Establishing School-Wide Standards for Engineering Writing: A Data Driven Approach

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Background

As a result of concerns about communication at our engineering school, this study explores the written communication standards that engineering faculty and undergraduate students consider most important. Concerns about communication surfaced in several ways. For example, according to several professors in engineering, students sometimes complain of receiving inconsistent advice about their writing and of being evaluated according to professors' "idiosyncratic" standards. In addition, surveys of alumni show that although they consider communication of the "highest importance," they are not satisfied with the education they received in this area. In general, the engineering faculty at Northwestern believe that their students receive a strong writing education in their freshman year, when they take a required course in Engineering Design and Communication, but lack sufficient follow-up opportunities to improve their writing as sophomores, juniors, and seniors. In particular, several faculty participating in the VaNTH (Vanderbilt-Northwestern-Texas-and Harvard/MIT) Engineering Research Center (www.vanth.org) are concerned about how their innovative efforts to integrate communication instruction into their classes can be promulgated throughout the curriculum.

To investigate these problems and gather data to help us improve the teaching of writing throughout the curriculum, our interdisciplinary committee--faculty from engineering, writing, and the learning sciences—collaborated to:

(1) systematically gather information about the writing standards that engineering faculty want to support
(2) discuss the standards with faculty in relation to preferred teaching methods
(3) disseminate those standards through a website

Our primary research question was to determine whether engineering faculty within and across disciplines share similar standards for "good engineering writing," with a standard constituting a statement such as "Good technical writing is organized so that main points are easy to find" or "In good technical writing, technical explanations are clear and logical." If it turns out that our faculty do indeed share certain values or standards about technical writing, then these questions follow:

- What standards do engineering faculty share?
- Are standards constant across disciplines?
- Do students share the same standards?
- And if so or if not, what does that imply about our teaching of writing or their learning?

This paper describes the research design and methods of inquiry we used to investigate these questions and presents preliminary results for the first two questions. These questions assess the extent to which faculty and students perceive their disciplines to have shared standards for good writing and which standards they believe their disciplines value.

Research design

Participants

Faculty and students at our engineering school were the study population for this research project. Faculty at this school constituted a self-selected group; in Spring 2004, we invited the entire engineering teaching faculty (201 people in 9 departments) to complete a paper and pencil survey about communication standards and writing in engineering courses (see *Survey Instruments* below and Appendix A). The survey was also available electronically, and faculty were encouraged, via e-mail messages, to fill it out before mid September 2004. By then, 65 faculty had completed the Communication Standards Faculty Survey. We utilized 64 faculty responses in the analysis, excluding one that did not report departmental affiliation.

To recruit undergraduate participants, we approached faculty from a cross-section of engineering departments about surveying students in their classes. While not truly random, this process ensured representation of students from all disciplines. Ultimately, the survey was administered in five classes, resulting in a sample size of 137 students representing all departments. This constituted approximately 10 per cent of the undergraduate student engineering population. The number of participants and their departmental affiliations are represented in Table 1.

For the interviews, we selected eight faculty,[1] using a maximum variation sampling strategy.[2] Maximum variation sampling involves purposively picking a wide range of variation on the dimension(s) of interest. It helps to identify important common patterns that cut across variations. Since our research interest was to identify commonly shared standards in written engineering, we used departments as the basic criterion to identify variation. Of the eight faculty selected, five indicated that they were willing to be interviewed. They represented Biomedical Engineering, Civil and Environmental Engineering, Chemical and Biological Engineering, Computer Science, and Materials Science and Engineering. Although these five faculty participants may not represent the entire faculty or faculty in all departments, they nonetheless helped us identify important common patterns that cut across variation, in this case, the departmental differences.

Survey Instruments

A survey was developed to assess faculty and student views of writing at the university. The instrument was originally designed for faculty. Slight modifications were made so that student

Table 1. Numbers of Study Participants and their Departments at the School

Department Name	Teaching faculty by department	Faculty responses	Faculty response rate	Student responses
Biomedical Engineering (BME)	39*	12	31%	20
Chemical & Biological Engineering (ChBE)	22*	6	32%	13
Civil and Environmental Engineering (CEE)	24*	7	29%	8
Computer Science (CS)	15*	6	40%	9
Electrical and Computer Engineering (ECE)	35*	5	14%	26
Engineering Science & Applied Math (ESAM)	10*	4	40%	2
Industrial Engineering & Management Science (IEMS)	15*	11	67%	21
Materials Science & Engineering (MSE)	20*	6	30%	29
Mechanical Engineering (ME)	21*	7	33%	9

*These numbers include all teaching faculty (tenured faculty, adjuncts, post-doctoral instructors, etc.)

perceptions could be compared to those provided by faculty. For both surveys, respondents provided answers using a Likert-scale format, with "unimportant" and "very important" serving as anchors. In most cases, answers were provided on a 5 point scale. However, question 2 utilized a three point scale.

The Communication Standards Faculty Survey (Appendix A), designed iteratively by the team members, explored *faculty* views about the following:

a) the extent to which their disciplines have commonly shared standards for good writing
b) the writing abilities their disciplines value
c) the extent to which they expect their students to demonstrate these abilities, in informal and formal writing
d) the extent to which they grade student writing performance in informal and formal writing
e) whether they distribute writing guidelines to their students, and if so, what these guidelines are, and
f) the courses they typically teach along with the written exercises these courses include

The Communication Standards Student Survey (Appendix B) explored *students'* views about the same aspects of writing, with minor differences. Student participants were asked to respond to the following:

a) the extent to which their majors have commonly shared standards for good writing
b) which writing abilities their majors value
c) the extent to which their instructors expect them to display these abilities, in informal and formal writing
d) the extent to which their writing performance is graded by their instructors, in informal and formal writing
e) whether they are provided with writing guidelines from their instructors and if so, in which courses these guidelines are distributed
f) the courses they have taken in their majors and the written exercises these courses include

In developing the faculty and the student surveys, two members of the research team, who are communication experts, led the discussions to categorize the communication skills that align with commonly held standards in the field, as demonstrated in leading technical communication textbooks[3, 4]; best practices from industry, gathered from the consulting firm of Communication Partners[5]; research in technical communication[6, 7,8] and team members' mutual agreement. We settled on eight categories of skills that reflect a well-written paper, as listed in Table 2. The survey was designed to probe for faculty and student agreement or disagreement in these categories. Due to the length of the survey and the depth of data analysis, only results from the first two questions will be presented here.

Table 2. Skills Linked to Communication Standards & Best Practices in Technical Writing

Ability to:
1- write *grammatically correct* sentences
2- write sentences that are *spelled and punctuated correctly*
3- write sentences that are *clear and direct*
4- *organize* a document effectively
5- write *clear explanations of technical subjects*
6- provide *evidence or reasoning to support an argument*
7- *summarize* information
8- write *complete and accurate bibliographic information*

Interview Protocol

To supplement survey data, a semi-structured interview protocol was developed. It was intended to explore the commonly shared standards faculty value and the ways in which (also the extent to which) they convey these standards to their students. Interviews were conducted by two of the team members who worked together in developing the interview strategies. The interview protocol is presented in Appendix C. Two team members conducted the interviews. After identifying the interviewees, we visited the participants in their offices individually and informed them about the nature of the survey and any pertinent Institutional Review Board policies. Interviews lasted approximately 45 minutes and were tape-recorded and transcribed for further analysis.

Data Collection
Surveys and consent forms were approved by the Institutional Review Board prior to administration. Fifty-eight faculty members sent their responses on written forms, and eight completed the survey online. Data collected from both sources were combined for analysis. A few faculty members completed both the hardcopy and the online forms. In these instances, duplicates were deleted and hard copy versions were utilized.

Student data were collected in classes thanks to the generosity of participating faculty. For this process, one of the team members visited the class and explained the research purpose to the student participants. Students were told that their participation was completely voluntary and neither their course grades nor other credentials in their programs would be affected by either their participation or their withdrawal. All student surveys were done with pencil and paper.

Analysis

Quantitative data were analyzed using the SPSS statistical package.[8] Means were compared using an analysis of variance procedure, enabling our team to compare disciplines and faculty and student responses to selected survey items. The findings of these analyses are reported in the next section. It is important to note, however, that the number of groups and participants within groups makes statistical analysis less meaningful. Only when faculty responses are combined across departments do we have sufficient statistical power to detect differences. Therefore, in some instances, trends and patterns of data are discussed.

The interview transcripts were analyzed utilizing the constant comparative method.[9] The two team members who conducted the interviews read the transcripts several times, coded them simultaneously, and searched for categories linked to the incidents interviewees had described. The goal of interviewing faculty was to explore their understanding of the communication standards in engineering and the extent to which they communicate these standards to their students. In particular, we were looking for insights or concepts that might not have been captured by the surveys. Even though we attempted to address most of the written communication standards in the survey items, we did not presume that faculty would agree on all the standards. Hence, in the interviews we asked questions similar to the survey items, though in a more open-ended and unstructured way. Interview findings are integrated with the quantitative findings; in this discussion subjects remain anonymous.

Findings

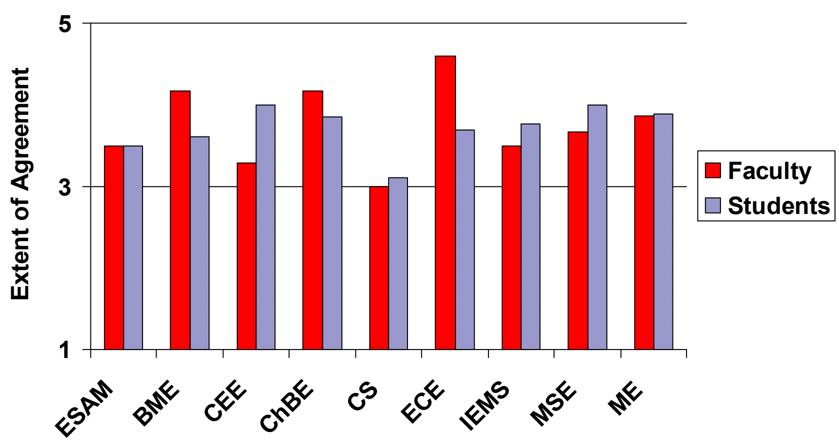
This section discusses findings from questions #1 and 2 from the faculty and student surveys—those inquiring directly about the belief that commonly shared standards exist in their discipline or major and, if so, what those standards may be. In the following paragraphs, questions appear in shortened form; the exact wording for each question can be found in Appendices A and B. Both summary survey data and interview data are included to provide a complete picture of the study findings. The interview questions can be found in Appendix C.

Question #1: "My discipline has commonly shared standards for good writing."

Results indicate that both faculty and students generally agree that there are commonly shared standards in their discipline or major. However, average responses for both groups hover slightly above the center of the 1-5 scale, indicating moderate agreement with this statement (see Figure 1). A few disciplinary differences are of note. For both students and faculty, the lowest averages are seen in Computer Science, a discipline that may not include as much written expression. However, for faculty, the strongest indication of shared standards is in Electrical and Computer Engineering, which at our school was at one time merged with Computer Science. We do not have a sufficient number of faculty responses to determine whether these differences are significant; however, the effect size demonstrating the magnitude of the differences between the department scoring the highest, ECE, and the lowest, CS, is 1.79. This indicates a very large difference in faculty opinions between departments.

Students in Electrical and Computer Engineering do not agree with this statement as strongly as faculty do. In fact, when examining similarities between faculty and students, one sees the largest differences in BME, CEE, and ECE. In contrast, students in Civil and Environmental Engineering and Materials Science and Engineering indicated the most agreement with this statement.

Figure 1: My discipline has commonly shared standards for good writing



Note: Higher averages indicate more agreement

The interview data help to elucidate these findings. As one interviewee from Chemical and Biological Engineering (ChBE) explained,

> My colleagues and I would probably agree on what is a well-written report. Whether we agree on explicit criteria or not, I don't know, but . . . basically I think there's common

understanding that we expect technical accuracy, . . . a certain brevity in reports, . . . and proper English usage and spelling and grammar.

A professor from Computer Science emphasized the organization and the structure in a paper. He said:

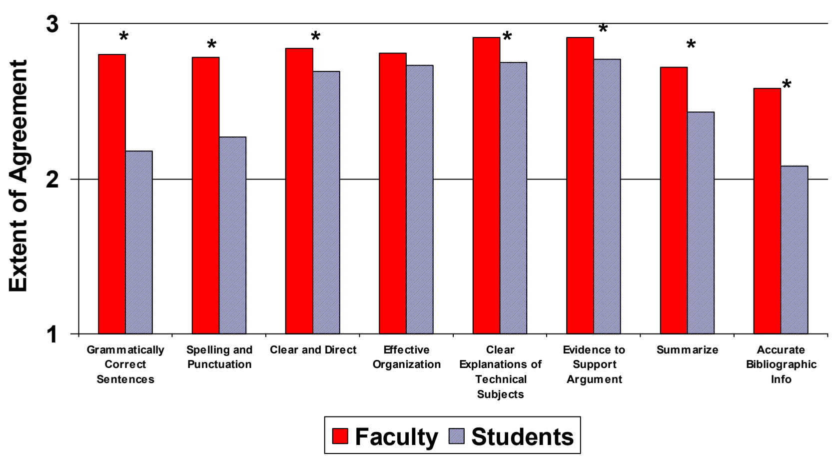
> There's actually a certain distinctive structure to the papers—it's very standard. . . there's a very well defined structure to the paper that everybody agrees on or everybody follows really. It is implicitly defined. And then there is a basic level of clarity and directness, coherent sentences and very clear communication, classical technical skills - technical writing characteristics that we just adhere to. Short sentences, direct statements, and use of active voice.

<u>Question #2: "Which standards does your discipline value? " (items 1-8, see table 2)</u>

When combining data from all departments, several significant differences between faculty and students are detected. As Figure 2 indicates, faculty rate all dimensions except "effective organization" significantly higher than students do. While this analysis may obscure disciplinary differences, it points to a gap between engineering faculty and student views on writing standards generally.

Faculty demonstrate considerable agreement about the writing standards that their disciplines value, with all departments ranking all items at 2.5 or above on a scale of 3. The greatest agreement is on the importance of writing clear explanations of technical subjects (6 out of 9 departments are in complete agreement as to its importance) and of providing evidence for arguments (4 out of 9 are in complete agreement).

Figure 2: Which standards does your discipline value?



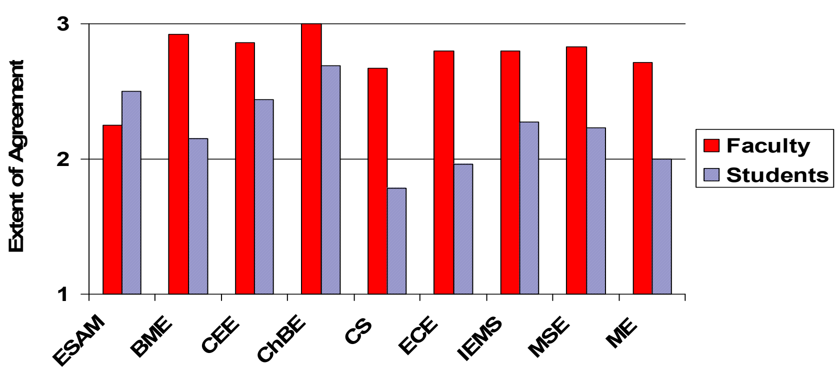
* = Significant Group Differences, p < .05

Note: Higher averages indicate more agreement

Students, however, demonstrate relatively high agreement with only some of these statements and appear to agree with faculty only in areas that involve organizational or argument based skills, such as writing clear explanations, providing evidence to support an argument, and organizing a document effectively. Student views seem to differ from faculty views in areas involving mechanical and stylistic skills, skills that many faculty may feel students should already possess before coming to college. These include the ability to write grammatically correct sentences, display correct spelling and punctuation, and provide accurate bibliographic information. These differences are also displayed in Figures 3, 4, and 5, which indicate agreement and disagreement by discipline. In general, students do not seem to feel that these skills are as valued in their majors as faculty feel they are valued in their disciplines.

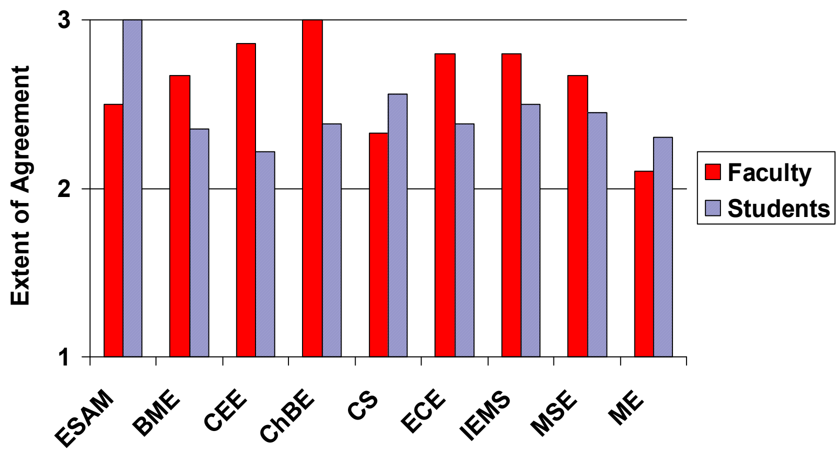
Once again, a few disciplinary differences are of note. As seen in question 1, faculty from Computer Science did not place much value on skills like grammar and spelling whereas faculty from Chemical and Biological Engineering consistently rated these skills as important. Large gaps between student and faculty perceptions appear across the board, with students typically rating stylistic skills as less important. This is not uniformly the case, however. Students in three departments (ESAM, CS, & ME) actually rated the skill of summarizing information to be more important than faculty.

Figure 3: Does your discipline value writing grammatically correct sentences?



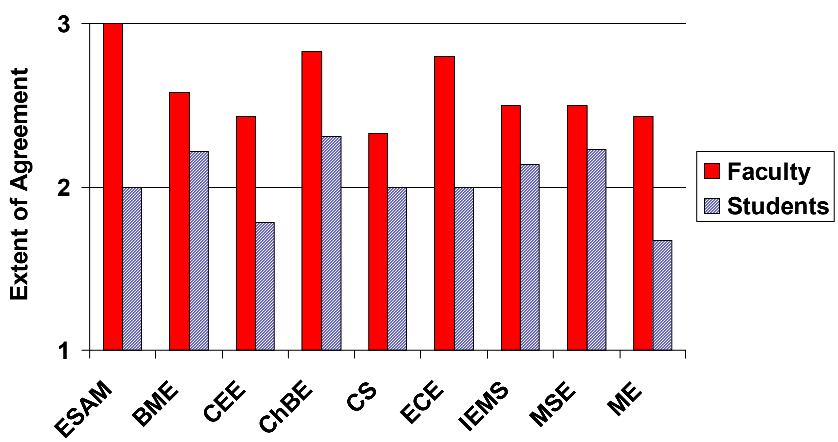
Note: Higher averages indicate more agreement

Figure 4: Does your discipline value the ability to summarize information?



Note: Higher averages indicate more agreement

Figure 5: Does your discipline value writing accurate bibliographic information?



Note: Higher averages indicate more agreement

Data from interviews provide additional evidence about faculty valuing content-related skills such as organization and argument over stylistic skills. The Chemical and Biological Engineering professor quoted previously pointed out the importance of technically correct statements:

> It's got to be clear, I have to be able to . . . understand . . . the objective . . .of the author. I think for professional level work it's more important . . . that it is technically correct. The style is of secondary importance I would say, but not unimportant in terms of reviewing the paper, for example, for a journal or something of that sort.

A faculty member from Biomedical Engineering (BME) advocated the importance of providing evidence to support an argument, particularly in academia. This faculty member explained that in order to convince the reader, students should know how to back up their argument with observation based statements:

> "…the ability to present one's point is, I think, first and foremost; if you're trying to convince someone to do something, then you really need to understand what it means to give supporting evidence.

In addition this professor added that, to convince the reader, the author (students in our cases) should provide diverse arguments.

A Computer Science professor referred to a "basic level of clarity and directness" that is expected, along with "coherent sentences and very clear communication." He also mentioned "proper English usage with correct spelling and grammar" plus "proper punctuation."

Among all, the least agreement among faculty is found in relation to the importance of providing accurate bibliographical information. Only three departments (ESAM, ChBE, and ECE) are at or near 3 (ESAM gives this area a 3, but the number of faculty is only 4); faculty in all departments assign a 2 or above to bibliography.

In contrast, students in all departments rate the importance of bibliographic information much lower than faculty do (Figure 3), with students in both CEE and CBE rating it significantly lower than faculty, and with students in ME and ECE showing a marginally significant differences when compared to faculty. A faculty member from CEE said she would appreciate a website that would show students how to cite the literature, write a bibliography, and avoid plagiarism.

Discussion

The high response rate for the survey by faculty suggests that faculty take this issue of writing in the engineering curriculum seriously. Anecdotally, support for this effort among faculty and administrators has been strong.

Faculty results from question #1, asking about commonly shared standards for good writing, demonstrate some agreement with this notion. On the one hand, this agreement suggests that faculty opinions about effective writing are commonplace rather than idiosyncratic. On the other hand, since the agreement is not strong, students may be justified in feeling that the standards stressed in one class or major may differ significantly from what they encounter in another.

Results from question #2 show that both faculty and students perceive the importance of "higher level" writing skills such as organization, writing sentences that are clear and direct, clear explanation, and providing evidence to support an argument. Evidence for this comes from a comparison of ratings within participant group. Of note is the uniformly high agreement from faculty on all dimensions except summarizing information and providing accurate bibliographic information. Particularly striking is the large difference between faculty and student averages for what are commonly considered basic skills such as writing grammatically correct sentences and proper spelling and punctuation.

Agreement among faculty about the importance of such areas as grammar, spelling, and bibliographic accuracy suggests that faculty have a strong sense of what is considered basic to professional writing. Apparently, their mental model of "good writing," most likely derived from their experience with publishing, includes the basics that would be required by any professional journal. However, students do not share these views, consistently indicating that these basic skills are not "valued" in their majors

What accounts for this discrepancy? Perhaps faculty minimize the importance of these basic areas in their teaching and grading of student work. Interviewees' comments demonstrate a reluctance to spend time on mechanical and stylistic matters such as spelling and grammar. The professor from CEE explained that it's "not my job" to teach spelling and punctuation, but also admitted that some students need help with these things. She, like the professor from BME, believes that students should have learned these basics about writing by the time they enter upper level courses. The professor from MSE explained that she "doesn't address" issues of good writing and sentence construction. She is more interested in whether students are discussing the data accurately or encountering uncertainty in the labs. This attitude—that writing instruction is important but peripheral to an engineering course—may explain why students rate these mechanical and stylistic areas lower and why they value as more important those aspects of writing that overlap with content.

High faculty agreement about the importance of clear explanations of technical subjects and evidence to support arguments further underlines how notions of form versus content in writing may play out in engineering writing pedagogy. When grading, faculty may prioritize writing areas they perceive primarily as content, or they may be unable to differentiate between a student's problems with content mastery and communication ability. It would be interesting to learn whether students who lose points in these areas—explaining technical material or writing persuasive arguments—realize that they are being graded on communication failures as well as content problems. More analysis needs to be done on the difference between what faculty say they value and how they grade.

In general, students seem to understand which writing standards will most affect their grades in engineering writing assignments. In the few areas that students rate as more important than faculty, such as the importance of writing clear and direct sentences, their evaluation may be based on faculty feedback. Perhaps faculty write phrases like "What do you mean?" or "not clear," or "logic" in the margin of students' papers; or perhaps they put a question mark in the margin next to confusing passages. This may be the reason why students focus on writing clear and direct sentences as opposed to other competencies that are expected from them.
In any case, since students do not need to publish and are often not held accountable for mechanics and style when they are not taking writing classes, they may lack the mental model of professionalism that fosters a respect for correct, conventional writing by their faculty.

Differences between faculty and students' perceptions of the importance of some skills by department suggest that students in some departments are not getting a clear message about what faculty value. Aside from comments and grades that students receive on written work, there may be few opportunities for faculty to convey their expectations of students.

Conclusion

Agreement is sufficient among engineering faculty on aspects of writing that they consider valued by their discipline and important in student writing to say that they share many ideas about what constitutes effective, professional writing. However, there appears to be a gap between what faculty value and what students feel is valued by faculty in their major. Based on these data, a useful step is to encourage better integration of writing instruction into engineering coursework. A website articulating best practices and shared standards of effective technical writing seems justified and a good starting point for improvement. A draft version of our standards for such a website appears in Appendix D.

However, a website alone is unlikely to address the most important issues raised by the preliminary data in this study. Engineering faculty will have to grapple with the problem of how to communicate their values about writing to the students in their departments and how to help them develop the sense of professionalism and pride that faculty associate with effective writing. How to attack these issues is probably best done by department, with input from learning scientists and specialists in communication. Is it possible to send the right messages to students about the importance of writing without significantly altering the focus of an engineering course or interfering with an engineering faculty members' priorities? That is the question we intend to pose to our faculty as we develop the writing standards website and related resources.

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Biographies

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Appendices

Appendix A
<u>Communication Standards Faculty Survey, Questions 1 and 2</u>

Directions: Please read the items carefully and indicate your responses as appropriate: by circling one of the indicators (1 to 5), checking the boxes, or filling in the blanks.

Name : ______________________________
Department : ______________________________

1. My **discipline** (field) has commonly shared standards for "good writing."

1	2	3	4	5	☐
strongly disagree				strongly agree	I don't know

2. Please indicate below which standards (writing ability) your **discipline** values. Put a check mark in one of the boxes next to each ability (i to viii) to show its level of importance for your discipline.

Ability to:	Unimportant	Fairly important	Very important
i- write grammatically correct sentences	☐	☐	☐
ii- write sentences that are spelled and punctuated correctly	☐	☐	☐
iii-write sentences that are clear and direct	☐	☐	☐
iv- organize a document effectively	☐	☐	☐
v- write clear explanations of technical subjects	☐	☐	☐
vi- provide evidence or reasoning to support an argument	☐	☐	☐
vii- summarize information	☐	☐	☐
viii- write complete and accurate bibliographic information	☐	☐	☐

Appendix B
Communication Standards Student Survey, Questions 1 and 2

Directions: Please read the items carefully and indicate your responses as appropriate: by circling one of the indicators (1 to 5), checking the boxes, or filling in the blanks.

Department : ______________________________

1. My **major** has commonly shared standards for "good writing."

1	2	3	4	5	☐
strongly disagree				strongly agree	I don't know

2. Please indicate below which standards (writing ability) your **major** values. Put a check mark in one of the boxes next to each ability (i to viii) to show its level of importance for your major.

Ability major values	Unimportant	Fairly important	Very important
i- write grammatically correct sentences	☐	☐	☐
ii- write sentences that are spelled and punctuated correctly	☐	☐	☐
iii-write sentences that are clear and direct	☐	☐	☐
iv- organize a document effectively	☐	☐	☐
v- write clear explanations of technical subjects	☐	☐	☐
vi- provide evidence or reasoning to support an argument	☐	☐	☐
vii- summarize information	☐	☐	☐
viii- write complete and accurate bibliographic information	☐	☐	☐

Appendix C

Written Communication Standards, Semi-structured Faculty Interview Protocol

Main research question: What are the communication skills (standards) that engineering faculty at McCormick expect undergraduate students to achieve in their courses.

The 12 questions listed below will direct the interview conversations. They are written alternatively; some of them may or may not be posed according to the conversation between the interviewer and the interviewee. This protocol is semi-structured; interviewer may pose emerging questions (not listed below) as appropriate according to the interview conversation. Each interview is anticipated to last not more than 40 minutes. It is recommended for the interviewer to skip the remaining questions in each part if the designated time limit is exceeded.

Part I- Introduction questions to warm up the conversation. (Limited to 5 minutes)

1 - What are the courses you typically teach in undergraduate level? (Alternative: Which ones include writing?)
2 - How many undergraduate students do you teach in one semester/ in one course? (Alternative: What year are the students?)
3 - Who reads and grades the written papers and exams in those courses?

Part II- Exploring the written communication standards in engineering. (Limited to 10 minutes)

4 - What are the commonly shared written communication skills and knowledge in your field of study? In other words, do your colleagues, people in your discipline, agree upon some particular characteristics of a well written academic paper?
(If interviewee doesn't speak about the standards or does not provide appropriate response or detailed explanations, the followings can be posed as appropriate)

- What is important in writing an academic paper in your discipline?
- What are the basic elements of a well written paper, and why?
- When you review a research paper, what do you consider the most important that the paper should include?

Part III- Exploring faculty expectations of their students to achieve through their undergraduate education. (Limited to 15 minutes)

5 - What are your expectations for your students' papers in written communication?
6 - How are those similar to or different than your expectations for an academic paper?
7 - Do you assess your students' ability to communicate effectively? And if so how? (alternative: When you grade your students' written work, which written communication standards do you consider the most important and which ones the least important?)
8 – (*This item is subject to change and will be revised based upon the interviewee's response pattern in the faculty survey. For instance if the interviewee has a highly positive response for the importance of writing clear explanation of technical subject in formal assessment, then the question will be-)* You are one of the advocates of the importance of "writing clear explanations of technical subject" in formal assessment. How do you convey that importance in your instruction?
9 - Do you provide instruction, guidelines, or a template to your students regarding your expectations of written communication standards? If so, what do you ask/tell your students to do?
10 - Are there impediments to integrating communication instruction in your classes? (e.g. lack of time, confidence in teaching, excessive student population, etc.)

Part IV- Backing up the findings from Part III. (Limited to 5 minutes)

(After the participant speaks about her expectations from her students to achieve in written communication, in order to "back up" the findings, the following question can be asked.)
11 - What are the written communication skills and knowledge you consider too advance for your undergraduate students? Why?
Note: In case the interviewee may feel uncomfortable of talking the "advanced" skills she doesn't expect her students to achieve, inform her that you are asking those "unexpected advanced" skills in order to clarify the "expected" skills, not to identify what is not taught.

Part V- Ending the interview. (unlimited)

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12 - My questions are up to here; do you have anything else you would like to add about the written communication standards in your field or your students' communication skills and knowledge you expect them to achieve? Or anything related I forget to ask, but you would like to talk about?
Interviewer will thank participant for her time and interest in participating the study. The recording will be stopped and the interview will end.
Based on the interviewee's response to the last item of the faculty survey, interviewer will ask her if she is willing to provide copies of the instructional materials she uses in her class to integrate communication. If she does, request to pick them up.

Appendix D
Standards for Technical Writing (v1)
The Robert R. McCormick School of Engineering and Applied Science
2004

Faculty at the McCormick School of Engineering and Applied Science expect all student writing to reflect a high level of professionalism and the standards for excellence that are generally followed in engineering journals and professional business documents. The following list of standards summarizes widely accepted views, best practices, and requirements from leading technical journals, technical communication textbooks, and feedback from Northwestern's engineering and writing faculty. They have been compiled here with the help of funding from a Walter P. Murphy grant for undergraduate education (2004-2005). Each standard is followed by guidelines or advice to clarify its meaning.

For examples and further explanation of the guidelines listed below, consult with Northwestern's Writing Place, www.writing.northwestern.edu. Remember: The guidelines provide general advice only; students need to adapt them to the requirements of a specific department, class, assignment, or journal.

Purpose, genre and audience

***Standard*: Excellent technical writing has a clear purpose that is well suited to its genre and audience.**

Guidelines:
- Choose a genre—e.g. laboratory report, literature review, abstract, proposal, case study evaluation, electronic memo—that matches your purpose and will fulfill your intended audience's expectations.
- State principle objective of the document early—in an introduction or purpose section
- Match level of technical discussion and formality to intended purpose and audience.
  - For audience, consider education, professional experience, reading level, and motivations.
  - Use clear and simple diction to make writing accessible to readers for whom English is not their first language.
- Match content, style, and layout (length) of writing to communication technology, e.g. print, e-mail, web-site, slide.

Organization

***Standard:* Excellent technical writing organizes information so that main points are easy to find and ideas are easy to follow.**

Guidelines:
- Use appropriate "front matter"—e.g., table of contents, abstract, executive summary—to preview a long document.
- In the introduction, in addition to stating the document's purpose, indicate how the document is organized.
- Use headings and other formatting conventions to signal major sections, such as Background, Methods, Findings or Results, Discussion, etc.
  - Divide large sections into sub-sections with second- and third-level headings.
  - Use typography that accurately reflects heading hierarchy* (e.g. 14-point font might be used for major headings and 12-point for sub-headings, or boldface might be used for major headings and italics for sub-headings).
  - Ensure that all information in a section logically belongs under that heading; for example, distinguish between findings, which belong in a Results section of a report, and interpretation of the findings, which belong in the Discussion section.
- Structure paragraphs to highlight one main idea, introduced by a clear topic sentence.
- Use transitional words and paragraphs to show how ideas are related:
  - From one idea to the next within a paragraph
  - From one paragraph to another within a section

    - From one section to another within a long document
- Number all pages, sections, slides, etc.
- Put additional information such as raw data or interview scripts in appendices; number appendices sequentially and refer to each in the body of the document.

Logic and reasoning

Standard: **Excellent technical writing (1) describes technical information clearly and logically and (2) makes strong, persuasive arguments.**

Guidelines:

- Summarize information succinctly and accurately.
- Synthesize research and key ideas; that is, integrate ideas from different sources to make a new point or argument.
- Describe complicated ideas by breaking them into parts and discussing them in a logical order (chronology, cause-effect, spatial organization, most important to least important, sequence—first, second, third, etc.)
- Back up all assertions with evidence, reasoning, and/or authority.
- Cite only credible sources and authorities; carefully evaluate all sources of information and data.
- Avoid over simplification, omission, or distortion of ideas and data.
- Consider readers' cultural backgrounds (ethnicity, nationality, religion, gender, occupation, age, etc.) when planning persuasive arguments.

Sentence structure and style

Standard: **Excellent technical writing is clear, concise, unambiguous, and direct**.

Guidelines:

- Eliminate redundant words and phrases.
- Choose carefully between active and passive voice.
    - Use active voice to avoid wordiness and ambiguity and to emphasize the agent of an action.
    - Use passive voice to emphasize the receiver of action or to promote coherence (i.e. "flow").
- Structure sentences for easier reading: put verbs and familiar information at the beginnings of sentences, lists and new information at the ends.
- Choose words carefully
    - Use technical terms precisely and accurately.
    - Avoid loaded language and bias.
    - Use plain, direct language that communicates clearly across cultures and countries.
    - Use jargon and acronyms only with audiences who will be familiar with them. Explain (define) all acronyms.
- For team writing: ensure consistency of style (voice, point of view, level of formality, etc.)

Tables, charts, graphs, and figures

Standard: **Excellent technical writing communicates visually as well as verbally.**

Guidelines:

- Use figures, charts, and graphs to help readers visualize information and therefore better and more quickly understand.
- Use tables to present numeric data in an accessible and space-efficient format.
- Use photographs, drawings, and maps to provide accurate visual depictions of objects, processes, and locations.

- Follow best practices in slide design: logical order and agenda slide, minimal text, large enough font, key idea in headline or take-away box.
- Follow best practices for graphs and charts: labels on axes, avoidance of 3D and legends, selective use of detail, appropriate scale.
    - Use the right kind of chart to communicate information—e.g. pie chart to show parts of a whole, bar graphs or 100% column charts for comparisons, flow chart to show process, etc.
- Number all figures and tables sequentially.
- Use a specific, accurate title for each figure and table that ties it closely to your text.

Equations and numbers

***Standard:* Excellent technical writing uses equations and numbers to communicate ideas.**

Guidelines:

- Use widely known and accepted formulas for calculations.
- Include all major calculations, if not in the body of the report, then in the appendix.
- Use equation editors to present mathematical formulas in the text.
- Provide units with a unit convention (i.e. SI units, Imperial units) for each quantity. NB: The international system of units (SI units) is most commonly used in engineering journals.
- Use scientific notations when expressing very large or small values (e.g. instead of 1,000,000, use $1x10^6$)
- Account for unavoidable uncertainty in measurement through the use of significant figures.
- Consider physical meanings of quantities when reporting (e.g. a human being cannot weigh 1000 kg).

Grammar and punctuation

Standard: Excellent technical communication adheres to conventional rules of grammar and punctuation.

Guidelines:

- Write grammatically correct, complete sentences.
    - Avoid using commas to connect complete sentences.
    - Make lists grammatically and logically parallel.
    - Make sure that all pronouns refer to clear antecedents.
- Follow conventional spelling and punctuation rules; proofread for correctness.
- Avoid overly formal language or grammatical constructions.

Bibliography and references

***Standard:* Excellent technical communication cites all sources clearly and completely.**

Guidelines:

- Provide complete, accurate bibliographic information for print sources, online sources, personal interviews, site visits, etc.
- Use the bibliographic style expected by your audience and discipline. For example, many engineering journals require formatting of references be done using AMA (American Medical Association) style, but others use the styles recommended by the ASCE (American Society of Civil Engineers), the ACS (American Chemical Society), etc.
- Include citation indicators within the text (i.e. numbers or author name and year), and link them to the references page (use a consistent format; order the references either with numbers or first authors' last names).