A "Communication Skills for Computer Scientists" Course

Lil Blume, Ron Baecker, Christopher Collins, and Aran Donohue
lilblume@rogers.com, rmb@kmdi.utoronto.ca, ccollins@cs.utoronto.ca, ad@cs.utoronto.ca
Department of Computer Science and Knowledge Media Design Institute
University of Toronto
40 St. George Street, Room 7228, Toronto, Ontario, M5S 2E4, Canada

ABSTRACT
This paper describes "Communication Skills for Computer Scientists," a novel undergraduate course at the University of Toronto. We describe in detail the three major instructional streams of the course — writing, speaking, and interpersonal communications. We present a novel approach to teaching writing, interactive multimedia web technology to teach public speaking, and specific interpersonal skills training as the integral parts of the course. We contribute a detailed description of the curriculum and report measures of success, both quantitative data and reactions from students in their own words.

Categories and Subject Descriptors
K.3.2 [**Computers and Education**]: Computer and Information Science Education — *computer science education, curriculum, literacy.*

General Terms
Human Factors

Keywords
Literacy, communication skills, writing, speaking, interpersonal communications, CC 2001

1. INTRODUCTION
Computer science educational programs stress CS and math. In universities that believe in a liberal education, students must also take courses from the humanities, arts, social sciences, and natural sciences. There is also a history of calls for additional communications or 'soft skills' training in computer science curricula [7, 8, 9, 10, 13]. Most computer science academics acknowledge the need for formal training in writing and speaking. These skills are also highly desired by computer scientists in industry and by employers [11]. Even computer science students rate the need for oral, written, and interpersonal skills a close second to technical skills [6]. Yet many universities do not require communications training as part of the curriculum, and, as we shall argue below, what is offered does not go far enough.

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We conducted a review of the B.Sc. (major in computer science) requirements at the "world's top 20 universities in engineering and information technology based on responses to academic peer review" as identified in the 2008 Times Higher Education – QS World University Rankings survey [1]. We selected this source based on its authoritativeness, international scope, and specific focus on technology programs. The universities in our review are large research-intensive institutions, similar to the University of Toronto, which is one of the 20. It is important to note the results may differ at undergraduate liberal arts institutions, colleges, and interdisciplinary programs that blend business and computer science that often have a business communications component.

The summary results, by region, appear in Table 1.

				Details of TC		
Region	#	HSS	TC	W	PS	IP
N.America	12	11	5	5	5	2
Europe	5	1	1	0	1	0
Asia	3	1	1	1	0	0

Table 1. Communication skills training across the top 20 research-intensive universities

Legend: TC = technical communications courses; HSS = numbers of programs with required humanities and social sciences electives; W, PS, IP = numbers of programs with courses that provide training in writing, public speaking, and interpersonal communication skills

Most North American programs require some liberal arts electives. Courses dealing with the social, legal, and ethical considerations of computing often contain writing and public speaking assignments. At five North American institutions, specific technical communications courses are offered in addition to liberal arts elective requirements. Most teach skills in both writing and speaking, but none but ours include comprehensive interpersonal skills training. The closest is MIT's 6UAT, a required course dealing primarily with oral presentations and technical writing that also provides some instruction in negotiation skills and techniques to give and receive criticism effectively. Georgia Tech's LCC3401 course on Technical Communications has some sections that incorporate management skills training. Berkeley's Engineering 140/190 Technical Communications teaches graphical communications.

In Europe, where the degree timeline is just 3 years, liberal arts courses are not usually required, perhaps also because there are higher expectations for what has been taught in secondary school. Only Imperial College London explicitly requires a course in technical presentations. Speaking and writing courses focussed on technical English are commonly required at Asian institutions in non-English speaking countries. However, only National

University of Singapore offers a course on interpersonal communications, but this is a liberal arts elective not incorporating writing and speaking and not tailored to prepare students for the computer science workplace.

In summary, none of the programs we surveyed offered a course with significant coverage of written, oral, and interpersonal communication skills aimed at computer science students.

Technical writing and oral presentation classes are not enough. Both speaking and writing skills are ineffective if computer scientists cannot also succeed in their interpersonal communications and interact competently and professionally with others, especially in conflict situations. Programmers must create programs specific to client needs. Designers of applications must understand user problems and preferences. Unless computer scientists can listen well to clients, confirm their understanding, and respond non-defensively to feedback, misunderstandings will arise causing a great deal of lost time and income.

We address the need for comprehensive communications training in our CSC290 course — *Communication Skills for Computer Scientists.* Most courses in communication skills address only writing or both writing and speaking. One exception that also deals with interpersonal communications skills is an experimental corporate training program in Germany [5].

Also relevant is the work of Beard *et al.* [4]. Mixed groups of accounting and IT students design and develop a major project. The students take on different roles and use many soft skills in interactions that occur during the project. In this way, they claim, their students learn teamwork skills such as listening and showing respect for others. Our approach differs. Rather than creating situations in which certain skills might be required in the process of doing other things, we spend class time teaching and practising specific interpersonal skills that students can then use when situations arise in their teamwork. Alumni of our course report a continuing positive impact on their employability and their ability to cope in a busy IT career:

"I underscored this formal communications training on my resume and during my interview, and I ended up getting the first job I interviewed for. I was one of the 20-some people from UofT hired by Microsoft right after graduation last year. I found the time spent in your class a good investment, and the skills useful in the workplace." (A.S., 2006, email sent upon getting his first job.)

"I noticed in my co-op [work] term that communication skills are very important and are an asset to have, especially in software development." (C.W., 2006)

This course has been offered six times as an elective at the main downtown (St. George) campus of the University of Toronto. There are typically 25-30 students in the class, and more requests for enrolment than we are able to fill.

At the beginning of the 13-week course we inform students of the need to choose an important issue in computer science as a topic for a major paper, oral presentation, and teamwork. The following 12 weeks provide the skills to make the final results the highest quality possible.

2. WRITTEN COMMUNICATIONS

The writing component of the course presents instruction in the style and mechanics of writing. We also teach correct formats for various kinds of writing; principles of effective technical writing; and quoting, paraphrasing, and citing sources. Seven graded writing assignments help move students forward in preparing their final report and give them experience writing in formats that will be useful to them in their future work. These include:

- A diagnostic essay, written and submitted during the first class. This gives the instructor a sense of major student weaknesses so that she can focus on areas of need.
- An email memo confirming their project topic and group members. Students must write in short, clear sentences, using a three-part memo format. They explain the reasons for their choice of topic and their plan for continuing the work. The instructor provides a model of a concise email memo.
- A summary of their group meeting with the teaching assistant (TA). The TA ensures that projects are on the right track and guides in their research. Students are then required to write a summary of the meeting confirming what they believe to have taken place and pointing the way to future work. This assignment gives students experience in writing a follow-up email, an essential task in their future employment when they need to confirm their understanding of a project.
- An initial report on their essay topic, including introduction, thesis statement, paragraphs outlining 2–4 areas of discussion referring to at least three academic references, and a reference list in an ACM-approved format.
- A résumé and job application letter showing their qualification for a specific job. This will be reviewed by guest interviewers and used in one of their presentations, the mock job interview.
- A progress report on their major paper and presentation. This will give them the format and experience for writing a progress report for work-related projects.
- An 8–10 page formal paper on the topic. Preparing this gives students experience in researching academic sources and building a coherent argument to prove a thesis.

Students also hand in short written assignments for each interpersonal unit. Writing these involves reflecting on their integration of new communication skills in their lives.

In our experience, many computer science students are not strong writers. The first essay reveals their writing weaknesses which tend to be ignorance regarding the mechanics of writing combined with carelessness. In addition, they mistakenly depend on spell checkers to find their errors. Since they rarely proofread their work aloud, they have not developed an ear for how good writing sounds, so their writing is full of repetition and wordiness.

A fundamental principle of our method of teaching writing is that we do not circle errors. *Students must find and fix them.* Corrections are completed for higher marks. We attach a page to the essay listing the types of errors and their general location. In addition to the basic mechanics of writing, this list includes errors in both style and content. Some student writing has errors on every line. These students will receive a detailed list of errors described line-by-line. They still must find and fix the errors themselves. Others might only have one error in the entire paper. In that case, the instructions are "find [type of error] somewhere in this paper." If it seems that more than a few students make the same kinds of errors (e.g. "then" instead of "than"), the entire

class is given exercises on that problem or sent to a website that has an exercise and test.

This style of evaluation uses marks for teaching and learning, not rewarding and punishing. Marking rubrics are given to students in most courses. But when asked why an essay received an A, B, or C, students will only give the vaguest answer, which is usually, "The instructor didn't like it."

In this course, students are told, for example, "This paper, as it is, is worth a D+. If you find and fix all the errors it will be worth a C." Or we might say, "This is an excellent paper, but you have to find and fix three typos for an A. Students are also informed that if the desired changes are not resubmitted, if they guess at a spelling (as they often do), or change the incorrectly spelled word to another word rather than look it up, their mark will drop from an originally given mark. Marks are given for style *and* content. University instructors often praise content, while ignoring style. Students in the course learn that the more you perfect the form, the more you perfect the content.

This works well for several reasons: 1) students have to look carefully for the errors and feel a sense of accomplishment when they find them; 2) students are active in finding and fixing whereas looking at an error circled and corrected by the teacher tends to be passive; 3) students learn what excellence looks like and what is involved in achieving it; and, 4) students learn to proofread aloud and realize that they often see what they want to see — not what is there.

"Other English courses would write general tips on my essays leaving me to figure out how to improve my writing. With all of your specific suggestions, I was able to instantly see how sentences could flow more smoothly." (J.C., 2006)

"The importance this course placed on proper spelling and grammar made me realize that I was being unfair to the reader of my messages." (F.V., 2006)

"I learned the value of reviewing and editing my work before submission. This led to submitting better work and improvement in my writing skills. Resubmitting edited work really allowed me to learn from my mistakes." (W.K.C., 2007)

"I first thought that no one should ever be so picky about such insignificant details. After attending every class and going through all the exercises, I now realize that detailed, elegant, and simple writing is critically important." (K.N., 2007)

Rewriting the assignments really helped me learn that proofreading can greatly improve the overall quality of my work." (H.S., 2008)

To make marking easier for the instructor, students resubmit work attached to the previous copies and the comments. Instructors can look specifically for the suggested corrections. The students improve so quickly with this method that the possibility of rewrites can be discontinued after several papers.

3. ORAL COMMUNICATIONS

Class oral presentations are designed to improve students' speaking skills and build their self-confidence. In addition to informal oral activities, the following exercises are prepared for evaluation. Students must deliver their speeches within specific time limits ranging from 60–120 seconds for the first four below. The final two might last up to five minutes each.

- Outline a CS-related topic with the goal of exciting other students to join you to work on various aspects of this topic in their individual research papers and the group panel.
- Pitch an idea for a new product or procedure to an individual such as a professor, a boss, or a venture capitalist.
- Introduce a speech. (We encourage students to create the introduction to their final presentation. This moves the main project along, forcing them to define areas of exploration.)
- Present statistical information that you've found related to your final paper. This should be a chart or a graph on a slide. Explain the information on the slide. To prepare for this presentation, we teach students to analyze the various ways data can be misleading and teach them ways of analyzing a study before trusting its statistical information.
- Participate in an in-class mock job interview with industry and academic interviewers.
- Present the main findings of your research as part of a panel of students working on a set of related topics.

Improvements in speaking ability are due in part to having frequent opportunities to speak in a supportive environment. Yet there are several other procedures in this class that cause dramatic improvement in speaking. 1) During the first four presentations, students are interrupted for coaching and taught on the spot as needed. The instructor tends to focus on points that will benefit the whole class. 2) Students are partnered for every presentation, marking one another, and giving one another specific feedback according to the criteria for that presentation. 3) All speeches are digitally recorded and posted online. While reviewing their videos, the students answer questions provided by the instructor. To receive a mark for a speech, students must view their video, tag critical points, and answer the questions.

The technology we use is called ePresence Interactive Media [2], (see also http://epresence.tv), an open-source rich media webcasting and archiving system. Although intended to allow both same-time and flexible retrospective access to events such as lectures, we use it here only to capture and allow later review of student presentations [3]. Instructors review and reply to these comments online. Others have used video to record presentations and even streaming video to distribute them (as is the case in [9]), but it is the capability to reflect on specific points in a presentation and to have a dialogue about it that is particularly powerful in our approach (see Fig. 1).

Questions reinforce the specific points made in class on a variety of issues. Here are some examples of questions we use:

1. Tag and comment on a spot where you feel you showed preparation and confidence. What are you doing that shows confidence? Refer to marking criteria such as loudness, speed, eye contact, enthusiasm, posture, and enunciation.

2. Turn the sound off and just watch your body language. Make two comments about what you see. These could be things that add to or detract from the presentation's impact.

3. *Elevator Pitch Question:* Put yourself in the position of the person being pitched. Come up with two specific tips to make your elevator pitch more interesting to the listener.

4. *Introduction to a Speech Questions:* As you watch your video, imagine you are a member of the audience and answer the

Figure 1. One moment from a CSC290 presentation

The Comments and Responses box in the upper right contains the dialog between student and TA about what the student is doing right and how he can improve, linked to specific points in the presentation along the bottom timeline. Here the student is reflecting on his use of eye contact to connect with the audience and gestures to engage them and keep their interest.

following from that point of view: Does the presenter grab your attention? Does the presenter connect with the audience? The student shown in Figure 1 is responding to these questions.

6. *Graphics Question*: Was your slide easy for the audience to understand? What design factors affected understanding?

"Watching the videos of my presentations helped out greatly as I wasn't aware of how much I stutter." (J. C., 2006)

"When I turned off the sound, I thought I looked like a crazy man. My eyes were wide-open, and scary… Although it was not intended, I looked like I was lying. These are both things I want to avoid in the future." (B.H., 2007)

"Looking over the introduction video and elevator pitch, I noticed I did not connect well with the audience… I did not look at them. I was very focused on my notes. … I made a conscious effort to avoid this in the final presentation." (N.K., 2007)

"I never knew that I spoke too fast for the audience to understand. When I looked at those very first videos of my own, even I could not hear what I was saying." (E.W., 2007)

"*For the first time in my life, I was able to see my presentation online, from the perspective of an audience. This awareness helped me to improve my final presentation.*" (E.C., 2008)

4. INTERPERSONAL COMMUNICATIONS

Interpersonal communications classes are designed to give students insight into their current habits and new skills for working with others. Our course deals with several topics:

- Perceptions and interpretations, leading to practice with a specific skill — the perception check. Students learn to differentiate their *interpretation* of an event from their *perception* of the event. When another person's behaviour creates difficulty, a perception check offers several equally likely interpretations and asks for feedback rather than jumping to conclusions and escalating a conflict.

Jumping to conclusions: "*You missed two meetings. You don't care about this team."*

Perception check: "*You've missed two team meetings. I'm wondering if you're having problems with time management or agreed to the meetings without checking your other commitments. What's up?"*

- Sending "I" messages, responding to "you" messages, leading to practice with a specific skill — "I" messages. Students learn to avoid accusatory language and take responsibility for their emotional reactions.

"You" message: *"You're ruining our presentation."*

"I" message*: "When you didn't come to the rehearsal, I felt very disappointed. Now I'm afraid that you'll show up at the final class without rehearsing with the rest of us."* Now wait for a response to begin a discussion. If there is no response, say "*I'd like it if you could take a look at your schedule now and commit to a date for the final rehearsal."*

- Effective listening, leading to a specific skill — listening with empathy. Students learn to evaluate a situation from another's perspective and to paraphrase both content and the underlying feeling when appropriate.

Neutrality: *"Don't worry you'll get another job."*

Empathy: *"You lost your lab job. You must be upset."*

- Communicating non-defensively, leading to a specific skill — non-defensive response to feedback, especially when it is perceived as criticism. Students learn to see other people's comments as primarily a projection of thoughts and feelings. Instead of rationalizing, avoiding, or responding with aggression or sarcasm — responses that tend to further the conflict — they learn responses that can potentially lead to mutual understanding and solutions.

TA statement: *"Your program was terrible."*

Student's defensive response: *"What do you expect? The system was down for 24 hours."*

Student's non-defensive response: *"What do you mean?"* (said without hostility)

- Facing conflict with confidence, leading to a specific skill — the clear assertive message that includes both listening and speaking assertively. Students learn that for a win-win solution, they have to have an understanding of the other person's problem as well as being able to assert their own point of view.

The clear assertive message incorporates five specific components making use of the above skills to begin a negotiation.

Presenting these topics in this order allows the students' interpersonal sensitivity to grow. Exercises and group activities give students practice in building their cognitive complexity. They become more thoughtful, appropriate, and effective in meeting with others.

The classes are presented in an interactive workshop format. Students practice applying new skills to difficult situations from their own lives. Their examples include disagreeing with team members about approaches to projects, feeling that their opinions have been ignored by other members, and perceiving lack of cooperation from other members. Another example is students having difficulties understanding professors but not knowing how to approach professors to ask for clarification. Versions of these problems exist also in their personal lives and will reappear in

their future workplaces where the stakes are far higher. Thus, it seems essential that we should give our students the tools and resources they will need to be successful interpersonal communicators.

"I always used to be shy about talking to someone I don't know. This is probably why I like computer science, no need to talk all the time. But because of the class format, all those discussions, teamwork, and exercises, I finally feel like I am not really afraid of people anymore." (M.D., 2007)

"If your teammate is not doing his job, then you could tell him that you feel worried about the deadline or frustrated about the work presented. This way, you could open communication with people and try to solve the problem together." (D.C., 2006)

"Before this course, I used a passive conflict style. I would usually avoid the other person. I would agree with everything they said. This style made my opinions look weaker and people avoided discussions with me since I provided no relevant counter points. Now that I know how to avoid conflict, such as responding to "you" messages nondefensively, I feel much safer in presenting my opinions." (F.V., 2006)

"No other course prompted me to engage in this much introspection. I was delighted when I applied assertiveness to a recent conflict and was commended by the other party about my productive suggestions and calm demeanor." (M.T.C., 2006)

"I dismissed others every time I felt uncomfortable. By impressive displays of sarcasm and theatrics, I had found a way to avoid showing weakness. The workshops helped give me options to use so I can be up front about my concerns." (H.S., 2008)

"I have been accused of causing someone's computer to fail, resulting in a hostile situation. Through interpersonal communication assignments, I've learned how to communicate nondefensively, a skill which will prove invaluable should I encounter such an unpleasant situation again." (A.G., 2008)

5. SUMMARY AND CONCLUSIONS

We have presented a novel communication skills elective course integrating instruction in written, oral, and interpersonal communications. Student rated the "value of the overall learning experience" to be "high," approximately 6 on a 7-point scale. They found the workload slightly above average and the difficulty slightly below average in comparison to other CS classes [1].

To create and deliver such a course, computer science departments must first acknowledge the importance of these skills and realize that great improvements can be made to students' communication abilities. English departments do not want the job. English professors rarely teach technical writing. Public speaking courses are often relegated to continuing studies departments or community colleges. CS departments must solve the problem themselves, by training or finding instructors who have many of the requisite skills and are willing to learn new ones. Ideally, an instructor would have 1) a graduate degree in English or closely related subject; 2) experience teaching writing, public speaking, and interpersonal skills to computer scientists or engineers; 3) strong organizational, interpersonal, and communication skills; and 4) demonstrated evidence of excellence in teaching.

We are eager to share our materials and techniques with others to help encourage the creation of similar courses.

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