



Work in Progress: Integrating Writing throughout the Engineering Curriculum

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Introduction

Communication skills continue to be a top ‘soft skill’ many employers consider weak, while educators believe engineering students possess strong communication skills upon graduation [1], [2]. In fact, in an ASME survey where 647 industry supervisors, 42 department heads, and 590 early-career engineers responded to a question on mechanical engineering graduates strengths and weaknesses, there was a discrepancy in how industry rated communication skills compare to the other two groups [1]. Only 9% of the industry supervisors rated communication skills as a strength of the graduates. In contrast, 40% of the department heads and about 37% of the early-career engineers believed graduates had strong communication skills when entering the workforce. This significant difference in perceptions should be alarming to all those in academia. Until recently, there were few actual studies on why industry rates communication skills so low or why many thought it was even a problem. In the past few years, researchers are beginning to delve deeper into the problem so we are able to address it at our own schools. Three studies in particular that have conducted their own literature reviews on the topic stress that a big disparity is that engineering programs do not give assignments that correspond to what practicing engineers encounter on the job [2], [3], [4]. It is suggested that incorporating needs of practicing engineering writing into the curriculum would alleviate some of the divide. de Souza Almeida [3] suggests selecting the most appropriate type of communication for the intended audience; writing clearly, concisely, and precisely; and being sure to include global communication. Donnell et al. [2] found that the main differences are in the goals of writing and the audiences – there is a disconnect between the classroom and industry. Kovalchuk and Schell [4] further add that writing should be meaningful, which includes being agentive, engaging, and learned for transfer. However, they found that faculty at their university usually did not follow these guidelines although they believed writing to be an important tool for student to learn and understand.

Universities and colleges have implemented various forms of writing for engineers over the years; however, the implementations have mainly been at the course level and not an overall curriculum change [4]. The need to assess the ABET outcome communicating with a broad audience is usually the main driver of these changes with programs assessing how well the students communicate within the criteria set for the respective assignments. This means that the writing is usually limited to laboratory write-ups, small class project reports, and a capstone paper (usually written as a team). In addition, most programs offer no formal or even informal instruction on writing beyond the required composition courses taken in the first year. Faculty check grammar and format in addition to the technical aspects, but opportunities for learning through feedback and correction are uncommon. Faculty then expect students to produce a high-level product three years later without practice and fully understanding the impact of written communication. Adding that students do not consider writing a high priority in their engineering studies, engineering undergraduate programs in general appear to be falling short on adequately preparing graduates to communicate in written format beyond the classroom.

In order to combat the lack of communication skills, particularly writing, the Engineering Program at Methodist University has made it a priority to integrate writing throughout the engineering curriculum that exposes students to writing instruction each year. Although individual course assignments are still used as the main avenue to practice writing, the importance of writing for the discipline and connection between each course are stressed throughout program. With the introduction of Methodist University's new Quality Enhancement Plan (QEP) on writing, the Engineering Program plans to strengthen the integration of written communication within the curriculum.

Writing Across the Curriculum

Methodist University embraces writing across the entire campus through several initiatives on writing improvement and appreciation for students and faculty. One such initiative is that at least one course in each major is considered a writing enrichment course where a significant portion of the course assessment is based on some form of writing. For most majors, this means a course in the third or fourth year of the program where students write a research paper related to the major. In the Engineering Program, we have expanded upon this concept by integrating writing in at least one engineering course every semester. However, we do have two designated writing enrichment courses: one in the third year and one in the fourth year.

In addition to the concept of Writing Across the Curriculum, the University provides several workshops and opportunities for professional development in writing, creating writing assignments, and assessing those assignments. The idea is for any faculty member to improve upon their own writing as well as increase their knowledge on how to help the students in their writing. Most recently, Methodist University has started to implement their newest Quality Enhancement Plan (QEP), which focuses on writing. In connection with the QEP, two new workshops have been introduced on the Hochman Method [5] and John C. Bean's book [6], *Engaging Ideas: The Professor's Guide to Integrating Writing, Critical Thinking, and Active Learning*. Mini-grants are available for faculty that incorporate ways to strengthen student writing in connection to these two resources. The Engineering Department is already incorporating Bean in one course and plans to introduce the Hochman Method in another.

Integration of Writing into the Engineering Curriculum

First Year

In the first year, engineering students take the traditional two-course sequence English requirement alongside all other students at the University. However, those are not the only courses where we expose engineering students to writing. Methodist University's Engineering Program has a two-course sequence in Introduction to Engineering that almost all incoming engineering students take starting in the first semester (dependent on adequate math placement). In Introduction to Engineering I, students and faculty discuss the requirements for the engineering major at Methodist University. The discussion includes asking students if they believe they will have to write in their engineering courses. The most common answer is 'no', which leads to a discussion on the importance of communicating as an engineer with a variety of individuals including those that are not engineers and how it is so important that there is an

ABET student outcome addressing it. This discussion is probably very similar to what other universities have, but at Methodist University, we also talk about the different forms of writing that they will see throughout their engineering education. The idea of this early discussion is to let students know that they cannot take those English classes for granted or ‘just get by.’

Most writing right now in the first semester is done in the English course. However, at the end of the Introduction to Engineering I course, students complete the “Becoming a World-Class Engineering Student” [7] self-assessment paper individually. We begin with this paper since it requires students simply to write about themselves and how they believe their first semester went as an engineering major. The faculty feel this paper is a good way to introduce writing into the engineering curriculum as it is a reflection paper on topics that were discussed in class throughout the semester. Students are required to follow specific length and spacing guidelines, but otherwise they are free to construct the paper as they seem fit. The paper guidelines, rubric, example, and template are all provided early in the semester so students may begin at any time. About two weeks before the final paper is due, a rough draft is required so that students can gain feedback on grammar, paragraph structure, and overall content. Although a complete paper is not required for the draft, some students take advantage and submit a complete paper. These students are then able to make small changes within the two weeks and even submit the final paper early. This paper serves as one part of their final exam in addition to a presentation on their Rube Goldberg project.

Faculty observations of overall content are that the students are critically assessing their own progress during the first semester and, for the most part, are following a logical order throughout the paper. The most egregious mistakes are sentence structure or incorrect sentence construction. Although it would be ideal to be able to spend time on these issues immediately, we use the papers as a baseline for future writing and to identify those that need additional help on grammar and structure.

In the first semester, students also complete an email writing assignment to a mathematics professor that they currently do not have. There is discussion (after they complete the assigned reading) on what constitutes an appropriate email to 1) someone they do not know, 2) a professional that holds a position above them, and 3) someone that does not know them. Students are given about two weeks to complete the assignment as they must first send their email to the engineering faculty to proofread. This exchange may take one email back and forth, or it may take several iterations. The idea is for students to understand emails must follow the same grammar and spelling rules of papers, but are usually short and concise. Once students receive the green light to send their email to the professor, they must also wait for a reply from that professor. After the reply, they must complete the email exchange with a ‘Thank you’. The engineering faculty is cc’d on all exchanges to ensure completion of the assignment. Before this assignment, students send emails with improper openings (or none at all), sentence fragments, and shorthand spelling, to name a few. After the assignment, student emails, for the most part, have been very nicely constructed and address the recipient appropriately.

During the second class session of Introduction to Engineering II, faculty and students have a discussion on what went well the first semester and what they think they can work on in the second semester. We use the World-Class paper as a talking point, which leads some students to

talk about improving their writing. Presently, that is about as far as we have taken that discussion. In the future we will include a visit to the Writing Center (although done in their first year university seminar, we plan to focus on how they can use it for the engineering assignments), discussion on Writing Across the Curriculum workshops discussed earlier, and having them critically examine their own paper. These activities would further stress how important writing is to the discipline and get them more comfortable with asking for help early and often. We have done similar activities with study sessions and visiting professors that have shown an improvement in students asking for help on technical problems. We hope this will produce similar results with writing.

In addition to the discussion, students are required to write two papers during the second semester. The first is an individual paper on ethics, and the second is a team technical report on their engineering design project. For the ethics paper, students select an event in history where possible unethical decisions were made. As a pair, they research the topic, being sure to answer a set of five questions, present the topic in class any way they would like (no PowerPoint required), and then write a 3-4 page paper (individually) on the same topic. There are no requirements for the number of resources or where they obtain the resources; however, they are required to correctly cite and reference their resources. This paper is then submitted to a plagiarism software program to obtain a likeness score. If the paper is below an acceptable score, the paper is accepted and graded for content, grammar, spelling, and format. If the paper is above the acceptable score, the paper is returned to the student for revisions. Each student that must make revisions is required to meet with faculty to go through the paper and discuss correct use of resources and how not to plagiarize. Past experiences have revealed that we expect students to know how properly to use resources in their writing, but they never receive adequate instruction. Therefore, this ethics assignment is used to introduce ethics in engineering as well as ethics in writing.

The last major writing assignment during the first year is a team technical report on their engineering design process project. This project spans almost the entire semester and is a community service project on campus. The idea behind the campus projects is that students are able to survey, interview, etc. the customers easily as well as visit their selected site weekly. An added bonus is that some teams are able to implement their solutions and see how it impacts campus life. In addition to the technical paper, each team is required to make three presentations throughout the process. The first is a simple poster board presentation on the problem and possible solutions. The second presentation is a professional poster at Methodist University's annual Center for Research and Creativity (CRC) Symposium where they talk about the problem, their top solution(s), and implementation, if possible, to individuals from all across campus, including the President, Provost, several of their professors, and fellow students. The last presentation accompanies the technical paper and adds the evaluation step of the engineering design process. As this is the third paper written in their engineering classes, students are now expected to follow format guidelines, use references and cite correctly, and understand the importance of proper sentence structure and spelling.

It has been observed through rubric assessments that the majority of the teams address each section of the engineering design process adequately in the paper. However, there is still work to be done on discussing the audience with the students as well as making sure they include enough

information to tell the story of their project and process. These assessments are used in ABET assessments for the course and will be compared to assessments in the Senior Design course to determine the growth of the students throughout their academic career.

Second Year

Writing in the second year has relied simply on small course project reports completed usually as a team, but sometimes individually, that were only a report on what they had learned about the technical aspects. Although students were receiving practice in their writing, they were merely mimicking what they had done in their composition courses yet still struggling with the basic concept of a clear and concise sentence; this was not providing the growth that we would like see. Therefore, the engineering program introduced the Hochman Method [5] in connection with the new QEP in the mechanics course to strengthen the students' writing as well as understanding of the course topics. Students were to complete short, quiz-like assignments by finishing a sentence based on the given instructions to develop higher-level sentences that include having to connect the engineering mechanics content. The hope was that using this method would help students develop their communication of engineering concepts to aid them in subsequent engineering writing assignments to a variety of audiences.

However, circumstances prevented full implementation of the method and only a couple of writing exercises were completed. Time needed to explain the process fully and how it relates to engineering writing was also limited. Therefore, we halted the implementation until the following year (forthcoming). During the next offering of the mechanics course, we will incorporate the Hochman Method into each section as short in-class quizzes, take-home in-depth assignments, and possible exam short answer questions. Faculty chose the mechanics course for this method because 1) no writing is taught formally in the second year of the major, 2) mechanics is the first highly technical engineering course the students take, 3) working on sentence structure in the second year connects their required English courses with the upcoming third-year engineering writing assignments. We found that students were not able to express the engineering concepts in written format in a way others understood their conclusions. This was particularly evident in the third year where students are required to write to lay-people (discussed in next section). Therefore, it is important that we address the basic sentence structure in the second year. This provides structured writing directly relating to technical concepts as well as feedback on how well the students are clearly communicating what they know.

The assessment in the second year will consist of a pre-test and post-test writing assignment during the semester. The pre- and post-tests are submitted to the QEP committee for further assessment on the students' ability to form comprehensible and complex thoughts in written format.

Third Year

The third year of the program contains two courses that focus on writing in a variety of formats. The first course is ISE 3200 Work Analysis and Design, which is the first designated writing enrichment course in the major. In this course, 55% of the course grade is based on application-

based assignments and a work sampling project. The second course, completed in the semester following ENG 3210, is Technical Writing, which is offered through the English Department.

Work Analysis and Design is a course taught in almost all Industrial Engineering programs in some form and usually contains weekly lab sessions where students analyze a problem based on the lecture material and then report on their findings through a short or long report. Experience with this class at another university showed students were able to analyze the problem using the correct technical concepts, but most lacked the ability to convey their findings beyond what is needed for a class assignment. Students tended to use statements such as “For this assignment...,” “We were required to...,” etc. that definitely indicated they were writing a course assignment instead of a report as an engineering consultant (students formed teams of engineering consulting firms). When developing the same course for Methodist University, it was obvious that the approach needed to change in order for students to treat the exercises truly as practice for their future careers.

The faculty member creating the course was currently involved in the writing community that was exploring *Engaging Ideas: The Professor’s Guide to Integrating Writing, Critical Thinking, and Active Learning* by Bean [6]. The concept that was most appropriate to create more of a focus and understanding of the audience for ISE 3200 was RAFT/TIP. This concept presents the **T**ask as an **I**ntriguing **P**roblem and then describes the **R**ole (or purpose), **A**udience, **F**ormat (or genre), and **T**ask. We developed writing prompts for each exercise that included each of these dimensions. Students worked as a team to analyze the problem presented and then were required to communicate their results and suggest a final solution to a specific individual, such as head of manufacturing or president of the company, but never the professor. The written communication was completed either as an individual or as team, depending on the assignment, in the format of an email, memo, short report, or long report. Students receive feedback from the ‘client’ (an actual architect was used as the audience for one assignment and read the submission) and/or the professor who selects a bid ‘winner’ each week.

As a result of the use of RAFT/TIP and connecting the assignments to actual problems in the workplace, students have not used “assignment,” “class,” “required,” etc. in their writing submissions. They also have been able to convey their findings and thoughts into short emails and one-page memos without overburdening the reader with extra details not always desired by executives.

In the semester after taking ISE 3200, students take ENG 3210 Technical Writing to develop specific writing skills used in engineering further. Although offered through the English Department, the engineering and English faculty work together so that the Technical Writing course complements the writing done in the previous semester as well as projects in the current semester. Specific topics include understanding the audience, global communication, interviewing a practicing engineer about writing in the discipline, user manuals and usability reports, and digital and social media. The Technical Writing course is designed to take the various forms of communication introduced in ISE 3200 and expand upon the students’ understanding of how they will use them in their careers. No data has been collected on this course yet, and the faculty have not had a chance to discuss the observations of the course. These are planned to take place in the upcoming summer.

Fourth Year

In the fourth year, students take the second writing enrichment course, EGR 4900 Engineering and Society, as well as the senior capstone design course. As the previous year was spent focusing on communication methods students may encounter in industry, EGR 4900 instead focuses on the research paper, which is important for those students wishing to pursue a graduate degree. Students lead discussion each week on topics related to engineering's impact on society as well as write a two-page mini-research paper on the topic. All other students answer a set of questions on the same topic so they can participate in the discussion. The mini-research papers are graded each week on grammar, format, content, and sentence structure to provide feedback for the larger full research paper due at the end of the semester. This setup allows feedback that is more detailed for each student while limiting the amount of time required grading the papers each week. Shorter assignments throughout the semester address concepts such as learning about the engineering online databases available to them, how to find papers from a specific author (students searched for papers written by the Department Chair), and how to expand their search by using the reference list of their top paper on the subject.

Preliminary observations indicate that students enjoy the format of the class and appreciate the detailed feedback provided before the major paper is written. The final major research paper is the paper that will be submitted to the University for the general education writing assessment that is conducted for every major on campus. Engineering will submit its first papers in 2021; following that assessment, we will be able to use those results to guide the program's overall writing integration. Initial assessments of the EGR 4900 papers indicate that the students still have room for growth in their writing. However, we will not have assessments from the full writing integration program until 2023 when the first cohort that experienced the total integration graduates. Until then, we will only use the scores based on the general education writing assessment to compare the engineering students with others across campus.

This is the first offering of our senior capstone design course. Therefore, we did not have any findings or observations except the writing requirements for the course at the time of this paper. In the senior capstone design course, each team will be completing a formal project proposal on their client-lead project as well as final report to the client. In addition, one team that is working with a team of Occupational Therapy graduate students is planning to submit a research paper to a conference. The focus of the writing in this course will be on communicating their technical results to non-technical clients or executives that do not have time to read about every detail of the project. As the program builds, we will continue to assess this course and how the earlier courses impacted the students' writing preparedness.

Future Plans

As this is only the fourth year of the Engineering Program at Methodist University, we are working on completing the first round of partial data collection and assessment (second year data will not be available until 2021). The plans are to develop longitudinal studies on how the students' writing improves (or does not improve) throughout their four years in the program through a series of rubric assessments, feedback from clients, QEP and general education assessments, and even peer evaluations. Incorporating writing in the engineering curriculum is a

requirement at Methodist University through our Writing Across the Curriculum initiative; however, as writing is an important skill for which prospective employers desire, we can further deepen the integration by implementing some of these concepts in every engineering class. The plan we have in place will begin that process. Our hope is to create a meaningful and seamless incorporation of writing from the first semester to the last.

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