes.

The following section will detail the results to the third research question pertinent to the implementations of the possible future changes to the assignment.

Implementations of Possible Changes to the Assignment in Future Quarter

The results of the analysis have supported the idea that the implementations of the changes or recommendations under Intervention result in student work improvement. This shows that the changes were implemented in an appropriate manner and the model of such implementation could work in future quarter. The implementations include providing the grading rubric and sample abstracts through the course website instead of including them into the instruction sheet that has a lot of information about P2 and providing the structured guidelines in a tabulated form. These models pave the way for future implementations as the results have shown the implementations in W14 are successful in providing a positive effects onto students' performance.

Future Work

The following table shows the possible recommendations to be implemented in the future.

Table 7: Possible Recommendations and Implementations for P2

Changes in the P2 Instruction Sheet	Additional Material/Steps for P2
<ul style="list-style-type: none">● Shortened and simplified parts of instruction sheet● Removal of the sample topic section (provided in course website)● Removal of grading sheet (provided in course website)● <i>Shortened version of the structured guidelines</i>● <i>Guidelines on how to synthesize explanations for technical information</i>	<ul style="list-style-type: none">● <i>Introduction of Peer Review for abstracts</i>● <i>Surveying Students Regarding Interventions</i>

The researchers generated the changes shown in Table 5 based on the results of this research. Several important issues that need to be addressed including reducing the amount of information on the instruction sheet so that the students would not be overwhelmed with the writing task, include guidelines to help the students synthesize explanations for technical information were considered during the brainstorming session. The researchers also decided to implement peer review of abstracts so that the students would be able to obtain feedback regarding their work.

All these will be implemented with the models used for Intervention detailed in this paper. The removal of the sample topic section and the grading sheet means that these will be provided on the course website, similar to how the sample abstracts and grading rubric were provided for the research. This will reduce the amount of information on the instruction sheet so that the students will not be overwhelmed with the task of P2.

Based on the literature review, some possible future changes include: asking questions in the introductory survey about student's familiarity with technical writing, including a question in the post-survey about student's comfort level after multiple technical writing assignments, and investigating the students' views about how effective the assignment was at increasing their technical writing skills. Additionally, students could be asked to review a sample abstract and identify the key categories that the researchers identified during this project.

Another interesting topic to investigate would be the other writing assignment in ENGR 14, the bridge project. Many of the other papers reviewed looked at writing assignments based on a design project, which is more similar to the bridge project in ENGR 14.

As detailed in the second part of the Discussion section, the possible recommendations or changes and the implementations of the recommendations will be present in future iterations of ENGR 14. The researchers will continue to work on improving the technical writing skills of the students with these recommendations to ensure that students will learn how to write a proper

abstract and gain an appreciation of the value of quality technical writing. The most promising area for future expansion of the research is mainly focused on student feedback and simplifying the instruction sheet. The researchers hope to continue exploring various ideas of education in technical writing.

Conclusion

This paper details the effect of rubric-based and instructional interventions in the freshmen/sophomore Introduction to Solid Mechanics course. The interventions that were implemented in the W14 iteration of ENGR 14 appear to have had a positive impact on student work. There is room for future work regarding student familiarity with technical writing and further refinement of the assignment to maximize student benefits.

Appendices

Appendix A

Fundamental Elements	Explanations
Statement of Project Topic	<ul style="list-style-type: none"> ● Tell the reader questions you are trying to answer ● Be specific and concise, just use one sentence
Brief Explanation of Background and Context	<ul style="list-style-type: none"> ● Introduce the reader to the subject; give simple and concise details on the topic ● Motivate the project; why are you working on this topic? What is interesting about this subject?
Brief Mention and Explanation of Theory Behind the Project	<ul style="list-style-type: none"> ● Introduce the reader to the theory or fundamentals you are applying to tackle the problem ● Use equations to simplify explanations ● Use laymen terms, do not use advanced technical jargon that might be difficult to understand
Reference / Details of Free Body Diagram (FBD)	<ul style="list-style-type: none"> ● Describe the FBD ● What are the loads and boundary conditions? ● Why do you model the problem at hand with this particular FBD?
Reference of Calculations	<ul style="list-style-type: none"> ● Refer to the calculations; cite them ● This helps in explaining difficult concepts
Statement and Explanation of Results	<ul style="list-style-type: none"> ● State the general finding ● Explain the findings: how is it significant? Does it answer my question? ● Comparisons with actual data will be helpful ● Use numbers and equations to simplify explanations if possible
Reference to Resources	<ul style="list-style-type: none"> ● Cite the resources used in appropriate sentence in the abstract ● This helps you to keep track of how you use a particular resource

Appendix B

Written Summary (27 pts)	Level 3	Level 2	Level 1
Summary includes appropriate material	title and authors, statement of topic, explanation of background and context, explanation of theory, reference/details of FBD, reference of calculations, statement and explanation of results, reference to resources; photo is attached	most elements present	missing several elements
Abstract is effective	well-organized, clear, and would be useful to someone deciding whether to listen to the presentation	somewhat organized and clear, but would leave reader uncertain about whether to listen to the presentation	disorganized, unclear, would make reader unlikely to listen to presentation
Theory or fundamentals are applied to the project	fundamentals or theory needed to address the problem are correctly identified	fundamentals or theory are partially identified	missing or incorrect fundamental principles
Mathematical and physical assumptions that allow model to be solved are identified	good, reasonable assumptions	there are assumptions but more appropriate ones possible	missing assumptions
Free Body Diagram (FBD) is effective	clear, correct, explained in the abstract	present, but not referenced or incorrect	missing
Calculations are complete	appropriate mathematical	mathematical mistakes	missing calculations

	model, correct evaluation of equations		
Results of engineering analysis are explained and interpreted	findings are stated and significance correctly identified	findings are stated, but significance is partially identified	does not state findings or address significance

Appendix C Statement of Problem

Grade	Content	Sentence Structure
High	Clearly state goal and attack approach	Succinct, concise, understandable in layman's terms
Medium	Contain either goal or attack approach, not both	Somewhat clear, may need several readings to understand
Low	Contain neither, or not understandable	Filler sentences, varying length without containing tangible information

Theoretical Explanations

Grade	Content	Sentence Structure
High	Clearly state theoretical method and concepts from the class	Succinct, concise, understandable in layman's terms
Medium	Insufficient mention of theoretical explanations	Somewhat clear, may need several readings to understand
Low	Contain vague mention of class content, or not understandable	Filler sentences, varying length without containing tangible information

Assumptions Made

Grade	Content	Sentence Structure
High	Good assumptions, fully explained	Succinct, concise, understandable in layman's terms
Medium	Mention, but no further explanations	Somewhat clear, may need several readings to understand
Low	Bad assumption, questionable, or not understandable	Filler sentences, varying length without containing tangible information

FBD Explanations

Grade	Content	Sentence Structure
High	FBD explained clearly	Succinct, concise, understandable in layman's terms
Medium	Mention, but no further explanations	Somewhat clear, may need several readings to understand
Low	Bad explanations of the FBD	Filler sentences, varying length without containing tangible information

Explaining

Grade	Content	Sentence Structure
High	Both mention and explain the results with contextual interpretation	Succinct, concise, understandable in layman's terms
Medium	Explain results without interpretation	Somewhat clear, may need several readings to understand
Low	Any excerpts coded as "Mention" during the coding process fall under the low category.	

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- [9] Seawright, Leslie E. "Teaching Technical Writing: Opportunities for International Collaboration." *International Journal of Engineering Pedagogy* 4`2 (2014): n. pag. Web. <<http://online-journals.org/index.php/i-jep/article/view/3438>>.

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