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Writing Proficiency in Engineering Technology Students and Skill Development in the Classroom

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Writing Proficiency in Engineering Technology Students and Skill Development in the Classroom

Little work has been done to understand the engineering technology student. The work that has been done often incorporates engineering technology students into the larger number of engineering students. This masks information that would be helpful in guiding and working with engineering technology students. While this is important, work to further understand these students, we chose to begin by exploring the writing skills of the engineering technology student, developing on other work done in this area. The work place demands the ability to convey thoughts and concepts; however the academic environment is not consistent in the development of writing proficiency.

If professors provide exercises that engage the student and provide a forum in which the student writes and develops those skills, students writing proficiency improves. Employers and professors recognize that engineering technology students, while technically competent, lack writing proficiency. There are a number of hypothesis of why this deficiency exists, however we are more concerned with ways to remedy the situation once students matriculate into the engineering technology program. A variety of techniques have been used, and we have developed an assignment that is intended to increase writing proficiency while learning the technical material.

This work provides examples of the resulting writing assignments, such as the "Big Question Reflection." This assignment was designed to develop technical writing competency in engineering technology students. We discuss assignment options and provide those teaching engineering technology students with an understanding of the research that has been done, the assignments that has been used, and the outcome of the writing exercises. Comments and input from engineering technology students, as well as instructor analysis will be provided as will recommendations for future work in this area.

Introduction

Most studies on engineering technology students often incorporate these students into the larger number of engineering students. This obscures those things that we should know about this student population. This vast area of study, while daunting, is best researched by studying issues that are known in other programs. Developing our understanding about this unique group of students, while learning how to best educate and motivate them.

Writing proficiency is an area that has been discussed for some time.[1] Employers have indicated that engineering technology students are unable to articulate clearly, in particular they are lacking in writing skills..[2] Regardless, the work place demands the ability to convey thoughts and

concepts in writing.[2] While this is the case, and is often known, academia is not consistent in the development of writing proficiency.[1,3-5]

The authors believe that well-crafted exercises used throughout the curriculum provide the necessary practice to increase technical writing skills. There are a number of conclusions that have been made to justify the lack of this skill. Rather than entering that conversation, we have chosen to explore ways to remedy this deficit once engineering technology students' matriculate into the engineering technology programs. We have developed an assignment, a compilation of successful and engaging tools that will develop technical writing skills in the engineering technology student. The intent of this work is to provide greater understanding of these students, while assessing the changes in their writing skills throughout the semester.

Literature Review

Students matriculating into engineering technology programs generally have SAT Verbal scores that are much lower than SAT Math scores; this is true of most students in STEM fields. [6] Those with higher scores are generally found in other fields in the humanities and arts. Based on this data, it is often inferred that students with stronger verbal skills are encouraged to go to fields outside of STEM.

The concept of writing across the curriculum has been researched, tried, and documented for decades. Earlier it was referred to as cross-curricular writing instruction, now it is more commonly referred to as "Writing Across the Curriculum." One must wonder why this has been such a discussed concept, and why it is so very hard for various entities to enact. Most academics would agree that writing skills are important and should be practiced to master.[7] The assertion that many researchers make is that it is the responsibility of the entire university to assure quality student writing skills. [1,3,4]

Institutions that have a formalized program have grown over the last 20 years. [5] This growth has not been without challenges. To have a successful program institutional buy-in is critical, if it's not supported from the top of the organization it is likely to fail. [8] Other factors that impact the success of this type of program include:

- Possible resistance from the institution's English department, with concerns that English competency may be developed outside of the traditional Freshman English course. [9]
- The belief that writing skills are developed prior to attending college. [10]
- Increased workload for faculty based on the type of required assessment. [5]

Some research indicates that the lack of writing skills is often attributed to the lack of consistent practice of those skills after leaving English composition courses. [11]

Further, research shows that instructors are not consistent in assessing writing assignments, when compared to standardized tests the scores are significantly inflated. [12] In later work Israel and de Jager [13] assert that for the engineering student correct language is imperative for career success. Engineers must communicate to share their work, concepts and technical content, these skills are imparted by instructors and fellow classmates as they learn and communicate within the classroom. [1]

Engineering faculty are not normally formally educated in teaching communication skills. [3] This causes inconsistency between faculty members and the results of their assessments which may be slightly more biased due to familiarity with the students. [13] While the assessment from class to class may exhibit a great deal of inconsistency, others support the notion that writing is a great way to promote learning. [14-18] The concept of writing to learn has not been studied much, only a few researchers have investigated this area of study. [19]

Writing to learn is a technique used by teachers to provide writing assignments with the intent of helping them understand the material they are studying. [19] Overall the goal of this type of assignment is to help students better understand concepts taking on different formats that are informal in nature or more formal. [20] These assignments must be crafted with care and best practices reviewed as writing does not inevitably lead to learning. [19]

It is through technical writing the authors chose to evaluate and teach the engineering technology students. This document is intended to share the chosen teaching method and the successes achieved by this technique.

Methodology

While discussing how students learn thermodynamics, fluids and other related material, faculty agreed that they students that engage with the material are those most likely to be successful. There was also agreement that if something could be done to engage the students in a subject in which they have little or no familiarity that students would be more likely to learn more than the material presented in class.

Assignment Options and Development

Considering assignments used previously and information provided by John Bean [21] in his text "Engaging Ideas," the instructor modified a reflection assignment used in prior courses and created "The Big Question Reflection." This assignment was intended to be open ended, accommodating student interest and development, using concepts derived from previous courses, and other research. [15,17,21,22] It was also designed with a reporting structure to assure progress was being made throughout the semester. Finally, students were engaged in the material and

searching for their own solutions, being encouraged to use both passive and active research techniques, with a summary and reflection of what was learned in the final submission. The initial assignment follows:

> "What would you like to learn in this fluids mechanics course? Have you thought about the things we will cover and may discuss in the course? Review your text and material related to the concepts covered in this course. Write a question and submit it for approval. It would be helpful if you submitted the question and a short description of why you chose that question."

Students were given a deadline and electronically submitted this assignment in the course platform. The instructor then reviewed these submissions, commented, guided, and provided suggestions for future research. The assignment statement for the final submission follows:

> "You are required to submit a final reflection and prepare a presentation on what you learned. The reflection is to be submitted online.."

Instructions were presented in class that students were to answer their own question and provide their thoughts regarding the process and what they learned. Excerpts regarding their personal learning experience are listed in Appendix A.

As noted earlier, there is usually a great deal of consternation due to the fact that this kind of open ended written assignment requires an increased workload for the instructor. Guidance and support throughout a constructivist research process for undergraduate students is required for assignment success. [23-26]

Preparation to Review Files

When the semester was completed, all of the submitted files for the initial and final submissions were downloaded. They were converted to one large .pdf, numbers assigned to each student, and names removed. Students with submissions in both submission data sets were counted, with 38 or 60% of the students submitting both assignments. A sampling of five which is slightly under 15% of students submitting both assignments was chosen for examination of this work.

Exploratory Preparation

The authors then reviewed each of the two files to determine the best path forward. Observations were recorded, based upon this review. Particular attention was given to the review of student writing skills from the beginning to the end of the semester, as well as skills from one student to

another. Further comparison of files was done to determine which students submitted both assignments.

Word Usage Review

The student assignments from the five randomly chosen students were uploaded to the software for word usage review in NVivo [27]. A word list and was produced for each student and then words were separated into technical and reflective components. Using the weighted percentages of the word frequencies a table was developed for further review of the word usage by the sample students.

Grade Level and Reading Ease Scoring

After viewing the information provided by the NVivo software [27], the authors chose to investigate each of the files reviewed using the Flesch Reading Ease formula[28], Flesch-Kincaid Grade Level [29], Coleman-Liau Index [30], and Automated Readability Index [31]. These four tests were chosen because the Flesch Reading Ease and Flesch-Kincaid Grade Level tests rely on syllables per word for the determination of those scores. While the Coleman-Liau Index and Automated Readability Index is based on number of characters per word. All provide a score that can be related to a grade level in the United States. There is debate over which is more accurate, therefore the authors chose to use both methods of evaluation.

Results

For the five randomly chosen students the following has been found.

General Observations

This assignment is scaffolded in nature; due to this the students often chose to use the same or similar wording from the first submission in the final submission, making assessment of writing proficiency difficult. The differences from student to student were at times remarkable. One student was very organized and carefully followed the assignment statement. In contrast, another students writing was very choppy and in places the content was not clear.

Word Usage Frequencies

The authors separated the analysis into technical and reflective components. Using NVivo weighted percentages of word frequencies student responses were heavily technical, but increased in reflective language between the initial and final assignments. Table 1 and Table 2

are not comprehensive lists of terms in the assignments; however the technical terms are representative of the core class concepts.

Table 1. Technical Terms Found in Assignments

Weighted Percentage										
Student ID	8		22		23		29		54	
Assignment	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Technical term										
Aviation			5.71	15.38						
Air	4.19	2.83								
Compressor	3.66									
Pressure	3.14	1.89			0.76	0.71	3.19	2.26		
System	2.36	5.66				0.88	2.19	3.41		
Model	1.57									
Energy	1.05								0.55	
Pneumatic	1.05						1.18	0.75		
Drawing		4.72								
Fluid					8.37	6.37	4.73	3.38	1.64	
Temperature					1.52	0.94				
Power					1.14	0.83	4.49	3.38		
Design					0.89	0.28				
Hydraulic					0.76		3.55	3.26	3.28	
Viscosity					0.76	0.47				
Safety			2.86	7.69		0.35				
Material						0.47				
Hydrostatic									1.09	
Total	**17.02**	**15.1**	**8.57**	**23.07**	**14.2**	**11.3**	**19.33**	**16.44**	**6.56**	**0**

Table 2. Reflective Terms Found in Assignments

Weighted Percentage										
Student ID	8		22		23		29		54	
Assignment	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Reflective Language										
Team			2.86	7.69						
Thoughts			2.86						1.64	
Choices					0.38	0.24				
Decided										
Reflection	1.05	3.77				0.59				
Designed	1.05									
Compared						0.71				
Considered						0.24				
Understanding							1.06	1.67		
Feel							0.89			
Issues							0.83	0.77		
Role							0.59			
Broaden							0.47			
Interesting								0.44	1.09	
Concern								0.42		
Aware								0.25		
Excited									0.55	
Hope									0.55	
Total	**2.1**	**3.77**	**5.72**	**7.69**	**0.38**	**1.78**	**3.84**	**3.55**	**3.83**	**0**

Grade Level and Ease of Reading Scoring

Data developed using the Flesch Reading Ease Score, Flesch-Kincaid Grade Level, Coleman-Liau Index, and Automated Reliability Index can be found in Table 3.

Table 3. Readability Scores for Sampling

	Student 8	Student 8	Student 22	Student 22	Student 23	Student 23	Student 29	Student 29	Student 54	Student 54
Type of Readability Score	Initial Score	Final Score	Initial Score	Final Score	Initial Score	Final Score	Initial Score	Final Score	Initial Score	Final Score
Flesch Reading Ease	70.5	63.3	46.0	51.5	52.2	55.8	35.0	45.8	48.4	55.8
Flesch-Kincaid Grade Level	8.5	10.6	12.6	11.7	12.5	10.8	15.0	12.0	11.3	9.5
Coleman-Liau Index	6	7	11	10	10	11	12	12	11	11
Automated Readability Index	7.6	10.4	13.4	11.9	13.8	11.9	15.9	13.0	11.6	9.2

The following graphs display that data for the sampling of students submitting both assignments, by scoring method; they follow in Figures 1, 2, 3, and 4. These graphs display the comparison of initial assignment submission and final assignment submission where the first column for each is the score from the initial submission, while the second column is from the final submission.

Figure 1. Flesch Reading Ease Scores

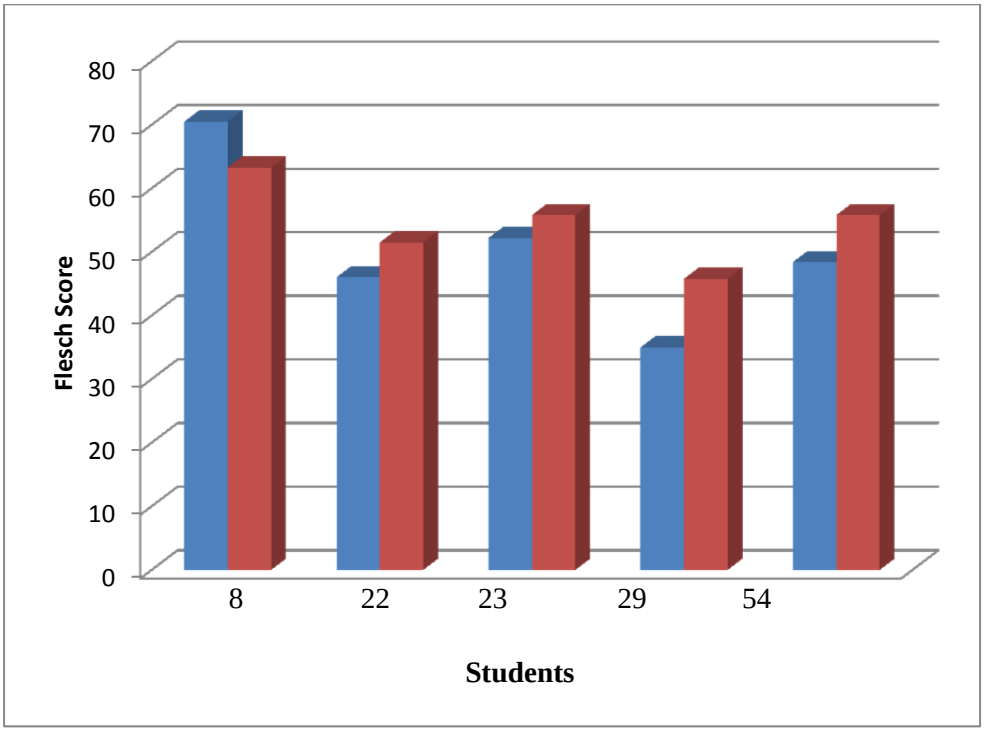


Figure 2. Flesch-Kincaid Grade Level

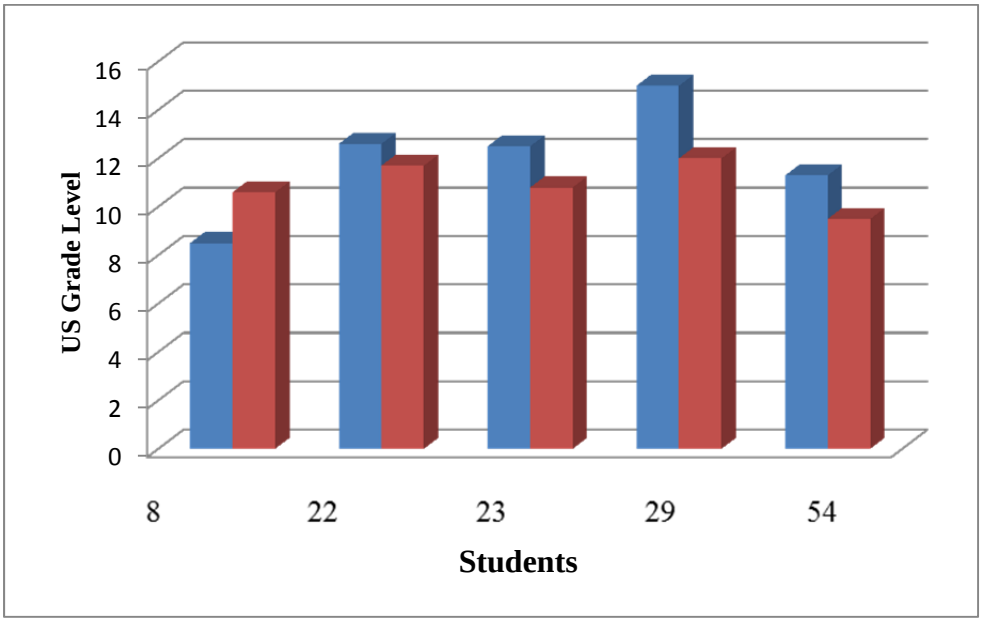


Figure 3. Coleman-Liau Index

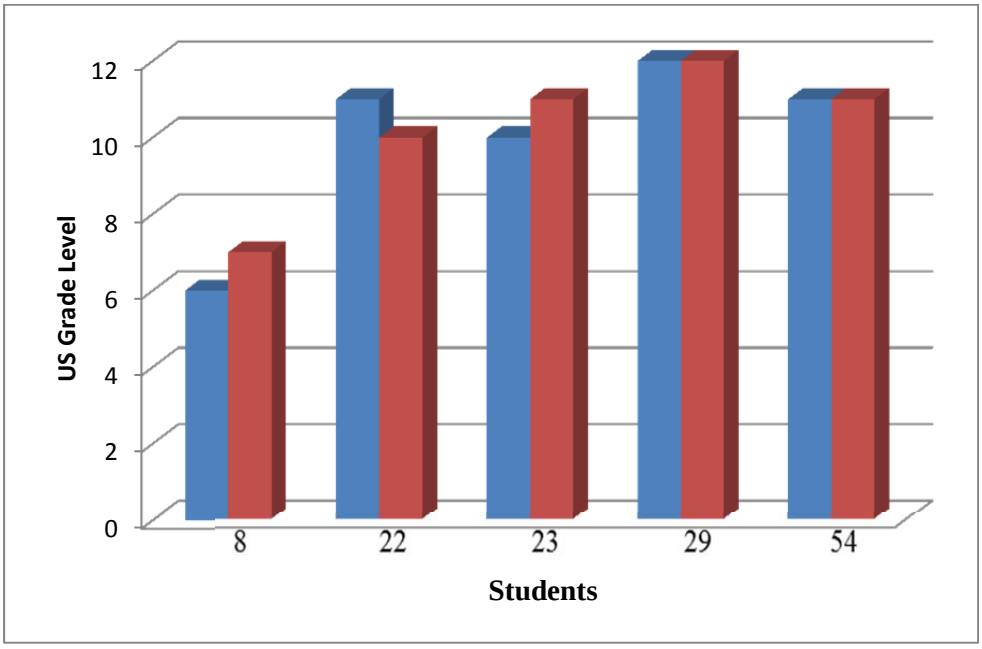
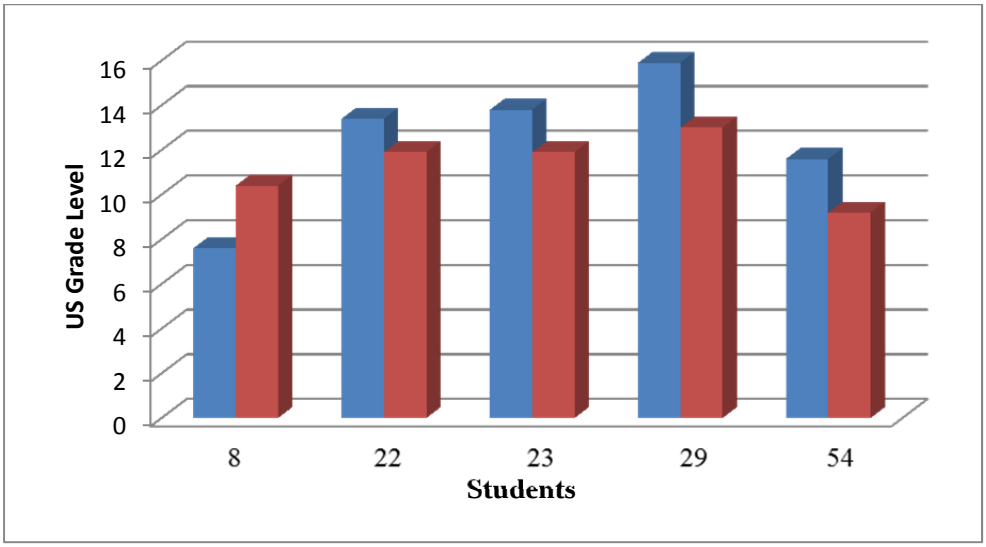


Figure 4. Automated Reliability Index



Discussion

General Observations

While a number of students chose to use the same or similar wording in both documents, the requirements of the assignment encouraged students to write more in the final submission. This

allowed the authors to compare student writing in the first and last assignment submissions. As noted previously there were four evaluation methods utilized to quantify either the number of syllables per work or characters per word. Using this method allowed the authors to compare two methods that were evaluating similar things and then compare the results of all four methods to support the authors' opinions regarding the change in writing skills.

Word Usage Frequencies

When reviewing the data presented in Tables 1 and 2 we see that Student 8 had approximately 17% technical composition in the first assignment and dropped to 15.1% in the second. This might be due to the shift from technical writing toward reflective writing per the assignment instructions. Among these students, the trend is toward an increase in reflective thinking and writing while still maintaining technical competency. It should be noted that Student 54 does not have data in the final submission that is because they did not use the same terminology nor frequent use of the same words as done by the other students.

Grade Level and Ease of Reading Scoring

Writing skills as evaluated by a computerized version the Flesch Reading Ease score indicated that students generally improved from the first to last submission. When increasing the margin of increase matched the margin of decrease for one student, however one increase of was significantly larger than the differences noted with the other students. The authors considered this outcome and suggest that as students developed their technical competence while researching became more confident and used larger words with more syllables. [25]

Further review of scoring relying on the number of syllabi per word is the Flesch-Kincaid Grade Level. In this case, the authors found that the student that decreased scores from initial to final submission in the Flesch increased grade level. All of the other students decreased their grade level. Changes in these scores are a total of less than two years regardless of student. Through review of the documents, this may be due to students feeling more confident about their research and understanding of the answer to their question.

Evaluating the documents using the Coleman-Liau Index views the number of characters per word and relates that to a grade level. The results of this test show that two of the students showed a gain from initial to final submission, two showed no change, and one shows a drop. The one that shows the drop is not Student 8 who has scores on the syllabus based test that dropped in the first case and increased in the second, both contrary to the results of all other students.

Finally the Automated Reliability Index concurs with the results of the Flesch-Kincaid grade level test. When comparing the data displayed in Table 3, the change in grade levels are approximately the same, although the actual grade level are slightly skewed.

The tests indicate and confirm the authors' opinions regarding improvement of writing skills as the students made their way through the course. Consideration must be made that includes the possibility that familiarity and comfort with the technical material following personal research may have contributed to this change.

Overall Outcomes of the Writing Exercises and Student Output

Not all students chose to provide input regarding this assignment and what they gained from the course. Comments and input from engineering technology students that chose to contribute their thoughts regarding the assignment are available in Appendix A.

Reviewing these statements provides a clear assessment that students found value in this assignment. While the structure and use of such an assignment may appear to be novel, it uses techniques that have been used elsewhere. The novel component is using the Big Question to develop engagement and continuing interest in a subject related to the material presented in the classroom.

Students believed that they developed an insight into topics that they enjoy, such as car parts, learning that there is so much more they could research on their topic, having an open ended assignment that allowed them to develop their own questions and get engaged in the subject matter. They appreciated being able to change the topic as they learned more about what they were researching to further narrow their area of interest. Finding solutions to problems they encountered in internships proved to peak students' interests and ongoing research. One student said that motivating senior is very difficult and they appreciated choose their own topic, suggesting that this makes the student want to do something. Another student suggested that the course and this assignment trained them to think differently, after researching a specific piping system they now look at piping systems in other places.

Based upon the comments provided by the students in their final reflection assignment, it is clear that this assignment encouraged learning, particularly in students that had motivational issues. This is an assignment that will continue to be used, encouraging this group of students to stay motivated and learning is important to the success of the student. Encouraging them to write about those things that they find interesting providing a forum in which they develop their writing skills.

Conclusion

Data presented in this research supports the "Writing Across the Curriculum" concept. It is clear that those that have practice in writing are able to get their thoughts across. However, it should be noted that one of the authors with many years in industry has noted that many of the students in this study have writing skills that mirror those found in industry. Unfortunately those are not always as clear or succinct as they should be for clear communication of thoughts and ideas.

The data that is presented in this research, while not conclusive provides an indication that writing throughout the duration of the semester has some positive effect. That supports the concept that writing throughout the curriculum would have more of an effect on students writing skills, thus providing industry with new engineering technology employees skilled in writing. Thus satisfying one of the skills that new employees need as defined by industry[32].

It is critical that students continue to be challenged by encouraging the use of their technical writing skills. To do that the concept of incorporating technical writing into every aspect of their education is critical. This research confirms that students at this level are able to integrate increase their technical writing skills by incorporating technical content into a reflective piece. It was observed that these students lose some of their technical edge while doing so.

Future Research

Further work in this area and in other subject areas such as thermodynamics would provide a better understanding of how students are motivated and encouraged to learn. While writing is a task avoided by many with higher SAT scores, students are encouraged to write when doing it about something they enjoy. Assignments that provide these opportunities, independently or through an entire curriculum, are anticipated to provide a venue to practice the development of their writing skills. A number of things need to be addressed in further research:

- How to level professor's experience and ability in developing and utilizing writing skills in their courses, regardless of the topic.
- How to develop assignments that are both interesting and engaging so students actually take the opportunity to write in all of the required venues.

There is a great deal of research regarding the use of programs using the basic tenets of "Writing Across the Curriculum." Unfortunately that research is most often found in the humanities and areas that lend themselves to writing. There is little research on students in engineering and the development of these skills, and even less on engineering technology students. Since we found that students writing skills do improve throughout the semester, research in this area must focus

on engineering technology students and the development of their writing skills throughout the curriculum.

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Appendix A
Comments and Input from Engineering Technology Students

The excerpts below are taken directly from the final submissions for "The Big Question Reflection" assignment.

Student 4 – "I have greater broadened my knowledge and even learned more than I thought I would have."

Student 5 – "I feel like I have gained the insight I was looking for when I initially chose my "Big Question." I now feel I have a strong understanding of how shocks operate, the differences between designs, and have a basic understanding of the design calculations and procedure for analysis. For how relatively simple the shock absorber is in design, there are many complications and factors involved when attempting to simulate their true performance. Not only did I learn about shock absorbers, this project demonstrated how intriguing and intricate their design process can be."

Student 6 – "As I look back to the beginning of the semester and what I had envisioned I would be learning in MET 313 I am impressed and satisfied that have not only been able to comprehend and apply the theories and calculations from fluid mechanics, but I feel that I will be able to retain and use this information outside of the classroom and even Purdue."

Student 11 – "I thought this whole project was interesting based on how just taking the time to investigate the problem a little has yielded so many small little problems that have built up over time to create much larger ones that also become much more expensive to fix."

Student 23 – "This project has helped understand the fluid choices and fluid mechanics of a vehicle, whether it be diesel or gasoline. I feel like while researching this topic, it has not only made me have better understanding of vehicle fluids but it also helped me understand the related topics that we have covered in class."

Student 27 – "I have learned a lot of information by doing this assignment for this course. I am glad that this was an assignment for us to complete."

Student 28 – "I feel as if I have learned quite a bit about this topic and I really have enjoyed being able to reach out to different people and just ask any kind of question that came to my mind. Also being able to have a project like this where it was really open ended allowed me to pursue different angles that I may have not been able to do otherwise if there was a more strict direction of where I needed to be headed."

Student 29 – "In answering my question I know that I have barely scratch the surface of the endless fluid power examples, but the research thus far has not only increased my knowledge of the topic but also my interest."

Student 30 – “In my opinion the best part of the Big Question reflection was having the ability to change what I was searching for as I went; this made my research more dynamic and gave me a much wider understanding of the big picture.”

Student 31 – “I believe learning this material has added value to my education and increased my understanding of fluid systems.”

Student 33 – “This process has been very rewarding to me because I was able to help solve a real problem in a manufacturing environment. I have learned a lot… how to better read and analyze a hydraulic print. This information will be very useful in my future career… I have enjoyed this process and I will be able to apply what I have learned in the near future.”

Student 34 – “After participating in this course as well as doing my own research on the topic. I have grasped a greater understanding of the implications of these pumps.”

Student 36 – “This process has allowed me to dive deeper into material of interest that I would otherwise most likely not explore on my own.”

Student 37 – “In conclusion, I am very pleased with my findings for my Big Question. I feel that I have learned quite a lot of information about not only this topic, but also fluid mechanics as a whole.”

Student 39 – “Overall, I think this was a worthwhile assignment. I might not be a master aerospace engineer, but at the very least, I can understand what is happening the next time I have a window seat on an airplane.”

Student 45 – “Although I barely skimmed the surface of the intricate world of mold design, I feel confident that my research will be beneficial if I enter the steel industry as planned post-graduation in May. Being able to compare the sand casting process to concepts discussed in the course has definitely helped me grasp concepts better and understand the importance of flow control.”

Student 46 – “Not only that but I think a research project like this was good because it made me apply knowledge I've gained from a lot of the classes I've taken in my previous three years…”

Student 49 – “From a big picture point of view, this project was certainly beneficial. I am a proponent for open ended projects that allow students to pick their own ideas. Motivating students to work can be a difficult thing for some professors, especially in a class full of seniors. In my opinion, the best way to motivate someone is to have them actually *want* to do something. If the project is picked for the students, more often than not, the student will not be extremely motivated. Since the students can chose their own topic, of course they will pick something they are interested in.

This will up their involvement and effort on the project where it otherwise may not be there. Another benefit to the open ended and self-picking model, is the students can pick a specific part

of the industry that they will directly use in the industry. I do not know if all students took such an approach as I did, if not I would highly recommend it to any student. It would actually be quite ignorant to not take this as an opportunity to get ahead in your particular industry. I look forward to putting some of the knowledge gained in this project to use when I start work with GE Aviation in the upcoming future.

The class as a whole, was superb in its' job of training us to think differently. I too, cannot help but take a quick peak at the valves and piping in the staircase in my apartment. Pondering exactly what they are and the thought and design process that go into the construction of everything."

Student 55 – "Overall I believe this is a good project […], it makes you go outside of your comfort zone to gather information for the topic."

Student 59 – "Doing some studying on hydraulics on my own gave me the chance to see different applications in the world where fluids have made it possible to achieve previously impossible goals."

Student 63 – "I am glad I had the opportunity to actively research this and have some valuable information to take back to work with me."