A Message from Recent Engineering Graduates in the Workplace: Results of a Survey on Technical Communication Skills

PNEENA SAGEEV
Center for Technical Communication
State University of New York at Buffalo

CAROL J. ROMANOWSKI
Department of Industrial Engineering
State University at Buffalo

ABSTRACT

Survey results reveal the impact of engineers' communication skills in adjusting to jobs and achieving career goals. A direct correlation emerges between the amount of technical communication (TC) instruction and career advancement. Former students then spell out recommendations for providing relevant TC instruction within the engineering curriculum.

I. THE CHALLENGE

Results of a May 1999 survey again confirmed the crucial role communication plays in today's engineering workplace.

However, although today's fast-paced, competitive workplace requires engineers to convey technical information quickly to diverse audiences, the overwhelming evidence shows that graduating engineers are inadequately equipped to meet this need. Numerous industry surveys, managers' comments, and academic studies confirm this assessment.[1–3] In fact, the Society for Manufacturing Engineers names "lack of communication skills" among the top "competency gaps" in engineers' education.[4] Also recognizing this need, ABET now requires engineering programs to demonstrate their students' competency in writing and verbally presenting technical reports.

Engineering professors, too, often complain about students' poor writing and presentation abilities. Even students entering our major courses at the State University of New York at Buffalo (UB) realize this deficiency.[5] Surveys conducted for 22 semesters revealed that, on a scale from 0 to 5, students on average rate their writing abilities at a low 2.7, and their oral presentation skills even lower at 2.4.[6]

Now, results of a May 1999 survey of recent graduates add important new evidence: former UB undergraduate and graduate engineering students, who have been working for three to five years, offer valuable information and insights that engineering educators can integrate into their curricula.

II. BACKGROUND: OUR ANSWER—AND CURRENT STATUS

To address this nationwide education problem at UB's School of Engineering and Applied Sciences (SEAS), in 1987 we initiated a technical communication (TC) program that focuses mainly on juniors and seniors. Our instruction combines several job-related features. It is based on information models, quality-control writing strategies, language guidelines, efficient teaching methods, and constructive feedback procedures—originated and proven in the workplace.[7] Further, all our courses address the main communication problems that engineers, scientists, and students consistently identify in numerous questionnaires and classes. Finally, almost from its inception, the program has benefited from the enthusiastic and dedicated support of an industrial advisory committee whose members also successfully mentor our students one-on-one.[8] Today, TC instruction reaches about 65 percent of our upper-level undergraduate students via both "stand-alone" 3-credit technical electives and short modules integrated into design project, internship, laboratory, and other engineering courses. The electives are also available for graduate students. In addition, a 2-credit TC requirement is integrated into a Master of Engineering final project.

However, after 12 years of instruction, our faculty in the recently named Center for Technical Communication (CTC) recognized the need to expand and enhance the program. Our goals were to encompass all students, including freshmen and sophomores, and to offer more opportunities for practicing TC skills.

Before embarking on new steps to expand our program, we needed to objectively:

- Assess the effectiveness of our current courses
- Identify areas and methods for optimally expanding and improving the TC program.

Because the problem exists nationwide, we believed our conclusions and recommendations would apply to many engineering schools.

To implement this assessment, several discussions with faculty members and our industrial advisory committee helped define the concepts for future program directions.[9] We also decided to survey our graduates to see how the current courses had impacted their workplace experiences and to solicit their suggestions for enhancing the program.

A. Program Basics Underlying the Survey

To better understand the survey instrument (appended to this article), method, and results, readers will need additional information about our program. The 3-credit electives, semester-long intensive courses, address three main topics. 1. "*Technical Communications For*

Engineers" covers the main types of documents and presentations engineers produce at their jobs. This flagship course focuses particularly on writing and orally presenting a proposal on a topic students select. 2. "*Procedure Writing In Industry*" covers writing quality control (QC) documentation (required for ISO-9000/9001 certification and other QC requirements). 3. "*Empower Your Technical Language*" emphasizes tools to further enhance students' editorial evaluation skills. In all these courses, the instruction and feedback are interactive and intensive, expanding students' discussion and listening skills.

Unlike the 3-credit electives, which address general communication skills, the short, 5-hour modules are tailored to focus on the particular communication assignments in a specific engineering course (e.g., a senior design project report and presentation; a lab report; an internship progress or final report; or a course-required presentation). Though the instruction and feedback are less intensive than in the elective courses, students are strongly motivated to improve their skills: TC merit accounts for 10 to 50 percent of their assignment grade—depending on the agreement reached between engineering professors and TC faculty.

The 2-credit graduate course, a requirement for the master of engineering program in the industrial engineering department, focuses on management perspectives and methods of preparing and producing many types of work-related documents and oral presentations. The following table compares these three types of courses.

B. Conducting and Analyzing the Survey

We targeted 1500 engineers who received undergraduate and/or graduate degrees from the School of Engineering and Applied Sciences between 1994 and 1996. After working for three to five years, they were able to provide both industry and engineering education perspectives. Also, they represented a broad range of job responsibilities in the private and public sectors, and of engineering disciplines—such as mechanical, industrial, chemical, computer, and electrical engineering.

To maximize response, we limited the survey to one page and also provided a link on our website for electronic responses. We then mailed the surveys with an accompanying cover letter and instructions for returning the questionnaire. The survey posed three key questions:

1. Percent of working time spent on writing, oral presentations, other oral discussions (e.g., meetings), and "teaming"
2. Specific TC instruction received at UB's school of engineering (e.g., electives, integrated modules)
3. Impact of TC instruction on their careers: did it help them get their job? Adjust to their work? Advance their career? Increase their salary? Give them recognition in their group? Increase their confidence?

Each question incorporated space for graduates to comment. At the end of the survey, we asked them for suggestions to enhance the current TC program and make it more effective in developing the TC skills today's engineers need.

Using responses to the type of TC instruction received, we developed an index that corresponds to the number of hours of technical communication instruction the respondents received at UB. Students taking a mini-course module in a lab, senior design, or internship course receive 5 hours of instruction. The required graduate course, *Managing Engineers' Communications*, compresses 35 hours of technical communication material into 28 hours of instruction. Students in the 3-credit technical communication electives, such as *Technical Communications For Engineers*, receive 42 hours of instruction. Therefore, we assigned 5 points to mini-modules, 35 points to the graduate course, and 42 points to the 3-credit TC electives. Each respondent's index is the sum of all TC instruction received at UB. For example, a respondent who reported taking a TC lab course module and *Managing Engineers Communications* was assigned an index of 40.

In analyzing the correlation between the index and the responses, we excluded any respondent with an index of 0 because we could not separate those respondents who had no technical instruction at UB from those who simply declined to answer that portion of the survey. The index ranged from 0 to 94 points, so we grouped the index levels into four categories:

1. An index of 5 points (the equivalent of one mini-module)

Course Type	Focus	Instruction Hours	Feedback Amount	Feedback Type	Comment
Elective	Proposals, memos, cover letters, reports, biosketches; Procedure manuals; Editorial emphasis	42	14 sessions	Both written comments and recitation	Includes producing and evaluating written and oral presentations and one-on-one mentoring
Modules	Design, lab, and internship reports	2-5	2-5 opportunities	Written comments; individual discussions	Integrated into engineering courses
Required	Managing engineers' communications	28	14 sessions	Written comments and recitation	Graduate course

Table 1. Technical communication course offerings and features.

Index	Number of Respondents
0 points	35
5 points	35
10-15 points	58
35-47 points	51
>52 points	14
Total Respondents	**193**

Table 2. Number of respondents in each index level.

2. 10-15 points (two or three mini-modules)
3. 35-47 points (at least one 2- or 3-credit course and possibly one or two mini-modules)
4. Over 52 points (more than one 3-credit course or a combination of courses and modules).

Thus, the more instruction a respondent received, the higher the index level. Table 2 shows the number of respondents in each index category.

To categorize the job functions, we asked the respondents to give their job titles and a brief description of their job functions. Based on their answers, we formed four major job categories:

Design and development: 56 respondents indicated their work involved system or software design, product development, or research and development functions.

Engineering: the 52 respondents in this category either identified their function as "engineer," or performed functions typical for engineers in their particular discipline (e.g., an industrial engineer working in production planning).

Management: 51 respondents stated they perform management functions such as project management or supervisory work.

Other: 30 respondents said their jobs involve significant interaction with customers and non-technical personnel, such as sales representatives, educators (high school and college), engineers responsible for implementing quality and safety programs, and technical writers.

Note that not all respondents gave job titles or functions.

C. Classifying Respondents' Comments

This short survey generated an astonishing outpouring of comments that covered 14 single-spaced pages. Clearly, the respondents felt strongly enough to write "volumes" about this technical communication issue. Though (or perhaps because?) they graduated just three to five years before the 1999 survey, they remained deeply concerned about improving engineering education.

We classified these 146 comments by "main theme" into four categories:

1. The importance of technical communication (31 comments)
2. The need for mandatory technical communication instruction (23 comments)
3. Improvement suggestions for the technical communication curriculum (64 comments)
4. Other comments about their engineering education at UB (28 comments).

In analyzing the survey results, we looked for correlations among job categories, index values, and the percent of time spent on written and oral communications. Interestingly, we found no distinct differences in responses among the various engineering disciplines.

In the results section, we quote respondents' typical, relevant comments.

III. Results

I feel that technical communication skills are a must for any engineer.

We received 208 responses, about 14 percent of the mailed surveys—considered a high return rate. Of these, 15 respondents sent in comments but did not complete the rest of the survey. The averages and comment trends after analyzing the first 110 responses remained unchanged, demonstrating the strong validity of the quantitative and qualitative results. Although the first question limited the high-end of the communication time choices to ">50 percent," more than ten respondents wrote in numbers ranging up to 80 percent. A copy of the survey instrument appears at the end of this article.

1) Time and communication on the job:

An engineer is only as good as his ability to communicate his ideas.

An astonishing 64 percent of these engineers' overall work time is spent on some form of communication (see Table 3). This result has far-reaching implications for employers and engineering schools:

Employers need to know that 64 percent of the salaries they expend on newly graduated engineers pays for their communication skills, not their engineering competencies. Clearly, technical ideas and results are not useful until and unless they are communicated and discussed. Therefore, employers are justified in demanding graduates thoroughly trained in communicating technical information.

Engineering schools need to prepare all their students for the real-world communication demands their graduates will face. Just providing an outstanding technical education is no longer sufficient, as many respondents observed. One respondent commented: "Technical communication is a very important aspect of our engineering life, and takes up almost 50% of our time at work." Another remarked, "Communication is absolutely crucial in large organizations, any technical sales-oriented positions, and for anyone with management aspirations."

2) Time spent on written communications: In general, engineers in all job categories spend 11-20% of their time on written communications; some design and development engineers reported spending more than half their work time on these activities. Figure 1 shows that respondents with a higher index tend to spend a higher percentage of their time on written communications, compared to those with a lower index value, perhaps reflecting more demanding assignments and responsibilities that require their superior skills.

Element	Average % time
Writing	32
Oral presentations	10
Other oral discussions	22
Total	64
Average time working in teams:	32%

Table 3. Average percent of work time spent communicating.

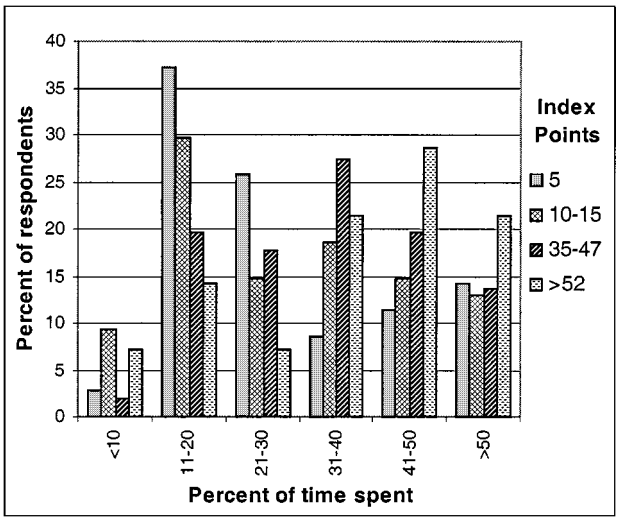

Figure 1. Time spent on written communication compared to index level (amount of TC instruction received).

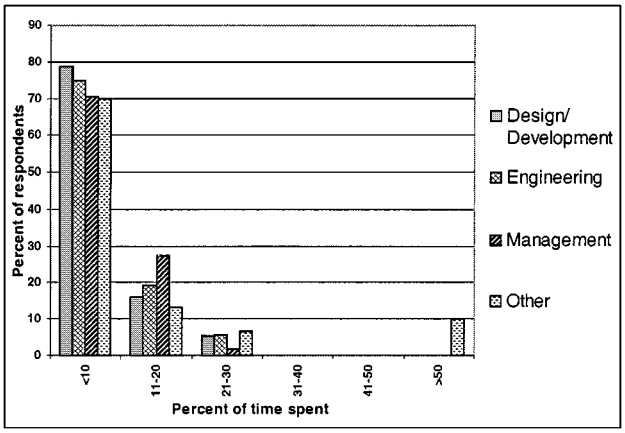

Figure 3. Relationship between the job category and the percent time spent on formal oral communication.

3) Time spent on formal oral communications: Figures 2 and 3 show that the overwhelming majority of respondents in all job categories and all index levels report spending less than 10% of their time on formal oral communications. However, despite the small amount of time spent on this activity, many respondents commented on the importance of including presentations in the technical communication curriculum. As one engineer pointed out, "Although formal oral presentations constitute a small percentage of time, a strong presentation can 'sell' conceptual products to upper management." Another respondent stressed, "A bad presenter is career-limited."

4) Time spent on other oral communications: Most respondents, regardless of index or job category, spent less than 30% of their time on informal oral communications. However, the importance of this type of communication skill should not be underestimated: this inadequacy could hamper an engineer's technical recognition, confidence, and promotion. One respondent noted, "As a young engineer, I find myself involved in projects with senior engineers, who do an excellent job in conveying ideas and concepts. I find that there is some difficulty on my part in conveying my ideas, therefore I tend to remain quiet in meetings. This, I believe, hinders me from proving to the senior guys that I understand the scope of the projects that I am involved in."

5) Time spent working in teams: Although the average is 32%, many engineers reported spending 50% or more of their time working in teams, a finding that implies a need for clear, effective communication in most job environments. Note that low-index respondents are most likely to spend less than 10% of their time in teams (see Figure 4, below). Because oral skills are important in teamwork, the previous quote by a young engineer who felt inadequate in team meetings may well apply to this group of low-index respondents.

B. The Impact of the Amount of Technical Communication Instruction

> I never took instruction in tech writing, but I wish I had. It is vital to me in my job.

Two interesting points appear in Figure 5. First, the percentage of managers with index levels of 5 points is markedly lower

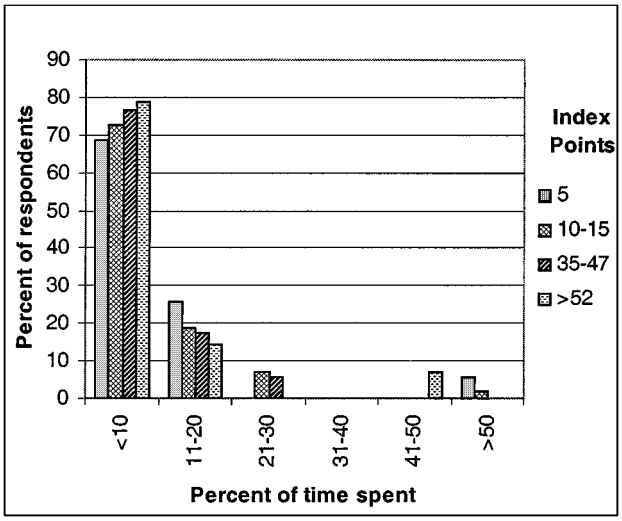

Figure 2. How index level (amount of TC instruction received) relates to percent time spent on formal oral communication.

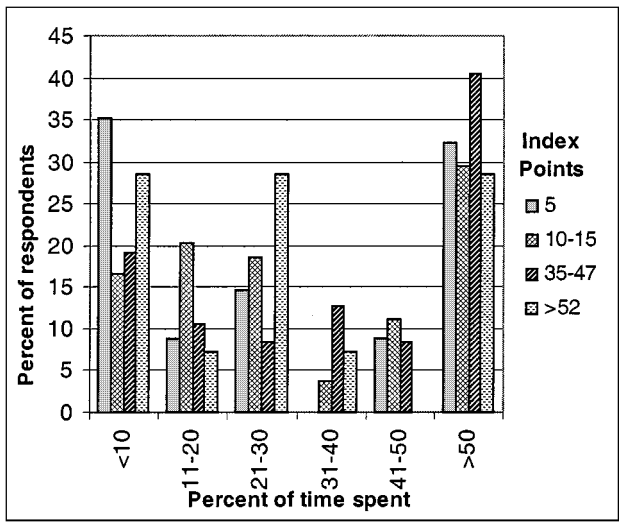

Figure 4. How percent time spent working in teams correlates with the index.

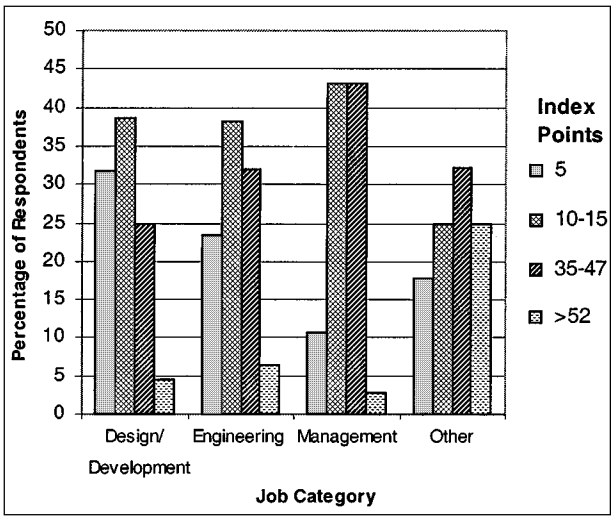

Figure 5. How job category relates to the index.

than those in design or engineering. Most managers had index levels between 10 and 47 points. Second, respondents in the "other" category—(e.g., customer "interactors," quality and safety engineers, technical writers) were more likely than those in the remaining three job categories to have an index greater than 52 points. These findings support the idea that advancement to engineering management or positions requiring highly developed interpersonal skills demand excellent communication abilities. As voiced by one respondent: "Communications make the difference between success and failure." Or, as another graduate succinctly wrote: "Technical skills are a given; communication skills differentiate."

1) Impact of the amount of TC instruction on careers: The amount of instruction respondents received correlates directly with the career benefits they gained. This strong relationship appears graphically in Figure 6. The compelling story told by this graph is best expressed in a quote from one of the respondents:

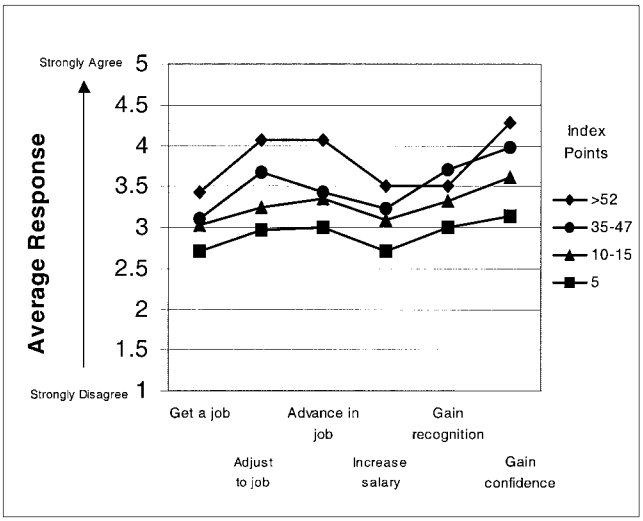

Figure 6. Question posed—How did technical communication instruction affect your engineering career? The correlation between the average response and the index.

> When I was in school, I think that my classmates thought that good grades were all they needed to excel. Communication skills were not a concern for them. At that time, I put a strong emphasis on communications skills for myself. I concentrated my efforts on the ability to communicate complex engineering concepts to laypersons. I still keep in touch with several of my classmates and I am convinced that my efforts in this regard have allowed me to excel far beyond them (as far as vertical company movement/ pay scale are concerned).

Importantly, a MANOVA (multivariate analysis of variance) of this dataset showed that the differences among the average response values were significant at the 95% level.

IV. Respondents' Comments

> There are a lot of very good technical minds in the workplace, but very few that communicate effectively.

A direct relationship exists between the respondents' index value and their typical comments. Of the respondents with a low index—those who received between 5 and 15 hours of instruction—20% recommended that TC instruction be mandatory. Surprisingly, the highest index group (>52 points) made no such comments, nor did they remark on the importance of technical instruction—perhaps because they were already reaping the benefits of their decisions to attend a demanding elective course in technical communication. Thirteen percent of the low index group and 17% of those receiving 35-to-47 hours of instruction commented on the importance of technical communication in their jobs. All groups offered many suggestions—even blueprints—to improve or expand the TC program.

Respondents with index values between 5 and 15 (meaning students who received relatively limited instruction and feedback, though they may have attended more than one module) typically commented that they regretted not receiving more TC training: they clearly recognized their disadvantageous position resulting from their insufficient, underdeveloped communication skills. Further, they stressed that because TC skills are so important at their jobs, instruction at engineering schools should be mandatory. Not surprisingly, the few respondents who stated that TC instruction was not important at all also noted they rarely work in teams.

On the other hand, respondents with index values above 35 typically noted the importance of TC skills in their jobs. They particularly stressed the major advantages they gained from their intensive TC instruction. Overall, they were satisfied with the instruction models and basics; however, they constructively suggested improvements for today's rapid communication demands.

From the overwhelming number of comments, the following themes consistently emerged:

- TC skills are crucial for graduating engineers, key to their promotion and advancement
- Good communicators say their skills *differentiate* them from the "pack"
- Some who are not comfortable speaking (even in a meeting) believe they are considered less competent technically
- Job-related communications must be short, quick, yet correct
- E-mail use is "huge;" but e-mail "etiquette" is often poor. Same comment for phone use and "office etiquette."

Suggestions for improving and expanding the current TC program followed common themes:

- Make the technical elective, "Technical Communication for Engineers," mandatory
- Include TC modules and practice in most engineering courses
- Oral presentations are especially important; students need more chances to practice and get feedback
- TC instruction should start in the freshman year
- Students need to learn new communication technologies and other skills—e.g., writing effective, correct e-mail; designing and maintaining web pages; holding team discussions; conducting meetings
- Learning to listen and ask the right questions is key
- Practice and instruction in teamwork is important—particularly for teams of engineers from different disciplines.

Our respondents also suggested considering replacing what they (and many engineering professors) call a "creative writing" requirement like English 101 or 201* with a technically oriented course that covers the TC basics of writing, speaking, reading, identifying audiences, and evaluating. They also suggested we extend our instruction options to include "refresher" modules or workshops for practicing engineers who need to improve their TC skills.

V. Conclusions: Lessons Learned…and Steps to Take

> Students need to learn basic people skills combined with technical communication skills or they will fail horribly when they enter the real world and have to compete with their peers.

Now, let's answer the questions that prompted the survey: what did it teach us about the effectiveness of our current courses? What insight can our former engineering students (now working engineering professionals) provide about expanding and improving the TC program in UB's engineering school? More broadly, what can we extrapolate to engineering education in general?

A. Lessons Learned

> Technical abilities are a given; communication and leadership differentiate.

First and foremost, our former students told us loud and clear: TC instruction must become an integral part of the engineering curriculum. No longer is it sufficient to educate students only in engineering subjects. The average 64 percent time they spend on various types of communication validates industry's requests that engineering schools urgently address this major "competency gap." These former students also taught us that most graduates are insufficiently prepared for the job-related communication demands they face.

Second, through their numerical responses and extensive comments, these graduates provided strong evidence of the impacts TC instruction and practice has had on their ability to function successfully as engineers. These skills helped them advance their careers and add "differentiating" value to their employers.

Third, the greater the amount and intensity of the instruction and feedback, the greater the benefit these graduates reaped: their TC skills helped them get and adjust to their jobs, obtain recognition and promotions, and build their confidence. The enhanced career success of the "high-index" respondents displays this point convincingly (see Figure 6). These students also consistently commented that their communication skills *differentiate them from the pack*—a not-so-subtle comment on the pack's skills!

Fourth, no longer do we have poll results only from the workplace, complaints from professors, and directives from ABET; now we also have survey results from our "customers," our products. They have delivered a report card on our past education efforts at UB—and spelled out directions for future TC instruction.

Fifth, they pointed out specific areas for our TC program at UB that may well apply to other engineering schools:

- Despite the small percent of time spent on formal oral communications, our respondents stressed that requiring students to give oral presentations is crucial for their future success. They especially noted that students need more opportunities to practice and to receive more feedback.[10]
- Since most engineers work in teams, students need to develop good communication skills to get their ideas across to colleagues and management. Thus, practice in team discussions, persuasive speaking, listening for content, and audience analysis is crucial.
- Those who left college without good communication skills now realize the importance of those skills—and think TC instruction should be mandatory.
- We are not reaching enough UB engineering students with extensive, demanding TC instruction.

Sixth, these "lessons" and recommendations can provide impetus for other engineering schools. Certainly, some schools (for example, the University of Washington) have long had extensive TC programs. However, our internal 1998 review[11] of 40 engineering schools showed that less than 50 percent offered any TC instruction; within this group, the majority dealt only with juniors and seniors. Only 12 percent integrated TC instruction into engineering courses. Thus, many schools can use these current results as ideas—even guidelines—for establishing or enhancing their TC programs.

B. Responding to this message: steps to take

To respond to this survey message at UB, we are now planning to broaden our TC program to cover all four undergraduate years. For this effort, we have established a steering committee that comprises engineering faculty from all our departments, the dean of undergraduate studies, mentor representatives from industry, and TC faculty. We are particularly examining alternative TC teaching methods and courses that maintain current integration or coordination with engineering courses but that offer four to six times as many hours of instruction and opportunities for feedback—both in written and oral communication. Also, we are defining the competency levels we expect students to attain during each of their four study-years. At the same time, we are building a consistent program of content models and communication techniques based both on our past successes and on our surveyed students' recommendations. Thus, students will have opportunities to continuously improve and

*At this university, these required English courses do not usually teach basic composition by studying literature and poetry.

hone their TC skills as they face increasingly complex assignments over their 4-year engineering studies.

To the engineering-education community, we suggest that schools take stock of their technical communication programs, evaluate them against the results and "lessons learned" from this survey, and develop a plan to upgrade their TC programs to meet the real needs of students, faculty, and industry (see references 2 and 5). Specifically, schools could:

- Push for intensive, mandatory TC engineering-related courses. Broaden these courses to include instruction on topics relevant to today's fast-paced communication environment.
- Include TC modules in engineering courses. This approach has important advantages: students must hone their grasp of the engineering material as a basis for learning to convey technical information clearly. Because students often already need to write reports and give presentations in many engineering courses, this approach "piggy-backs" on this built-in requirement—without adding additional credits to the engineering curriculum. Further, integrating the TC and engineering subject grades strongly motivates students to improve their communication skills.
- Start the TC program early in the freshman year. Develop a consistent program that enables students to continuously increase their communication competencies
- Develop new TC instruction modes and options, coordinated with engineering courses, that give students more opportunities for practice and feedback to reinforce their skills—both written and oral.
- Initiate a mentoring program so students have opportunities to work directly with experienced workplace engineers and managers.

Implementing these suggestions will require collaboration among professors, TC specialists, administration, alumni, the business community, and industrial advisers to develop efficient yet effective TC programs within an already crowded engineering curriculum.[12] Because of the growing number of technical courses engineering schools are requiring, adding stand-alone TC instruction and even incorporating TC elements directly into engineering courses poses an extremely difficult challenge.[13] But the end result of preparing students for the real-world job environment mandates efforts to deal with this problem.

We welcome feedback from our engineering-education colleagues and are establishing a website to share solution ideas, report progress, and identify resources. You can access this website at http://www.eng.buffalo.edu/ departments/CTC/TechComm.

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12. Seat, E., J.R. Parsons, and W.A. Poppen, "Enabling Engineering Performance Skills: A Program to Teach Communication, Leadership, and Teamwork," *Journal of Engineering Education*, vol. 90, no. 1, 2001, pp. 7–12. This insightful article describes an innovative minor in "Engineering Communication and Performance" the engineering school developed in conjunction with counseling psychology and human services. From a teaching perspective, a key element that contributed to their instruction's success was the recognition that engineers typically learn in a particular, problem-solving style. They therefore molded and geared all

their courses to this learning style. For the past 15 years, this very approach has guided the development of all our TC courses at UB's School of Engineering and Applied Sciences.

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Technical Communications Survey

Center for Technical Communication
UB School of Engineering and Applied Sciences

Name: (optional)_____ Title:_____

Company: _____ Years of Service: _____

Principal product/service: _____ Your Function: _____

When did you graduate from UB? _____ Undergrad Major: _____ Grad Major: _____

In your current position:

	≤ 10%	11-20%	21-30%	31-40%	41-50%	>50 %
What percent of your time **overall** do you spend on written communications? E.g., e-mail, team writing, reports, letters, proposals, work instructions, etc.						
What percent of your time **overall** do you spend on formal oral presentations?						
What percent of your time **overall** do you spend on other oral communications? E.g., meetings, shop floor discussions, electronic video conferencing, etc.						
What percent of your work is in teams?						

Other comments on time spent communicating: _____

What technical communication instruction did you receive at UB? (Check all that apply)

- ❑ Lab course
- ❑ Internship course
- ❑ Senior design
- ❑ Other courses or seminars
- ❑ EAS 480/ 580: Tech Communications for Engineers
- ❑ EAS 483/583: Procedure Writing
- ❑ EAS 460: Empowering Your Technical Language
- ❑ IE 591: Engineering Management

What is the impact of your technical communication instruction on your job?

	Strongly Agree	Agree	Don't Agree or Disagree	Disagree	Strongly Disagree
Helped me get my job					
Helped me adjust to my job					
Helped me advance in my job					
Helped increase my salary					
Gave me recognition in my group					
Increased my confidence					

Other _____

Suggest improvements to technical communication instruction for engineering students:

_____

_____

If you have additional comments, please feel free to write on the back of this page.