Design of an ECE Technical Communication Course for Accelerating Engineering Careers

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Abstract

While engineering schools have aspects of technical communication in their required coursework, most newly hired engineers have gaps in their communication skills that hinder their career advancement in industry. Making matters more complicated is the fact that many programs focus on teaching engineering fundamentals and leave "soft skills" to other departments. Given this environment, an approach tailored to engineering communication is needed to meet the unique requirements for engineers in industry.

The purpose of this paper is twofold. 1) examine various forms of communication engineers must possess and their importance, and 2) describe the design, implementation, and assessment of a new senior-year and first year graduate ECE course which is specifically aimed at developing the critical communication skills for engineers in industry. For the first part we used a survey of managers and executives at Intel Corporation to determine the most important gaps. For the second part we use the following 5 lenses for technical communication:

Lens 1: ***Audience Type*** - Technical, Business, Customer
Lens 2: ***Audience Seniority*** - Entry, Mid-Level, Executive
Lens 3: ***Communication Form*** - Document, Verbal, Presentation
Lens 4: ***Purpose*** - Educate/Inform, Influence/Sell, Request a Decision
Lens 5: ***Length*** - 30 seconds, 3 minutes, 30 minutes

We start the course with the area engineers are most familiar with: Informing (lens 4) Entry level (lens 2), Technical audiences (lens 1) in documents or presentations (lens 3) for 3 minutes (lens 5). We then build skills to make the transition to communicating and influencing business audiences. Lastly, we make the most difficult transition to effectively influencing customers.

The course is delivered as though the students are engineers in industry and their assignments are based on common real-world communication tasks. They must summarize technical articles in short, written emails and present a short summary without notes (as though they were providing an update in a staff meeting). Critical to this course design is instructor/peer, real-time verbal feedback as well as video of all presentations for student self-reflection. Longer form technical, executive and customer presentations are incorporated into the class with the students providing real-time feedback to their peers as though they were fellow employees in the company. Asking the students to provide positive and constructive feedback changes the dynamic of the audience from passive to active listeners and participants. Fun games are also used to introduce concepts such as analogies and illustrations to convey complex topics.

The effectiveness of our approach is confirmed by assessing the students' assignment grades pre and post course which show significant improvement. Similarly, based on the student course ratings data students rated highly the relevance and usefulness of this course. We believe that with the skills they develop in this class, students will start their engineering careers well-prepared to progress upward professionally.

1. Background

While engineering schools have aspects of technical communication in their required coursework, most newly hired engineers do not possess the communication skills to excel in industry. Making matters more complicated is the fact that many programs focus on teaching engineering fundamentals and leave "soft skills" to other departments. Given this environment, an approach tailored to engineering communication is needed to meet the unique requirements for engineers in industry.

The challenge of communicating complicated, technical material is one that has beleaguered engineers and engineering schools for decades. Engineers must be able to communicate across various levels of technical depth, across various verbal and written forms of communication, and must ensure the audience comprehends them. Because engineers often are deeply responsible for their company's innovation, they play an outsized role in their company's success. When exploring some defining characteristics of engineers who progress more quickly through their company's ranks vs. other engineers who progress more slowly, the ability to communicate is a skill disparity between those two populations. Even the most brilliant engineers who can't convey their ideas will struggle to be appreciated within a company. While hard data is difficult to come by this observation seems to be widely shared by executives across high-tech companies.

For our purposes, we are considering technical communications to be the art of sharing technically complex material in written or verbal form with an audience in a way that fits within the available time and maximizes audience comprehension. Prior works in technical communication for engineers and engineering students were documented in, e.g., [1] – [15]. Sageev and Romanowski in [1] showed survey results that revealed the impact of engineers' communication skills in adjusting to jobs and achieving career goals and found a direct correlation between the amount of technical communication instruction and career advancement. A survey of 73 top-ranked U.S. and Canadian engineering schools examined initiatives that engineering schools were taking to improve communication instruction for their students [2]. The survey reveals that 50% of the U.S. schools and 80% of the Canadian schools require a course in technical communication. The survey found about 33% of the schools utilize some form of integrated communication instruction, and another 33% offer an elective course in communication.

Only 10 schools have created engineering communication centers to provide additional individualized coaching and feedback for their students. In [4], the design and implementation of a Technical Writing and Communication course anchored in Project-based Learning was discussed, which sought to improve areas of persistent communicative challenge for an engineering student population. Wolfe in [5] analyzed how technical communication textbooks fail engineering students. The Project to Integrate Technical Communication Habits (PITCH) is being implemented across seven engineering and computer science undergraduate programs in [6], with the goal to develop written, oral, and visual communication skills and professional habits in engineering students. Graduates of engineering degree programs must have substantial communication skills if they are to function effectively in industry and government [7]. The work of infusing technical communication and teamwork within the ECE curriculum was

discussed in [8]. Students from the College of Humanities have teamed up with faculty from engineering to develop communication and teamwork instruction to be integrated into the existing engineering curriculum. The ability to communicate effectively is a crucial skill for today's engineers and the ABET curricular initiative reflects this requirement [9, 16]. A complete evidence-based paper describes the techniques used in the project based first-year Cornerstone of Engineering course to address the need for building communication skills for first-year engineering students [10]. Even though this skill can be taught and assessed, the results of past surveys show that engineering students are inadequately equipped to meet this need. The University of Houston has a Technical Communication for Engineers class that focuses on engineering communication skills including written proposals, specifications, progress reports, technical reports, individual and group oral presentations, essays on engineering ethics, contemporary engineering issues, and the impact of engineering decisions [11]. Duke University offers an Engineering Design & Technical Communication class for first-year students [12]. Sorby and Bulleit in [13] provide a comprehensive, practical, engineering-specific introduction to communicating effectively on the job. The IEEE guide to writing in the engineering and technical fields was described in [14]. In [15], Echevarria and Serrano discussed every engineer's and technical professional's guide to creating and delivering compelling presentations for even the most non-technical audiences.

The survey results described in this paper echo the findings and position in [1, 7, 9, 16]. In this paper, we expand the work in [2, 4, 6, 8, 10, 11, 12, 13] by developing a technical communication class for ECE undergraduate senior students on how to effectively deliver the types of oral and written communication reports specifically required by major high-tech companies, targeting different audiences including technical audience, business audience and customers in the industry.

Recently we asked managers and executives at Intel Corporation about newly hired engineers and their typical ability to communicate in various forms. Intel has over 100,000 employees which includes a large population of engineers. We surveyed 35 managers and executives across both business and technical disciplines. Full text of the survey is given in Appendix C. Twelve managers responded to the survey. We also asked them to share their view of the importance of engineers being proficient at communicating across 3 types of communications:

- Written – We are limiting our focus here to emails, chat channels (such as teams or slack) and technical papers (formerly whitepapers).
- Verbal – Verbal updates include 1:1's, brainstorm sessions, daily stand-up meetings, SCRUM meetings, staff meeting opens, ad-hoc phone discussions, etc. These updates do not have prepared materials such as slides or documents and are NOT significant decision meetings. They are typically direction-checking and/or educational in nature.
- Presentations – There is an audience of more than one person (typically >4-5). These are typically longer in duration than an update, such as a topic in a staff meeting, and are accompanied by slides and/or documents. The objective can be for decision-making or education.

They were then asked to rate the importance of the communication abilities of typical engineers that are being hired into their organization across the three communication forms. The scale used

was from 1 (“Not Important”) to 10 (“Extremely Important”). Similarly, they also evaluated newly hired engineers’ abilities in these areas using the scale from 1 (“Skills Are Not Present”) to 10 (“Fully Meets Expectations”). The results highlight a large skill disparity between the communication skills that are required for new engineers and the abilities they possess coming out of school. The results are depicted in Figure 1.

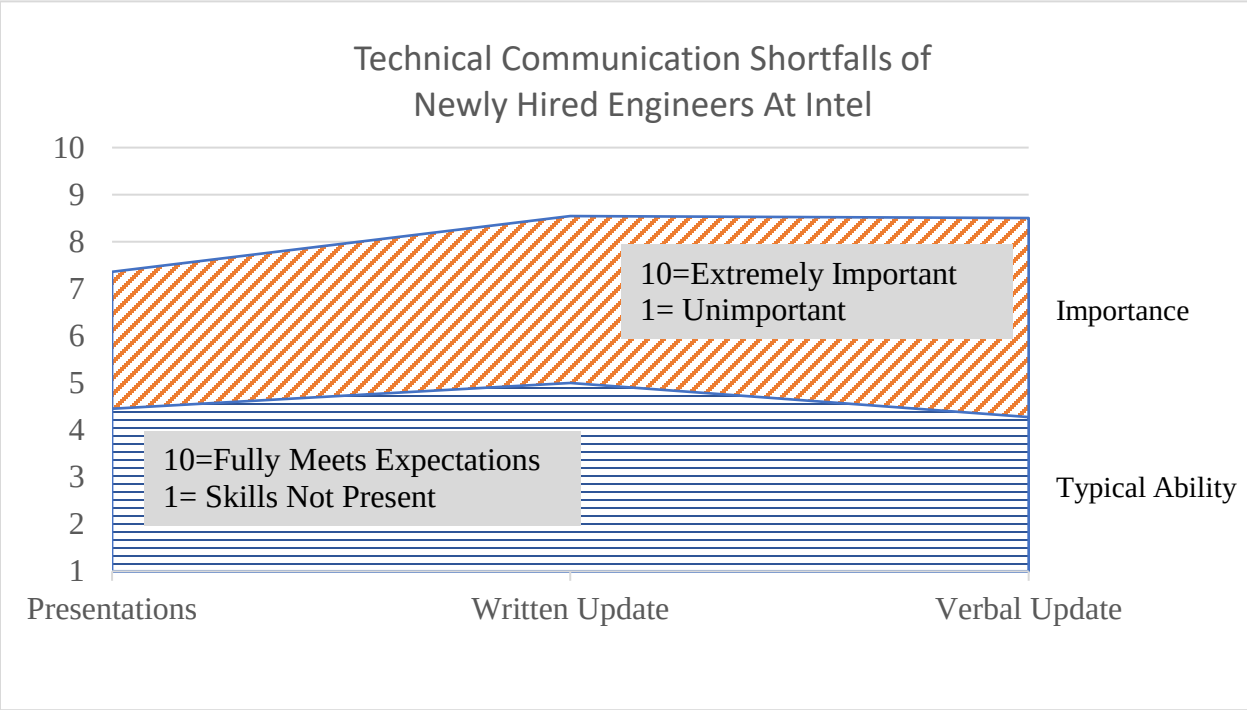


Figure 1. Importance of the three forms of technical communication: Presentations, Written Update, and Verbal Update, and performance of newly hired engineers in these categories.

Written and verbal updates were considered highly important, both scoring 8.5 out of a possible 10, yet typical engineering students only achieved an average of 5.0 and 4.3 respectively. We believe this represents more than just a gap. This is a technical communication chasm that must be addressed.

To drill deeper into this gap, managers and executives were asked to rate the importance of various aspects of each communication form but this time on a scale of 1-7, where 7=Extremely Important, 5=Important, 3=Nice to Have, 1=Not important at all. The goal of this survey was to highlight which traits were most important for students to possess in each communication form and therefore serve as a guide to focus the curriculum toward our students’ skill building.

Table 1. Results of the survey on the importance of components of Verbal Update skills.

Components of Verbal Update Skills	Score (1-7)
The ability to listen and respond/inquire effectively	6.8
Being present in the conversation and connected	6.7
Is an effective and receptive listener to inputs and feedback	6.4
Demonstrates logical thinking	6.3
Speaks in plain language to be understandable	6.2
Provides potential options and/or next steps	6.0
Answers direct questions briefly (avoids unnecessarily long answers)	5.9
Inclusive, encourages others to speak/contribute, and listens	5.7
Speaks clearly (good volume, tone, cadence, delivery, etc.)	5.6
Shares their opinion of tradeoffs that can/should be taken	5.5
Is able to read the room to adjust accordingly (pace, depth, level of interest, etc.)	5.5
Demonstrates technical depth and/or expertise	5.4
Exhibits confident body language	5.2
Demonstrates an understanding of competing priorities	5.1
Demonstrates an understanding of business strategies	4.8

Table 1 reflects the importance of various traits associated with Verbal Updates. Interestingly, traits associated with active listening, connecting with the audience, and being willing to accept input/feedback all scored at the top of all traits surveyed. Typically, engineers believe the most important trait they can demonstrate is technical depth, but that trait scored in the lower portion of the surveyed traits. This could be because technical depth is considered a pre-requisite and it may be an over-simplification to deduce that demonstrating technical depth is not valued. It is also interesting that the traits associated with a more informal and/or flexible delivery (speaks in plain language, answers questions briefly, encourages others to speak) score highly. This type of communication is not traditionally exercised regularly in the engineering curriculum.

Table 2. Results of the survey on the importance of components of the Presentation skills.

Components of Presentation Skills	Score (1-7)
The presenter is prepared and knows the material	6.5
Answers direct questions concisely (avoids long answers); Acknowledges when they don't know	6.3
Demonstrates logical thinking	6.3
The presentation has structure: beginning/intro/exec summary, main content, and an end/summary/next steps/decisions	6.3
Speaks in plain language to be understandable	6.3
Discusses appropriate details	6.3
Is an effective and receptive listener to inputs and feedback	6.3

The presentation is designed according to the audience (junior or senior, tech or business, etc.)	6.2
Speaks clearly (good volume, tone, cadence, delivery, etc.)	6.2
Effectively manages time and content to fit within the allotted time	6.2
Discusses the risks and/or tradeoffs	6.1
Shares their opinion of tradeoffs that can/should be taken	5.8
Recognizing others when appropriate through the presentation	5.7
Demonstrates technical depth and/or expertise	5.6
Demonstrates an understanding of business strategies	4.9

Relative to Verbal Update traits, Presentation skill shown in Table 2 showed 11 traits scoring at or above 6 while Verbal Updates had only 6. It is interesting again that "Demonstrating technical depth" scored near the bottom of these traits while softer skill traits such as answering questions directly, structuring the presentation well, and speaking in plain language scored much higher.

Table 3. Results of the survey on the importance of components of Written Update skills.

Components of Written Update Skills	Score (1-7)
Effectively summarizes complex topics	6.5
Logically organizes thoughts	6.5
Provides appropriate level of technical details (the "how" and the "why")	6.5
Makes their intent known quickly/clearly	6.4
Is able and willing to communicate positive and negative messages	6.2
Can be brief/efficient in their communications	6.1
Does not become emotional/personal when engaging in difficult topics	6.1
Action items & next steps are clearly called out with names and timelines	6.0
Addresses the most important elements initially	5.9
Solicits inputs/feedback ahead of time before publishing/sending	5.8
Effectively uses pictures, graphs, tables to convey complex concepts	5.8
Demonstrates technical and/or business value	5.8
Shares their opinion on prospective decisions or next steps	5.8
Shares the business/technical implications of their topic	5.6
Is a good grammatical writer	5.3

Table 3 reflects Written forms of communication such as email and longer forms such as technical papers. The traits that scored the highest centered around summarizing complexity (versus highlighting the complexity to make the engineer appear smart), organizing the material to make it understandable for others and providing appropriate details to explain the technology. Interestingly, more formal writing requirements such as utilizing good grammar scored at the bottom of the surveyed traits.

Note that this survey is exploratory and is intended to give us preliminary data to start the course design. To make the results more generalizable, we will need to expand the survey to a larger number and a more diverse set of companies. However, the results were shared anecdotally with executives from other high-tech companies including major computer hardware and software companies with agreement on the need for improvement of newly hired engineers' communication abilities. Of particular note was the strong consensus view from every company that engineers need to be more skilled in making their points concisely and making complex topics understandable for non-experts. Surveyed managers clearly prioritized certain communication skills and identified which skills are lacking in the newly hired engineers. We have used this information to focus our attention to high-priority areas with relatively poor performance. In the future we will share our observations with faculty at our and at other universities and incorporate their observations and feedback into our course design.

Many of the most important skill traits represented across the three communication types (verbal, written, and presentation) fall under the heading of higher cognitive skills in Blooms taxonomy. As such, they require special attention in developing instructional activities that will help students develop these skills.

2. Communication Principles

The course is developed around a framework to aid in optimizing the student's technical communication skills. By clearly identifying and focusing on each of the 5 elements or "lenses", students can efficiently and effectively convey technical information. These lenses are:

Lens 1: *Audience Type* - Technical, Business, Customer
Lens 2: *Audience Seniority* - Entry, Mid-Level, Executive
Lens 3: *Communication Form* - Document, Verbal, Presentation
Lens 4: *Purpose* - Educate/Inform, Influence/Sell, Request a Decision
Lens 5: *Length* - 30 seconds, 3 minutes, 30 minutes

1. Audience type: There are 3 unique audience types, and each requires distinct approaches to convey information to them. Technical audiences are capable of comprehending the technical depth and tend to appreciate the "what" (the new design or technology) and the "how" something works. This is the audience that most students identify with themselves in engineering schools. A second audience type is an internal business audience. This audience is less concerned about the technology directly and more interested in the impact or "value" of the technology on their internal business. An example would be how they will be differentiated from the competition. The customer audience is similar to the internal business audience, but the customer audience appreciates the impact and value to their own business.

2. Audience seniority: The seniority of the audience is an important aspect to focus technical communications. Entry level individuals tend to appreciate the direct implications of the item being discussed. For example, an entry-level businessperson wants to know what the customer value is and what it is worth. An entry-level technical person appreciates the technical fundamentals of the topic, i.e., how it works and the technical implications. Executives have a very different set of communication expectations. Technical executives want to understand

competitive differentiation and industry leadership. Business executives want to hear about the implications to customer/partner alignment, strategic objectives, and leadership possibilities. Mid-level audiences are focused on execution risks/tradeoffs, and competitiveness.

3. Communication Form: Often, the situation will dictate what form of communication is the most appropriate. Documents are longer-form written communication that allow the author to delve into details and a richer form of storytelling. Despite the flexibility to delve into detail, written forms such as emails must be tailored to fit the needs of the audience. The ability to concisely convey information and clearly highlight the necessary and relevant information quickly is a trait that is highly valued and often not exercised in traditional communication classes. Verbal updates are the most common forms of communication and range between planned and spontaneous verbal communications. The ability to confidently discuss material while tailoring language to the audience to maximize comprehension is highly valuable. This form requires the communicator to be actively listening and tailoring their responses appropriately. The third communication form is a presentation. In this form, there are two important aspects, the presentation material, and the delivery. The presentation material must be tailored to the audience with a storyline that maximizes understanding through the use of pictures, images, simplified diagrams, metaphors, and the like. The second aspect of a presentation is the delivery. Here the person must be in command of the material, well-practiced in their delivery, able to read the audience in terms of their comprehension and have the ability to tailor their delivery to meet the audience where they are to maximize comprehension. The delivery is not a speech that can be memorized because a speech doesn't allow for active listening and real-time changes to adapt. The delivery must be thought of as a discussion between the presenter and the audience who will be communicating through verbal and non-verbal cues such as body language.

4. Purpose: The goal of any communication dictates how to tailor the content. For educational or informational communications, the goal is to provide maximal context. Influencing and/or selling requires the communicator to convey an understanding of the needs of the audience and then connect their offer as a means to address the audience's needs. Requesting a decision requires the communicator to develop credibility with the audience and portray a deep understanding of the problem and the implications of the proposed solution.

5. Length: The longer the communicator has to convey their story, the easier it is. The longest forms are typically in the 30-60 minute presentations or long form technical documents (which require a long time to read and digest). In this form, the communicator can build up the context, describe options and tradeoffs, answer ample questions and even invite other people to join them in the communication. The difficulty in this long form is to maintain the audience's interest and connection with the material. As the time available shrinks, the communicator must distill down the content to the most vital elements. For example, being able to convey the necessary information within 3 minutes is an important skill to possess. Balancing the background and context with available options and the proposed direction forward is a skill that requires practice. The most refined form here is a 30-second "elevator pitch". Identifying precisely what must be communicated and how to achieve maximum comprehension from the audience in such a short time is something that is an advanced skill.

3. Course Structure

Courses at Portland State University are based on 11-week long quarters and most ECE courses have four contact (lecture) hours. This course is targeted at senior undergraduate and graduate-level engineering students. It was piloted during the Spring term of 2022 as an elective 4-credit course for undergraduate students. Depending on the results of the pilot offerings and student interest this course may become a required course for one or both groups of students.

Because most engineering instructors/professors are not typically experts in technical communication in industry, this class is taught by an adjunct instructor who is an executive in industry and holds an engineering degree. The ability to span between the needs of technical, business, and customer leaders with the foundations of engineering students is important. The course is structured to mimic the most common communications engineers will face when hired after graduation. Each student is treated as a "new hire" and the class is a peer group of engineers within the company.

Because technical depth is important for technical communication, students are asked to choose their own topics for all written and verbal assignments throughout the course. The ability to express their technical context/background and technical depth of understanding on the topic is important. A computer engineer would not possess the same technical depth and background on the topic of electrical power distribution and hybrid power as a power engineer. The course is designed such that each engineer is communicating in their wheelhouse as they would when working in industry.

Every student activity, update, and presentation is videotaped so that each student can review their work individually after class. In practice, it is clear that many people are unaware of how they look and sound when they are communicating with others. It is only through the often-times uncomfortable process of watching themselves communicate that students begin to internalize the feedback they receive from the instructor or peers.

A detailed schedule with a weekly distribution of topics and assignments is given in Table 4 in Appendix A.

4. Communication Tools and Principles

Framing of technical communication: Independent of the form of communication (written, verbal, presentation) students are encouraged to follow a consistent flow in their communication:

1. Set the context
    a. Provide a background and/or remind the audience where you last left off.
2. Make your intentions known quickly
    a. Is this an informative discussion, decision meeting, escalation, etc.?
3. Why is this important?
    a. Without audience buy-in that the topic is important, the discussion cannot continue.
4. Maintain audience attention and interest
    a. Get the audience emotionally invested and/or capture their imagination

5. Establish clear next steps

Outline: While an outline is a tool that is certainly not unique to technical communications, the complexity associated with technical topics makes the storyline organization critical. Planning out the storyline to maximize understanding is foundational to successful communication. Often times students and newly hired engineers underestimate the difficulty of conveying complex topics and simply expect that the audience will understand them. As explained below, it is only through utilizing a structured storyline approach to conveying information that people can regularly show success in connecting to and influencing their audience.

Outline writing proceeds as follows:

- First, students are instructed to start with writing down the objective(s) of the communication.
- Next, they write the current state followed by the outcome they want as a result of the communication.
- In the next step they break down the major points they need to make that will bring the audience from the current state of understanding to the desired end state.

The students are instructed that for a story to flow, these interim points need to logically flow and build upon each other leading up to the desired outcome. Once those major points are organized the student is asked to provide the 1-3 supporting elements for each major point paying special attention to the values of the audience and/or decision-maker. This outline structure is an invaluable tool for all written communications. One note is that the student always must be cognizant of the time that is available which determines how many points can realistically be discussed. A 30-minute PowerPoint presentation has much more flexibility than a 5-minute verbal update.

Presentation & written composition planning: Throughout the class, students are encouraged to think about how to create a compelling storyline to convey a technical topic. The basic principle described is to start with the current state, then write down where you want to end your presentation or document/email. That represents the start and the finish of the journey the author intends to bring their audience through. From there, the student needs to factor in the available time and the format of the technical communication. To use an analogy, the start of a storyline is like one bank of a river and the end point of the communication is the other bank of the river. In the real world, there are no bridges to perfectly span the sides of the river. There are only steppingstones or lily pads that the audience can use to complete the journey from bank to bank. Those steppingstones (or major points) must be planned by the author to ensure they provide a familiar foundation for the audience to land upon and are not spaced so far apart that the audience cannot follow the points and instead falls into the river trying to leap between points. This journey must be planned and refined to make the journey as efficient as possible.

Practice, practice, practice: Of all the tools that students have at their disposal, the simple art of practicing their storyline and delivery is easily the most under-used and yet most effective tool. Students are encouraged to practice the delivery of their messages in front of a mirror NOT to the point of getting it right, but instead practice until they can’t get it wrong. Engineers’

credibility can be harmed when they appear unprepared or lack confidence in their delivery of technical content.

5. Major Assignments

Technical Summary: Each week the students are required to write up a technical summary. The summary should be 1-2 short paragraphs that describe a technical topic in the news that week. Students choose a topic that is aligned with their technical background. This exercise mimics sharing information over email with a manager or their peers about something the student recently read. The summary should use a common language, not techno-speak jargon, and highlight what is novel about the topic in a concise and compelling manner.

1-minute Challenge: Every two weeks the student is asked to stand in front of the class and discuss their technical summary from that week. Notes and slides are not permitted for verbal delivery. The student is expected to present for approximately 60 seconds and then take questions from their peers and instructor. This exercise is meant to mimic staff meeting updates that engineers will be asked to participate in on the job.

Technical Presentation: The course starts off with focusing on the technical audience since this audience is typically the most familiar to students. In week 4 of the class, students are asked to identify a topic that they are familiar with – often times this corresponds to their senior project or graduate work. They are then asked to write a 2-page technical paper aimed at a technical executive describing their topic. Additionally, they are asked to prepare a PowerPoint presentation for a technical audience and deliver that presentation to the class. Depending on the size of the class, each student is allotted 5-10 minutes for their presentation followed by a question and answer period.

Business Presentation: The course then transitions to business audiences and by week 7 of the course, the student is asked to write a 2-page paper for a senior business audience and deliver a 5-10 minute PowerPoint presentation followed by a question and answer period.

Customer Presentation: The last section of the course transitions to focusing on the customer audience. The 2-page paper and presentation serve as the final assignment for the course.

6. Skill-Building Activities

Journey Line: Students are first asked to introduce themselves to their fellow students through a "Journey Line" which is a picture of important elements in their life from birth to today. This exercise consists of students drawing a horizontal line on a piece of paper, then starting at the left of the line, writing their birthplace. The student then chooses a handful of life events that were meaningful for them over their life. Positive events are drawn as points above the line and negative events are drawn as points below the line. The right-most portion of the line is "Today". The student then draws a connecting line between the events in chronological order. Each student spends a maximum of 5 minutes to share their story with students. This exercise is intended to help break the ice between students by finding the similarities or interesting

differences between students. It also gets the students accustomed to talking in front of other students – an activity they will be performing many times throughout the course.

In The News Verbal update: Students are asked to partner up with one other student and choose a technical topic that is currently in the news. They are given 15 minutes to prepare a 3-5 minute verbal update for the class. Both students are expected to talk during the report out to highlight the important aspects of the topic. The students are encouraged to choose topics that they are familiar with so they can draw from their knowledge and background on the topic. The ability to and comfort with communicating verbally to their peers and a manager are critical skills to possess in industry.

In The News Presentation: Similar to the previous exercise, this activity extends the update to include 20 minutes to prepare simple PowerPoint slides to aid the team of 2-3 students in conveying the important aspects of the topic to the class during their 5-minute report out.

Welcome to Earth: This activity is a favorite among students. The premise is that over many decades, Earth has been monitored by extraterrestrials. They have mastered the human language and other aspects of day-to-day life, but there is one area they do not understand…sports. Student groups of 3-4 are each given a unique sport (basketball, soccer, tennis, baseball, etc.) and are asked to create a 10-minute presentation describing basic game play including the goal(s) of the game, the playing surface and equipment used, the basic rules of the game and what makes the game so enjoyable. The challenge is to determine how to describe a game without using terms that are inherent to the game…for example explaining the sport of basketball but refraining from saying the goal is to make a basket and to score the most points. The audience in this case doesn't know what a basket is (until it is described) and does not understand how many points a score can be worth. Decomposing these sports down is extremely challenging and is easy for students to see how this applies to deeply technical topics. Using jargon that is not broadly understood inhibits the audience from understanding technical topics. Students become sensitized to jargon, planning out how to build upon concepts toward complex ideas. This exercise is deceptively difficult – especially explaining the sport of baseball in 10 minutes.

Analogy Exercise: Analogies can be a very powerful tool for engineers to describe complex topics. In this exercise, students are paired up. One student is the describer and one is the artist. The describer is shown a picture by the instructor and then asked to use analogies to describe to their artist partner what to draw on the whiteboard in front of the class. Everyone in the class is aware of the original picture, except for the artist so that all students can see and hear how others are attempting to use analogies to describe an object to the artist. Once the description is completed, the original picture is shown to the artist and there is a discussion about what worked and what did not regarding the analogies used to describe the picture.

7. Course Effectiveness Assessment

Since this course is still under development so is the assessment. Its primary purpose at this time is to diagnose any potential problems and to provide initial evidence of the effectiveness of the approach. For the former, we developed an end-of-term survey to collect student feedback and

for the latter we analyzed student performance on a writing assignment at the start and at the end of the class, as discussed next.

At the beginning of the term, students were asked to choose a technical topic in the news that they were familiar with and write a brief technical summary to a hypothetical manager. This assignment was not factored into their grade for the course, but it did serve as a baseline for each student to compare their progress over the term. The average grade was 65% (D) using the predefined rubric (Table 5 in the Appendix B). As shown in Figure 2, by the end of the term, students had mastered each of the elements represented in the rubric demonstrating their progress and retention of the material taught in the class.

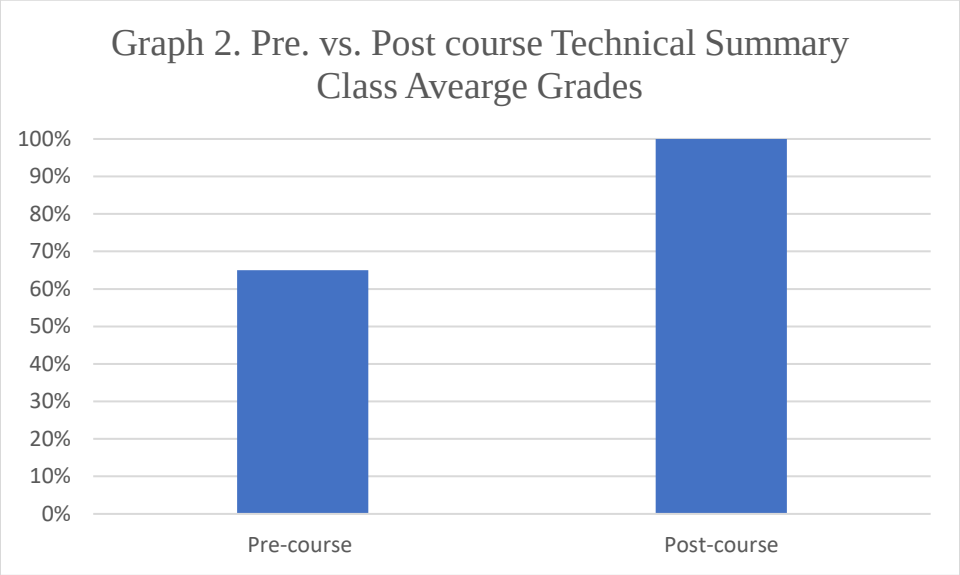


Figure 2. Results of evaluation of writing assignment at the start (pre-) and the end of the term (post-).

Student feedback was collected through a 29-question end-of-term survey that included the following questions (among others):

The course as a whole was…
Amount you learned in the class was…
Relevance and usefulness of the course content was…
Course organization was…
Your involvement in this course (doing assignments, attending classes, etc.) was…

Out of 13 students only 4 submitted the survey which prevents any firm conclusions. In general, students seemed to have valued the structure of the curriculum, the ability to develop their skills, and the connection between the coursework and the expectations they will be held to when employed in industry.

Scoring rubrics for other assignments are provided in Appendix B but the results have not yet been analyzed. Finally, we should point out that a course like this can be used to assess many ABET Student outcomes, such as [16]

- ABET Criterion 3 SO #3: An ability to communicate effectively with a range of audiences
- ABET Criterion 3 SO #5: An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- ABET Criterion 3 SO #4: An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- ABET Criterion 3 SO #7: An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

However, this would require a careful mapping between the course and program assessment.

8. Conclusion

Developing a course that is tailored to engineers started out as an appeal from industry asking for help in addressing a shortfall in communication skills in newly hired engineers. Analysis of this problem started by dividing the technical communication into three forms: written update, verbal update, and presentations, with special emphasis on the needs of the high-tech industry. Next, gaps in the communication skills of the newly hired engineers were identified through a survey of managers. Finally, the most important components of each form of communication were identified which enabled more focused course development. To frame the course development, a set of five lenses was developed which enabled us to construct exercises and assignments to address each one. The resulting course which is the basis for this paper was based on real-world tasks identified by the industry that students will face daily in their careers. The course is still being actively developed but the initial results are promising. We believe that by increasing access to courses such as this to a broader population of engineering students about to enter the workforce, we empower them with critical skills for their professional development and career advancement.

Appendix A: Course schedule

Table 4. Schedule (110 minute classes, 2x per week) – 4 credits

	Topics	Assignments
Week 1	Introduction – Journey Line / syllabus review	
	Knowing the audience, story-telling basics	Tech Summary
Week 2	Outline & Structuring communications	
	Sharing your point of view without "selling"	Tech Summary & 1-min challenge
Week 3	Verbal delivery to maximize credibility	Midterm #1 (technical)
	(continued)	
Week 4	Business Audience basics	
	Visual Aids	Tech Summary
Week 5	Avoiding Jargon – "Welcome to Earth"	
	Simplifying complex topics	Tech Summary & 1-min challenge
Week 6	Active Listening While presenting	Midterm #2 (business)
	Managing nerves while talking	
Week 7	Welcome to Earth #2; Customer Audience Basic	
	Language selection, body language & credibility	Tech Summary
Week 8	Advanced Analogies & visual aids	
	Pitching an idea without "selling"	Tech Summary & 1-min challenge
Week 9	Pitching an idea without "selling" (continued)	
	Guest speakers from industry	Tech Summary
Week 10	Resumes – selling yourself	
	Student choice of topics	Tech Summary & 1-min challenge
Week 11	Final	Final

Appendix B: Scoring Rubrics for Assignments

Table 5. Tech Summary

Max Score	Written Technical Summary
10	Comprehensively summarizes the story
20	Writing is clear, concise and professional
10	So-What factor - raises the reader's interest
10	Length of summary is appropriate

Table 6. 1 Minute Challenge

Max Score	Verbal Summary
10	Comprehensively summarizes the story
10	So-What factor - raises the reader's interest
10	Fits within the 1-minute time budget
20	Delivery is clear, confident & well-rehearsed

Table 7. Mid-terms and final

Max Score	Presentation Delivery & Content
10	Comprehensively summarizes the story
10	So-What factor - raises the reader's interest for target audience
10	Delivery fits within the time budget
20	Delivery is clear, confident & well-rehearsed

Table 8. 2-page Technical Summary

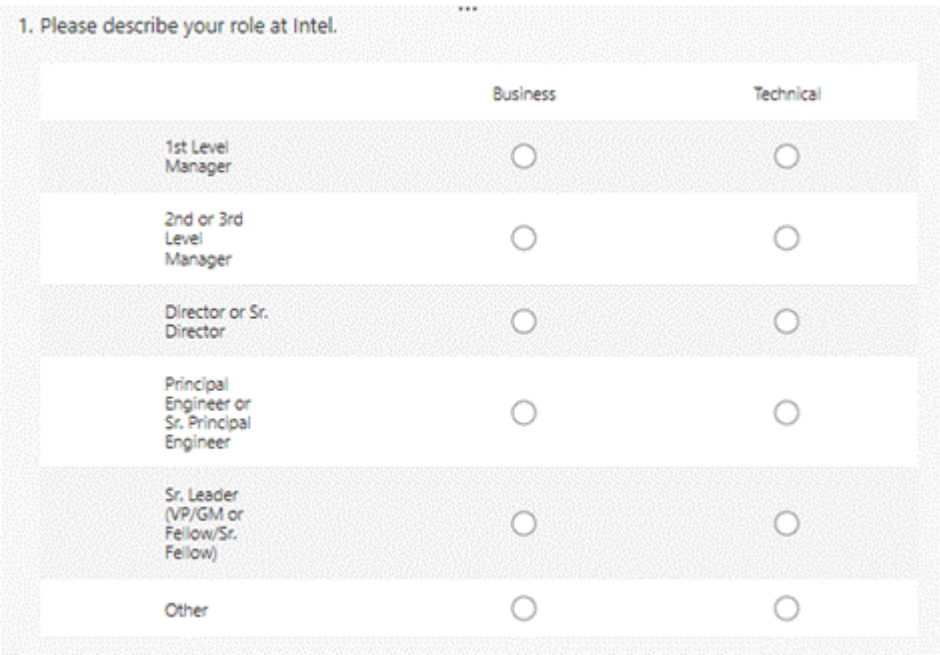
Max Score	2 Page Technical Paper
10	Comprehensively summarizes the story
20	Writing is clear, concise and professional
10	So-What factor - raises the reader's interest for target audience
10	Effectively utilizes visual tools such as graphs/charts

Table 9. Grading Weights

Weight	Graded Elements Throughout Term
20%	Weekly Tech Summaries & 1-minute Challenge
10%	Class Attendance & participation
20%	Mid-term #1 (Technical Audience) [Presentation + 2-page Summary]
20%	Mid-term #2 (Business Audience) [Presentation + 2-page Summary]
30%	Final (Customer Audience) [Presentation + 2-page Summary]

Appendix C: Industry Survey

Survey Section 1: Respondent's Role



1. Please describe your role at Intel.

	Business	Technical
1st Level Manager	○	○
2nd or 3rd Level Manager	○	○
Director or Sr. Director	○	○
Principal Engineer or Sr. Principal Engineer	○	○
Sr. Leader (VP/GM or Fellow/Sr. Fellow)	○	○
Other	○	○

Survey Section 2: Skills & Traits Priorities

We want to understand your experience for the typical skill level from newly hired junior engineers and how important these areas are.

Verbal updates definition: Verbal updates such as 1:1's, brainstorm sessions, daily stand-up meetings, SCRUM meetings, staff meeting opens, ad-hoc phone discussions, etc. These updates do not have prepared materials such as slides or documents and are NOT significant decision meetings. They are typically direction checking and/or educational in nature.

2. Please rate how important **verbal update** skills are for new engineers (as defined above).

0	1	2	3	4	5	6	7	8	9	10

Not at all important — Extremely important

3. Based on your experience, please rate how likely new engineers will have **verbal update** skills (as defined above).

0	1	2	3	4	5	6	7	8	9	10

Not likely at all — Extremely likely

4. Based on your experience, please rate the importance of each **verbal update** skill. 1 = not at all important, 3 = nice to have, 5 = important, 7 = extremely important.

	1	2	3	4	5	6	7
The ability to listen and respond/inquire effectively	○	○	○	○	○	○	○
Being present in the conversation and connected	○	○	○	○	○	○	○
Answers direct questions briefly (avoids unnecessarily long answers)	○	○	○	○	○	○	○
Speaks clearly (good volume, tone, cadence, delivery, etc.)	○	○	○	○	○	○	○
Demonstrates logical thinking	○	○	○	○	○	○	○
Demonstrates technical depth and/or expertise	○	○	○	○	○	○	○
Demonstrates an understanding of competing priorities	○	○	○	○	○	○	○
Shares their opinion of tradeoffs that can/should be taken	○	○	○	○	○	○	○
Demonstrates an understanding of business strategies	○	○	○	○	○	○	○
Speaks in plain language to be understandable	○	○	○	○	○	○	○
Provides potential options and/or next steps	○	○	○	○	○	○	○
Is able to read the room to adjust accordingly (pace, depth, level of interest, etc.)	○	○	○	○	○	○	○
Is an effective and receptive listener to inputs and feedback	○	○	○	○	○	○	○
Exhibits confident body language	○	○	○	○	○	○	○
Inclusive, encourages others to speak/contribute, and listens	○	○	○	○	○	○	○

Section 3: Presentation Skills

Please rate based on your experience for the typical skill level from newly hired junior engineers and how important these areas are.

Presentations definition: There is an audience of more than one person (typically >4-5). These are typically longer in duration than an update, such as a topic in a staff meeting and are accompanied by slides and/or documents. The objective can be for decision making or education.

5. Please rate how important **presentation** skills are for new engineers (as defined above).

0	1	2	3	4	5	6	7	8	9	10

Not at all important — Extremely important

6. Based on your experience, please rate how likely new engineers will have **presentation** skills (as defined above).

0	1	2	3	4	5	6	7	8	9	10

Not at all likely — Extremely likely

7. Based on your experience, please rate the importance of each **presentation** skill. 1 = not at all important, 3 = nice to have, 5 = important, 7 = extremely important.

	1	2	3	4	5	6	7
Speaks clearly (good volume, tone, cadence, delivery, etc.)	○	○	○	○	○	○	○
Recognizing others when appropriate through the presentation	○	○	○	○	○	○	○
Discusses the risks and/or tradeoffs	○	○	○	○	○	○	○
Answers direct questions concisely (avoids long answers); Acknowledges when they don't know	○	○	○	○	○	○	○
Shares their opinion of tradeoffs that can/should be taken	○	○	○	○	○	○	○
Speaks in plain language to be understandable	○	○	○	○	○	○	○
Discusses appropriate details	○	○	○	○	○	○	○
Demonstrates logical thinking	○	○	○	○	○	○	○
Effectively manages time and content to fit within the allotted time	○	○	○	○	○	○	○
Demonstrates technical depth and/or expertise	○	○	○	○	○	○	○
Demonstrates an understanding of business strategies	○	○	○	○	○	○	○
Is an effective and receptive listener to inputs and feedback	○	○	○	○	○	○	○
The presenter is prepared and knows the material	○	○	○	○	○	○	○
The presentation has structure: beginning/intro/exec summary, main content, and an end/summary/next steps/decisions	○	○	○	○	○	○	○
The presentation is designed according to the audience (junior or senior, tech or business, etc.)	○	○	○	○	○	○	○

Survey Section 4: Written Updates

Please rate based on your experience for the typical skill level from newly hired junior engineers and how important these areas are.

Written updates definition: We are limiting our focus here to emails, chat channels (such as teams or slack) and technical papers (formerly whitepapers).

8. Please rate how important **written update** skills are for new engineers (as defined above).

0	1	2	3	4	5	6	7	8	9	10

Not at all important — Extremely important

9. Based on your experience, please rate how likely new engineers will have **written update** skills (as defined above).

0	1	2	3	4	5	6	7	8	9	10

Not at all likely — Extremely likely

10. Based on your experience, please rate the importance of each **written update** skill. 1 = not at all important, 3 = nice to have, 5 = important, 7 = extremely important.

	1	2	3	4	5	6	7
Effectively summarizes complex topics	○	○	○	○	○	○	○
Is a good grammatical writer	○	○	○	○	○	○	○
Logically organizes thoughts	○	○	○	○	○	○	○
Provides appropriate level of technical details (the "how" and the "why")	○	○	○	○	○	○	○
Makes their intent known quickly/clearly	○	○	○	○	○	○	○
Addresses the most important elements initially	○	○	○	○	○	○	○
Can be brief/efficient in their communications	○	○	○	○	○	○	○
Solicits inputs/feedback ahead of time before publishing/sending	○	○	○	○	○	○	○
Is able and willing to communicate positive and negative messages	○	○	○	○	○	○	○
Effectively uses pictures, graphs, tables to convey complex concepts	○	○	○	○	○	○	○
Demonstrates technical and/or business value	○	○	○	○	○	○	○
Shares their opinion on prospective decisions or next steps	○	○	○	○	○	○	○
Shares the business/technical implications of their topic	○	○	○	○	○	○	○
Action items & next steps are clearly called out with names and timelines	○	○	○	○	○	○	○
Does not become emotional/personal when engaging in difficult topics	○	○	○	○	○	○	○

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