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Integrating Industrial Feedback into Role-Playing Scenarios in Laboratory Classes for Improved Technical Communication Skills Transferable to the Workplace

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Abstract

Good communication skills are necessary for students entering the workforce. However, due to a continually changing communication landscape, courses that integrate communication skills into the engineering curriculum may not align with the skills students need. In this paper, information was solicited from practicing engineers in industry regarding the types of communication genres they engage in, how often they use the genres, and what communication skills they find most important. In general, the industry representatives engaged in a variety of oral and written communication genres including interactions with vendors or customers, email correspondence, meeting agendas and notes, providing and receiving feedback, technical instructions, feasibility studies, letters and memos, technical reports, and more. Industry representatives emphasized that shorter, more concise reports are of greater value than long reports and that oral presentation skills should be a focus. Additionally, audience consideration is a valuable skill for the students to acquire as engineers are required to communicate with a variety of stakeholders. A typical engineering course may not provide opportunities for students to learn and practice the diversity of practical skills they would use as practicing engineers. With the information presented herein, changes to course design and assessment can be made in communication-focused courses, and elsewhere in the curriculum, to target communication skills transferable to the workplace.

Introduction and purpose

Although the technical skills taught within engineering departments are likely similar to those taught within all engineering programs, professional skills are where graduates can stand out when entering the workforce [1-3]. Proficient communication in particular has been directly linked to enhanced career progression [4], yet many engineering graduates lack these important skills. Despite the immense value of communication skills for undergraduate students, effective integration of these skills into the engineering curriculum can be challenging. Students often do not recognize the significance of the technical communication work they do as an undergraduate to their future careers and need to learn communication skills that are transferable to the practice of engineering. As the standards and norms of effective communication in engineering depend heavily on the context of engineering practice, engineering communication is situated and rhetorical [3]. Therefore, one way to help shift the students out of a "student-just-completing-assignments" mindset is to have them assume an identity in the engineering profession through situated learning, where communication assignments are situated in the "real world" and reflect discipline specific workplace genres. Since students can see the relevance to their future careers of what they are learning, this approach can also help foster student engagement.

A role-playing scenario was implemented into a senior engineering laboratory class at a land-grant institution approximately five years ago. In the role-playing experience, students are "interns" at a consulting company. Lab objectives are written as "company memos," instructors are given management titles such as CEO and CFO, and tailored assignments target different genres of engineering technical writing. Initially changes were based on an instructor's previous industry experience, however, the landscape of communication in engineering practice changes rapidly. In order to ensure what was being taught in the class was relevant to current practice, a

survey regarding how often one uses different communication genres and the communication skills they find most important was sent to members of the Department Advisory Committee (DAC) who have a wide range of industry experience. The goal of the survey was to determine what should be incorporated into the curriculum in order to improve the students' chances of success in their future careers.

Methods

A survey (in appendix) based on the "Workforce Communication Skills Survey" [5] was sent as a Qualtrics survey to five DAC members that represent chemical engineers at various stages in their career; one participant recently retired, three were senior level managers and two were process engineers. These industry representatives work in sectors ranging from energy (WBI Energy) including oil and gas (Cenex, Conoco Phillips) to semiconductors (Micron) and materials science (3M Corp.).

The survey focused on genre, technical communication skills in general, oral communication skills, and written communication skills. It asked how often the survey taker used different written and oral communication genres on a Likert scale with 1 corresponding to never, 2-yearly, 3-monthly, 4-weekly and 5-daily. The survey also asked what technical communication skills they felt were most important on a Likert scale from 1 to 5 with 1 being not important and 5 being very important. Additionally, open-ended questions were asked regarding the communication skills new engineering graduates need to improve and how they would suggest doing that. All five DAC members responded and the Qualtrics data was compiled and analyzed in Excel.

Results and discussion

As previously mentioned, the industry representatives surveyed were at different points of their careers and had different experiences from working at small to large companies and in different areas like consulting and management. The industry representatives indicated that in terms of genres, email messages, meeting minutes, and meeting agendas were their top three commonly used communications (Figure 1). Additionally, meeting facilitation, videoconferences, and presentation materials were ranked as being used daily to weekly as well. From an academic standpoint, at Montana State University, the laboratory and design courses required written reports that were longer in length (8 pages or more), which from the industry perspective, reports they used were ranked in the order of: short reports (less than 3 pages), proposals, lab reports, and then formal reports (more than 3 pages), but noted that the job role plays a large part in the importance. For example, when asked to elaborate on which communications do they consider the most important and why one respondent stated *"Proposals, feasibility studies, and technical instructions…have the greatest impact on our operating system, growth, and revenue opportunities…(time/money/stress implications)"* while another wrote *"Writing and responding to emails since it is vital to documenting key communication… Oral communication is important to develop and maintain relationships with people outside of your company."* Based on these results, it is important to consider exposing students to a variety of genres for deliverables. Incorporating meeting agendas, meeting notes, presentations, and a variety of report lengths give students exposure to many of the communication types they may see in their future careers.
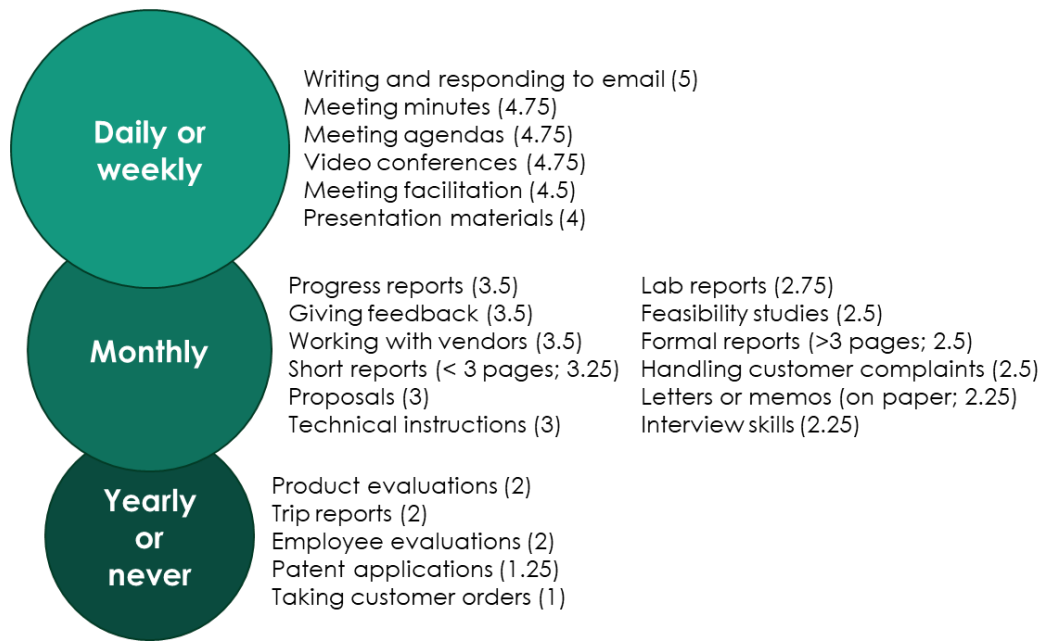
Daily or weekly

Writing and responding to email (5)
Meeting minutes (4.75)
Meeting agendas (4.75)
Video conferences (4.75)
Meeting facilitation (4.5)
Presentation materials (4)

Monthly

Progress reports (3.5)   Lab reports (2.75)
Giving feedback (3.5)   Feasibility studies (2.5)
Working with vendors (3.5)   Formal reports (>3 pages; 2.5)
Short reports (< 3 pages; 3.25) Handling customer complaints (2.5)
Proposals (3)   Letters or memos (on paper; 2.25)
Technical instructions (3)   Interview skills (2.25)

Yearly or never

Product evaluations (2)
Trip reports (2)
Employee evaluations (2)
Patent applications (1.25)
Taking customer orders (1)

Figure 1. *Rankings on how often industry representatives use different genres in their engineering position where 5 represented daily, 4 weekly, 3 monthly, 2 yearly, and 1 never. The average Likert scale scores are listed after the genre.*

As mentioned in the open-ended responses, genre selection depends upon the purpose of the communication, the context and, importantly, the audience. Industry representatives responded that they interact regularly with different audiences. They have daily or weekly interactions with colleagues, supervisors, subordinates, clients, and suppliers/vendors while at the monthly level, they interact with colleagues from international branches and the public. The details of what a colleague or subordinate needs to know regarding a project is much different than the information a supplier or the public needs, impacting the genre that would be most effective. Therefore, it is important to design communication assignments that deliberately target different audiences.

In a separate question regarding important communication skills (Figure 2), the ability to communicate clearly and concisely was the highest ranked item, followed by listening skills, presenting supporting evidence, understanding the objectives, and audience consideration. When asked about skills specific to presentation and writing (Figure 3), formal presentation skills and meeting facilitation were ranked highest for presentations while concision, sentence structure, grammar, and appropriate visuals were ranked highest for writing. Based on these responses, a course with learning objectives regarding communication skills for engineering students would benefit from designing assignments that include a variety of genres and audiences, and that target specific skills. In order to guide the students and assess student learning, rubrics that are carefully designed to assess technical skills in parallel with specific industry-relevant communication skills can be used [6, 7]. Rubrics can also serve student learning as diagnostic tools that identify gaps in knowledge and help structure effective feedback.

Technical Communication Skills

Extremely Important

Ability to communicate clearly and concisely (5)
Listening skills (5)
Evidence for conclusions and recommendations
Comm. and understanding the purpose/obj. (4.75)
Audience consideration (4.75)
Receiving feedback (4.5)
Accuracy of technical content communicated (4.25)
Giving feedback (4.25)
Following instructions (4.25)

Very Important

Relevance (4)
Informal verbal summaries/reporting (3.75)

Moderately Important

Precise technical terminology (3.5)
Communicating information in a logical order (3.25)
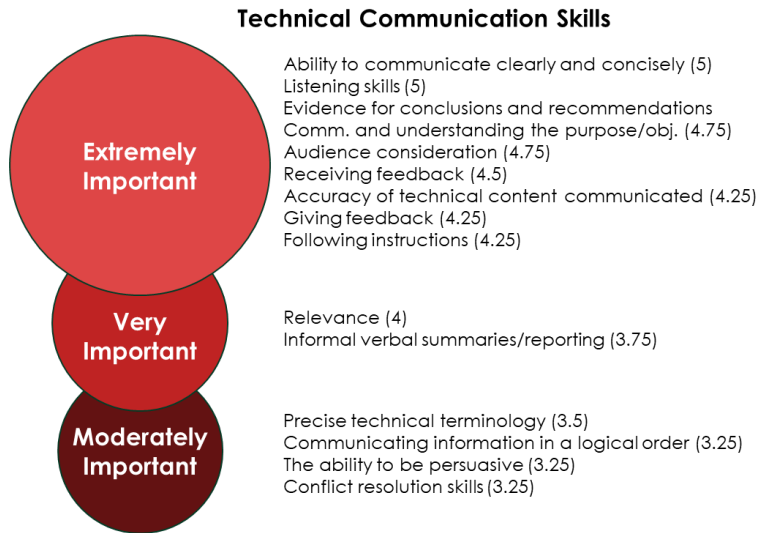The ability to be persuasive (3.25)
Conflict resolution skills (3.25)

Figure 2. Rankings of technical communication skills from the industry representatives where 5 represented extremely, 4 very, 3 moderately, 2 slightly, and 1 not important. The average Likert scale scores are listed after the genre.

Presentation Skills   ## Writing Skills

Extremely Important

Formal presentation skills (4.5)
Facilitation during a meeting (4.25)

Text is concise and succinct (5)
Sentence structure (4.5)
Grammatical correctness (4.25)
Appropriate/meaningful use of visual elements (4.25)

Very Important

Conversational skills (4)
Slide formatting (4)
Finishing a meeting or presentation on time (4)

Spelling and punctuation (4)
Text flows logically with good transitions (4)

Moderately Important

Ability to answer questions (3.75)
Professional appearance and manner when speaking (3.5)
Natural cadence and flow of speaking (3.5)
English speaking skills (3.5)

Logical use of organizing structures (3.5)
Proper formatting of figures and tables (3.5)
Citations accurate, retrievable by reader (3.25)
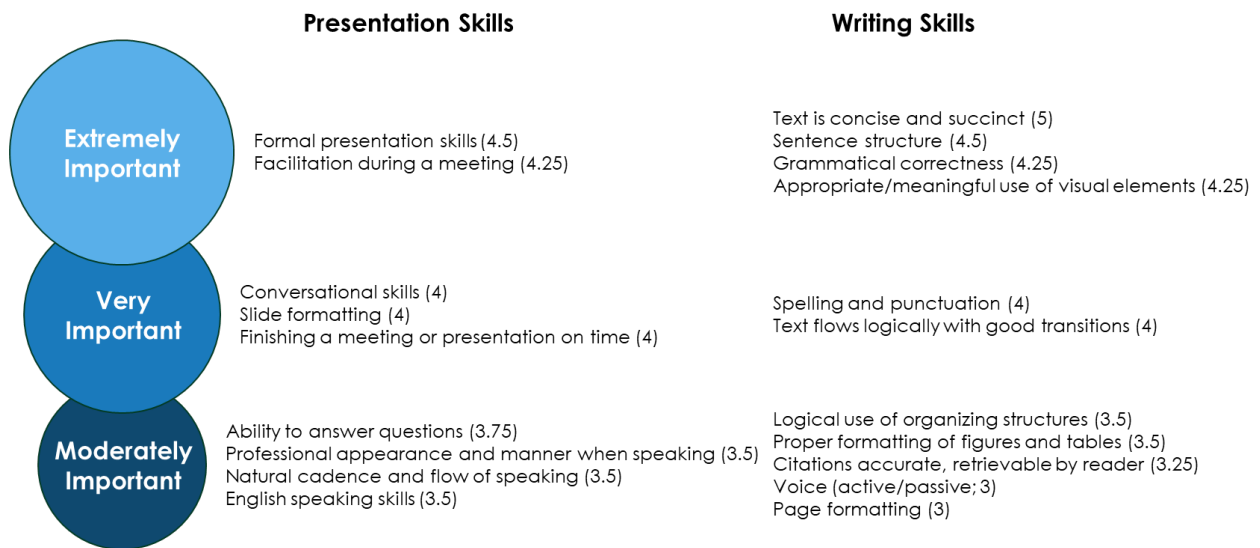Voice (active/passive; 3)
Page formatting (3)

Figure 3. Rankings of presentation and writing skills from the industry representatives where 5 represented extremely, 4 very, 3 moderately, 2 slightly, and 1 not important. The average Likert scale scores are listed after the genre.

To close the survey, two open-ended questions were asked, including "What communication skills do new engineering graduates need to improve?" and "What are the top one or two ways new engineering graduates can improve their communication skills?" The responses to the communication skills question mirrored what the industry representatives stated in the Likert survey with skills such as understanding audience and context, concision, organization, and relevance all being mentioned. Additionally, in terms of genre, there was mention of having students write better memos, technical instructions, and proposals, while also needing to have

oral presentation skills, both in-person and virtual. For the question regarding how engineering students could improve their communication skills, understanding their audience was mentioned by multiple industry representatives. Finally, practicing oral presentations and understanding the expectations of the deliverable was also mentioned.

Significance and implications

For the laboratory course at Montana State University, significant changes were made in response to feedback from the industrial representatives. Based on survey results, instructors incorporated assignments on meeting agendas and notes as well as a group presentation into the course. Additionally, the rubrics used to grade the deliverables were revised to better reflect important industry-relevant skills. Instructors were also transparent about why assignments were given and how they were relevant to the engineering practice. Student and alumni feedback regarding course changes has been positive and a future study will study the impact of the course on alumni's early careers.

For engineering educators seeking to institute changes in courses with technical communication learning objectives, these survey results can be used to guide design of industrially relevant assignments and rubrics, as well as course materials and lectures. It is recommended that instructors also be transparent about why assignments were given, and how they are relevant to the engineering practice in order to foster student engagement. As the communication landscape continues to change, instructors should consider soliciting feedback from industry representatives relevant to their graduates.

Acknowledgements

References

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[3] M. C. Paretti, L. D. McNair, and J. A. Leydens, "Engineering Communication," in *Cambridge Handbook of Engineering Education Research*, A. Johri and B. M. Olds Eds. Cambridge: Cambridge University Press, 2014, pp. 601-632.

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[6] J. R. Brown, S. G. Wettstein, and D. J. Hacker, "Rubric development for technical reports in chemical engineering unit operations laboratory courses," in *2023 ASEE Annual Conference & Exposition*, 2023.

[7]   S. G. Wettstein, D. J. Hacker, and J. R. Brown, "Validation of a Senior-Level Chemical
        Engineering Laboratory Course Technical Report Rubric that Aligns with Industry Expectations,"
        International Journal of Engineering Education, vol. 40, no. 1, pp. 108-115, 2024.

Appendix – Industry Survey

In the following survey, we ask you to answer two general short-answer questions followed by a questionnaire containing specific items where you will rank the frequency and importance of various communication modes and skills.

In a few sentences, please give your initial responses to the following questions (no need to spend significant time, it can be whatever comes to mind first):
1) What communication skills do new engineering graduates need to improve?
2) What are the top one or two ways new engineering graduates can improve their communication skills?

Communications					
WRITTEN	How often used				
	Daily	Weekly	Monthly	Yearly	Never
Writing and Responding to E-Mail Messages	5	4	3	2	1
Letters or memos (on paper)	5	4	3	2	1
Proposals	5	4	3	2	1
Progress reports	5	4	3	2	1
Lab reports	5	4	3	2	1
Feasibility studies	5	4	3	2	1
Product evaluations	5	4	3	2	1
Technical instructions (like SOPs)	5	4	3	2	1
Meeting minutes	5	4	3	2	1
Meeting agendas	5	4	3	2	1
Short reports (less than three pages)	5	4	3	2	1
Formal reports (more than three pages)	5	4	3	2	1
Trip reports	5	4	3	2	1
Employee evaluations	5	4	3	2	1
Patent applications	5	4	3	2	1
Presentation materials	5	4	3	2	1
ORAL					
Giving Feedback	5	4	3	2	1
Communicating with the Public	5	4	3	2	1
Facilitation During a Meeting	5	4	3	2	1
Handling Customer Complaints	5	4	3	2	1
Taking Customer Orders	5	4	3	2	1
Talking to/working with vendors	5	4	3	2	1
Interview Skills	5	4	3	2	1
Video Conferencing Skills	5	4	3	2	1
Desktop Conferencing Skills (Net Meeting)	5	4	3	2	1
AUDIENCE					
Clients/customers	5	4	3	2	1
Colleagues	5	4	3	2	1

	5	4	3	2	1
Colleagues from international branches	5	4	3	2	1
Supervisors/superiors	5	4	3	2	1
Subordinates	5	4	3	2	1
Suppliers/contractors/vendors	5	4	3	2	1

Other (please specify):

Which communications (three max) do you consider to be the most important and why?

In an average week, what percent of your work time is spent on:

       Oral communication:

       Written communication:

As a practicing engineer, please rank how important the following skills are:

Communication Skills					
Importance of Skill	Very Important......... Not Important				
Communicating and understanding the purpose or objective of the communication	5	4	3	2	1
Consideration of the audience, i.e. who the communication is for; needs and knowledge of topic considered.	5	4	3	2	1
Communicating topics/information in a logical order	5	4	3	2	1
Understanding what information/content is relevant to the communication	5	4	3	2	1
Accuracy of technical content communicated	5	4	3	2	1
Precise and appropriate use of technical language/terminology	5	4	3	2	1
The ability to communicate clearly and concisely	5	4	3	2	1
The ability to be persuasive	5	4	3	2	1
Giving feedback	5	4	3	2	1
Receiving feedback	5	4	3	2	1
Oral Communication Skills					
Importance of Skill	Very Important......... Not Important				
Following instructions	5	4	3	2	1
Listening skills	5	4	3	2	1
Conversational skills	5	4	3	2	1
Conflict resolution skills	5	4	3	2	1
Facilitation during a meeting	5	4	3	2	1
Informal verbal summaries/reporting	5	4	3	2	1
Formal presentation skills	5	4	3	2	1
Slide formatting (i.e. visually appealing, use of graphics, less text)	5	4	3	2	1
Finishing a presentation or meeting on time; good time management	5	4	3	2	1
Ability to answer questions	5	4	3	2	1
Professional appearance and manner when speaking	5	4	3	2	1
Natural cadence and flow of speaking	5	4	3	2	1
English speaking skills	5	4	3	2	1
Written Communication Skills					

Grammar/Mechanics	Very Important......... Not Important				
Spelling and punctuation	5	4	3	2	1
Sentence structure	5	4	3	2	1
Grammatical correctness	5	4	3	2	1
Text flows smoothly and logically with good transitions	5	4	3	2	1
Text is concise and succinct, i.e. short and simple sentences	5	4	3	2	1
Voice (active/ passive)	5	4	3	2	1
Page Formatting, i.e. page layout-margins, spacing, font	5	4	3	2	1
Logical use of organizing structures, i.e. topic sentences, headings	5	4	3	2	1
Appropriate and meaningful use of visual elements (figures, tables, etc) to communicate technical content	5	4	3	2	1
Proper formatting of figures and tables	5	4	3	2	1
Figures/Tables referred to and described in the text	5	4	3	2	1
Text provides sufficient evidence/support for conclusions and recommendations, i.e. interpretation of data is logically argued in order to draw conclusions.	5	4	3	2	1
Citations accurate, retrievable by reader	5	4	3	2	1

Other characteristics valued (specify and rate):

Which communications skills (three max) do you consider to be the most important and why?