A Just-In-Time Model for Teaching Technical Communications
in a Multidisciplinary Capstone Design Course

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Abstract

This paper describes how the level of both the instruction of and the expectations for the technical communications associated with a multidisciplinary capstone design course in the Cullen College of Engineering at the University of Houston have been upgraded through a growing relationship with the University of Houston Writing Center. Even though the evolution of this activity is still in progress, the interaction has already resulted in a series of just-in-time workshops, opportunities for individual consultations for the students with peer Writing Consultants, the general upgrading of the communication requirements for the course, and the development of extensive instructions and grading criteria for oral and written assignments. This interaction has already expanded to other courses and other departments in the College of Engineering. The model can be replicated on other campuses.

Introduction

There seems to be a general consensus that diminishing communication skills among school-aged children and young adults is reaching crisis proportions. This concern is not limited to students at certain universities, or those majoring in technical fields. In "Why Johnny Can't Write, Even Though He Went To Princeton," the *Chronicle of Higher Education*[1] highlights the problem of students progressing through their undergraduate education without developing the writing skills necessary to communicate effectively in their chosen fields of study. In particular, employers of recent engineering graduates have noted for years a deficiency in the communication skills of college graduates. This issue is summarized and discussed in the article by Norback et. altera[2] which also provides an extensive "literature review of writing and presenting in engineering."[2]

Colleges and universities of all types, from the Ivy League to urban public institutions such as the University of Houston (UH), are struggling to institute ongoing, meaningful approaches to the teaching of writing in order to provide students with the skills they need to be successful. Traditional composition courses cannot adequately prepare students for the writing required to solve discipline-specific intellectual problems or help them understand the complexities of their chosen professions. Through writing, students develop academic literacy and become intellectually engaged while expanding the depth and breadth of their topical knowledge. Students who do not achieve writing fluency are at risk of educational disenfranchisement and failure.

Typically, engineering students are taught communications in generic professional or technical writing courses that imitate traditional Freshman composition courses. However, the efficacy of such stand-alone, general education courses is now being questioned in favor of discipline-specific courses and programs. A discipline-specific approach to communications instruction has become a reality in many colleges of engineering. Several examples follow:

Virginia Tech:[3,4] The Department of Mechanical Engineering, with over 1000 undergraduates, 250 graduate students, and 40 faculty has a faculty specialist in technical communications. This faculty member does not teach a specific undergraduate course, but participates in undergraduate laboratory and design courses. The laboratory courses require either short laboratory reports or both formal written and oral reports. This faculty member also teaches graduate workshops that emphasize presentations (thesis defenses and conferences) and writing skills (theses and journal articles).

Georgia Tech:[5] The Department of Electrical and Computer Engineering, with 110 faculty, 1800 undergraduates and 1000 graduate students, employs a "lecturer and coordinator" who intervenes in three laboratory courses and a project engineering course.

University of Texas at Austin:[6] The Department of Mechanical Engineering with 60 faculty and over 1000 undergraduates has employed a senior lecturer (for over ten years) who offers one course in engineering communications as an "immediate" prerequisite to the Department's capstone design course and then intervenes in the capstone design course itself.[7]

Prior to Spring 2003, the UH College of Engineering had few options for their students in terms of technical communications instruction. The English Department at UH periodically offered a general technical writing course, but never on a regular basis. The College of Technology continues to offer a technical communications course, but because it is geared toward another college's majors, and based on their curriculum, it is considered inadequate for engineering students. Technical communications training in the College of Engineering has been more or less the task of individual faculty members in discrete courses. Laboratory courses usually require written and sometimes oral lab reports. Typically, design classes have a reporting component: students develop, manage, and execute the work of a project, writing periodic documents that both aid in the planning process and model reporting to clients. In both cases it is the course instructors' responsibility to set standards for quality, reserve class-time for communications instruction, and deliver that instruction themselves. Neither instruction nor evaluation of

technical communications has been developed or delivered with the support of anyone trained in communications; nor has there been standardization among engineering instructors regarding basic skills, formats, or values for technical communications.

The creation of a multidisciplinary capstone design course in the Cullen College of Engineering became an impetus for broader change. Required for all undergraduates in three of the College's five departments, Electrical and Computer Engineering, Industrial Engineering, and Mechanical Engineering, the course focuses on project-based activities conducted by multidisciplinary teams of four students each [8,9]. Apart from the completion of projects and validation of project results, the main emphasis of the course is to provide instruction and practice in technical communications and project management skills. To improve the technical communications component, the capstone design faculty began working with the Writing In the Disciplines (WID) program, based at the UH Writing Center, to examine communications needs and effective instructional tools. The result was a multi-faceted program of support for student skill development and implementation of instructional tools. In addition to a series of just-in-time workshops and individual writing consultations for students, the program included upgrading communication requirements for the course, and developing grading rubrics for oral and written assignments. Now in its third semester of implementation, the technical communications program developed by the authors of this paper appears to be prompting greater curricular changes at the College level.

Recent History of Writing Practice and Instruction at the University of Houston
UH attracted some attention in the early 1980s when it became one of the first urban public universities to require a significant core curriculum for undergraduates. This core consisted of 54 hours of courses divided among three tiers: general introductory knowledge, discipline-specific knowledge, and knowledge integration. The University also imposed a new graduation requirement: satisfactory performance on an exit examination in writing. The core curriculum remains. However, in 1999, the Texas Coordinating Board for Higher Education mandated that all public universities permit portability and transferability of the core curriculum; UH thus reduced its core to conform to those adopted by others. The exit writing exam was discontinued in Fall 1999 when it was determined that the effort and expense were not producing worthwhile results; without similar entrance or mid-program examinations, and rigorous but normalized mechanisms for evaluation, the process failed to reveal actionable outcomes.

US News & World Report has identified UH as the nation's most culturally diverse large research university[10]. In a university thus challenged by a linguistically and academically diverse student body, ensuring writing competency is a daunting but crucial task. It was this high-need, limited-resource environment that led the young Writing Center – established by the English Department in Fall 2000 to provide assistance to students in core composition classes – to develop an instructional model based on "Writing Consultants," or peer writing coaches. At UH, Writing Consultants are full-time students, primarily undergraduate, who have demonstrated high aptitude in writing and leadership skills. Fewer than half of Writing Consultants major in English or Creative Writing; more than 55 % are Honors College students. In statistically significant use, this model has proved successful at UH, and appears promising for larger-scale writing instruction at UH and on other limited-resource campuses.

Through small group meetings and tutorials, Writing Consultants provide sustained, individualized writing instruction unencumbered by disciplinary or grading duties that could compromise the consulting relationship or the student's learning process. The Writing Center began training Writing Consultants as front-line instructors when revamping an ailing Developmental Writing Program in January 2001. After Writing Center intervention, the pass rate soared from 65% to 90%, and has since maintained that level. The increased pass rate was validated – and the Writing Consultant model was proven effective – by a year-long independent study demonstrating that in subsequent writing courses, Developmental Writing students deemed "underprepared" upon university admission achieved final grades at or above the mean final grade of their "prepared" peers.[11] This model has been adapted for English as a Second Language (ESL) composition courses, with similar results.

Development of a Discipline-Specific Paradigm for Writing at UH
Effective communication is the expressed goal of writing instruction. However, as intellectual demands change by discipline, the rules, practices, and values of writing also change. In response to increasing faculty interest in discipline-specific writing, the UH Provost's Office created a Writing In the Disciplines (WID) program in Fall 2002 within the Writing Center. Whereas the Writing Consultant model addresses the diversity of academic preparedness among students with individualized programs of instruction, WID builds upon that model by reflecting discipline-specific values in academic writing.

WID is based on the premise that writing is thinking, and thus should be both taught and used as a learning tool throughout all fields of study. WID staff partner with faculty, departments, and colleges to answer the following questions:
- What are common forms and writing conventions within this discipline?
- What writing skills are required at each level?
- What are students' common writing weaknesses and strengths?
- What is "good writing" in this discipline?

As these questions are addressed, the perception of writing instruction and practice on the UH campus fundamentally changed. Writing is no longer the province of one department or a skill mastered through a basic course; it is the responsibility of the university at large. The WID Program began as a resource for faculty motivated to examine and improve writing practices in their disciplines, but it has been significantly expanded as interest in discipline-specific writing has spread across campus.

Just as there is no one model for effective student writing at UH, there is no single model for effective writing instruction. In keeping with the guiding principle of discipline-specific writing, UH has encouraged departments and faculty to address the writing "problem" in an appropriately particularized manner. The WID Program supports these efforts by developing methods, procedures, instructional tools, and implementation plans that address student writing needs within individual courses, academic departments, degree programs, and colleges.

Especially in departments where writing has not traditionally been emphasized, faculty may be apprehensive about integrating meaningful writing activities into their courses. Through consultation, directed department meetings, and professional development workshops, the WID Program partners with faculty to promote effective writing instruction and secure broader

support for curricular innovations within their academic departments. Faculty learn to incorporate meaningful writing tools and strategies into their current syllabi and assignments, and generate creative solutions to address student writing needs. WID Initiatives result from articulating these solutions, setting standards for student writing, and developing explicit assessment criteria within each academic department or college.

WID Initiatives require a close working relationship between the academic department and WID staff. Writing is integrated into course material, content objectives, and goals as a learning tool, thinking process, and a demonstration of knowledge. When writing and writing support are embedded within a course, students are likely to:
- Recognize, reflect, and internalize the Professor's investment in writing,
- Take assignments, meetings, and feedback seriously, and
- Improve in skill and content areas.

Writing is used as a tool for learning course material, and students are given ample, course-based opportunities to improve their writing skills. The integration of course material and writing exercises improves student confidence and performance level in both content and skill areas; it also provides instructors with meaningful feedback on student learning.

During the 2002-2003 academic year, WID sponsored a faculty colloquium with a guest speaker, presented a departmental workshop, launched WID Initiatives in five academic colleges (Business, Engineering, Liberal Arts and Social Sciences, Pharmacy, and Technology). In 2003-2004, the Writing Center has expanded WID partnerships to include the Colleges of Hotel and Restaurant Management, Natural Sciences and Mathematics, and Law. In three academic semesters, the WID Program has established ongoing partnerships with faculty from nine of twelve colleges at UH, yielding twenty-two customized WID Instructional Initiatives in discipline-specific writing.

The WID Program at UH draws upon the Writing Consultant model and its underlying premise of sustained and contextualized writing instruction and practice. By teaming faculty and trained writing specialists at the staff and student-peer level, the WID Program creates dynamic instructional teams. Writing Consultants in the WID Program also permit long-term, student-centered writing assistance outside the classroom. In the Thesis Writers Project high-performance students are assigned a Writing Consultant to serve as a writing resource during the completion of a major two-semester, research-driven project. In another year-long WID Initiative outside the traditional classroom, Law Center faculty developed a two-part writing diagnostic with WID staff, and delivered it to 330 first-year law students. Based on assessment of these writing samples, some students were identified as "at-risk," and have been participating in a three-tier instructional intervention involving Writing Consultants, third-year law students, and Law Center faculty. Although extensive data on these programs is not yet available, initial results are promising.

WID Initiatives also test cutting-edge pedagogical strategies in demanding educational situations. In Fall 2003, the WID Program and Conrad N. Hilton College of Hotel and Restaurant Management launched a pair of linked courses in human resource theory and business writing. Using interactive, three-dimensional, web-based media to create a "virtual hotel," students address the writing and communication challenges within the hospitality industry. This

comprehensive context provided an immediate, valuable context for student writing, and encouraged student engagement with the course material.

The Development of Senior Capstone Design

The UH Department of Mechanical Engineering (ME) introduced a project-based capstone design course in the early 1960s. Required of all ME undergraduates, it was conceived as the culminating experience in a four-course design sequence in the BSME degree. The course simulates a professional situation, in which students work in teams address a specific problem that can be solved through the design, construction, testing, and validation of an artifact. It has existed in its present form since 1981, when local industry became the primary provider of projects. The content of the course began to expand in the 1980s. Various engineering design issues became the focus, and course material dealt with codes and standards, linear programming and optimization, engineering economics, and project management.

Throughout the mid-1980s, the course goals remained the same even as the student population changed. First the Department of Industrial Engineering (IE) joined the course. The intent was to provide an interdisciplinary experience for students, who would serve on design teams composed of both ME and IE students. However, relative sizes of the two departments – demonstrated by annual graduation rates of approximately 60 BSME students and 10-15 BSIE students – and the ME-focus of most projects kept many students teams from an interdisciplinary experience. In 1991, Ross Kastor began teaching the course after retiring from Shell Oil Company with 40+ years experience as a drilling engineer and internal trainer. While Kastor altered the schedule of lecture topics, the project-basis of the course remained relatively unchanged. Four years ago, the Department of Electrical and Computer Engineering (ECE) joined the course, making it a degree requirement for all ECE students entering in Fall 1998 and thereafter. Immediately, some ECE students opted to take the course as an elective. That number grew over a four-year period: in Fall 2002, approximately thirty ECE students enrolled, and in Spring 2003, fifty-five of eighty-six enrolled students were ECE majors. It is anticipated that the course will expand, with enrollment from the three departments reaching approximately sixty students in the fall and one hundred students in the spring.

In anticipation of this expansion and diversification in course enrollment, ME professor Rick Bannerot and ECE professor Paul Ruchhoeft joined the senior design instructional team in Spring 2002. The initial task was to evaluate and revamp, if necessary, the course content and operations and prepare for an increase in course enrollment of as much as 200%. A previous paper reviewed these changes in the course content and philosophy as a result of this initial evaluation[8]. As part of the second task, team-teaching the course, most of the course lectures were repackaged to emphasize direct project facilitation and interactive learning through critique sessions used widely in the visual arts. These collaborative learning meetings are centered on informal presentations and peer reviews of team project work directed by faculty facilitators.[12]

The Just-In-Time Model for Technical Communications in Senior Capstone Design

One semester is often not enough time to initiate and complete a meaningful project, let alone introduce additional material. To provide students with as much time as possible for project work within the one-semester constraint, the capstone faculty decided to focus on material that directly

supports the projects. Therefore, the course is currently limited to skill development in project management, teaming, and engineering communications.

The details of the course structure can perhaps be best understood from the Spring 2004 capstone class schedule as seen in Table 1. During this semester, the course enrolled eighty-eight students. To organize class meetings, project teams, reporting deadlines, and course responsibilities, those students were divided into twenty-two numbered teams of four students each. Teams were grouped into six Cohorts (C1, C2, C3, etc.) according to project area, to ensure that regular instructor-facilitated cohort meetings (in green on Table 1) would provide opportunities for meaningful interactions and peer feedback. In addition to regular cohort meetings, instruction was provided through Writing Workshops (listed on the schedule in purple by topic and date), of which students attended a minimum of four during the semester.

Finally, each student was assigned a letter (A through D) that corresponded to assignment responsibilities and deadlines. Every student was responsible for one written report and one oral report during the semester. While report development is the product of individual effort, reports are based on the team's progress on the project, and timed to coincide with key stages in project planning: proposal, progress report, and technical report. Individuals presented reports to their own cohort plus two other rotating cohorts every two-three weeks. The schedule indicates deadline information (in blue), including date, time, report type, and team member responsible (by letter).

Tuesdays: 5:30 to 8:30	Thursday: 5:30 to 8:30

UH Writing Center (WC) plumb; Facilitated meetings green; Group due dates red; Individual due dates blue

Tuesdays: 5:30 to 8:30	Thursday: 5:30 to 8:30
Attendance Required in W122D3	Attendance Required in W 122D3
Course expectations and philosophy	Apply for projects (due to at end of class)
Website, Projects, UH Writing Center	Projects, Teams Cohorts announced
Informal mixing; form teams	
January 27, 2004	**January 29, 2004**
Cohort Meetings I, C376D: C1 @ 5:30; C2 @ 7:00	Cohort Meetings I, N376D: C3 @ 5:30, C5 @ 7
WC#1 @ 5:30, WC#2 @ 7 (Abstracts, Intros, & Conclusions)	Cohort Meetings I, N357D: C4 @ 5:30, C6 @ 7
	WC #3 @ 5:30, WC#4 @ 7 (Abstracts, Intros, & Conclusions)
	Planning Report #1 due from Cohorts 1 & 2
February 3, 2004	**February 5, 2004**
Cohort Meetings II, N376D: C1 @ 5:30; C2 @ 7 in N376D	Cohort Meetings II, N376D: C3 @ 5:30; C5 @ 7
WC #5 @ 5:30 (Proposals) C2, C5, & C6	Cohort Meetings II, N357D: C4 @ 5:30; C6 @ 7
WC#6 @ 7 (Proposals) C1, C3, & C4	WC#7 @ 5:30 (Tone In Professional Communications)
Planning Report #1 due from Cohorts 3,4,5,&6	
February 10, 2004	**February 12, 2004**
Cohort Meetings III, C376D: C1 @ 5:30; C2 @ 7:00	Cohort Meetings III, N376D: C3 @ 5:30, C5 @ 7
WC #8 @ 5:30 (Mechanics and Proofreading)	Cohort Meetings III, N357D: C4 @ 5:30, C6 @ 7
	WC #9 @ 5:30 (Mechanics and Proofreading)
February 17, 2004	**February 19, 2004**
Proposal: Oral (A) and Written (D)	Proposal: Oral (A) and Written (D)
C1, C2 & C3 @ 5:30 in W122D3	C4, C5 & C6 @ 5:30 in W122D3
WC #10 @ 5:30 (Progress Reports) C4, C5, & C6	WC #11 @ 5:30 (Progress Reports) C1, C2, & C3
	Planning Report #2 from Cohorts 1 and 2
February 24, 2004	**February 26, 2004**
Cohort Meetings IV, C376D: C1 @ 5:30; C2 @ 7:00	Cohort Meetings IV, N376D: C3 @ 5:30, C5 @ 7
Planning Report #2 due from Cohorts 3,4,5,&6	Cohort Meetings IV, N357D: C4 @ 5:30, C6 @ 7
WC #12 @ 5:30 (Tone in Professional Communications)	
March 2, 2004	**March 4, 2004**
Progress Reports: Oral (B) and Written (C)	Progress Reports: Oral (B) and Written (C)
C1, C5, & C6 @ 5:30 in W122D3	C2, C3, & C4 @ 5:30 in W122D3
WC #13 @ 5:30 (Paragraph Structure)	Planning Report #3 due from Cohorts 1 and 2
	WC #14 @ 5:30 (Paragraph Structure)
March 9, 2004	**March 11, 2004**
Cohort Meetings V, C376D: C1 @ 5:30; C2 @ 7:00	Cohort Meetings V, N376D: C3 @ 5:30, C5 @ 7
WC #15 @ 5:30 (Using Figures, Examples, etc)	Cohort Meetings V, N357D: C4 @ 5:30, C6 @ 7
Planning Report #3 due from Cohorts 3,4,5,&6	WC #16 @ 5:30 (Using Figures, Examples, etc)
March 16, 2004: Spring Break	**March 18, 2004: Spring Break**
March 23, 2004	**March 26, 2004**
Cohort Meetings VI, C376D: C1 @ 5:30; C2 @ 7:00	Cohort Meetings VI, N376D: C3 @ 5:30, C5 @ 7
	Cohort Meetings VI, N357D: C4 @ 5:30, C6 @ 7
WC #17 @ 5:30 (Technical Reports) C2, C3, & C4	WC#18 @ 5:30 (Technical Reports) C1, C5, & C6
March 30, 2004	**April 1, 2004**
Technical Reports: Oral (C) and Written (B)	Technical Reports: Oral (C) and Written (B)
C1, C4 & C5 @ 5:30 in W122D3	C2, C3 & C6 @ 5:30 in W122D3
WC# 19 @ 5:30 (Mechanics and Proofreading)	Planning Report #4 due from Cohorts 1 and 2
	WC# 20 @ 5:30 (Mechanics and Proofreading)
April 6, 2004	**April 8, 2004**
Cohort Meetings VII, C376D: C1 @ 5:30; C2 @ 7:00	Cohort Meetings VII, N376D: C3 @ 5:30, C5 @ 7
WC #21 @ 5:30 (Progress Reports) C2, C3, & C4	Cohort Meetings VII, N357D: C4 @ 5:30, C6 @ 7
Planning Report #4 due from Cohorts 3,4,5,&6	WC #22 @ 5:30 (Progress Reports) C1, C5, & C6
April 13, 2004	**April 15, 2004**
Progress Reports: Oral (D) and Written (A)	Progress Reports: Oral (D) and Written (A)
C3, C4 & C5 @ 5:30 in W122D3	C1, C2 & C6 @ 5:30 in W122D3
WC #23 @ 5:30, WC #24 @ 7 (Posters)	WC #25 @ 5:30, WC #26 @ 7 (Posters)
	Planning Report #5 due from Cohorts 1 and 2
April 20, 2004	**April 22, 2004**
Cohort Meetings VIII, C376D: C1 @ 5:30; C2 @ 7:00	Cohort Meetings VIII, N376D: C3 @ 5:30, C5 @ 7
WC #27 @ 5:30, WC #28 @ 7 (Extended Abstracts)	Cohort Meetings VIII, N357D: C4 @ 5:30, C6 @ 7
Planning Report #5 due from Cohorts 3,4,5,&6	WC #29 @ 5:30, WC #30 @ 7 (Extended Abstracts)
April 27, 2004	**April 29, 2004**
Set up Posters by noon	Poster Session 10 to 5:30
May 4, 2004	**May 6, 2004**
** Semester Over **	Final Technical Report Due

Table 1: Capstone Course Schedule, Spring 2004

The entire class met together only three times during the semester: twice during the first week and once for the final examination. The small-scale instructional modules – critique sessions in cohort meetings, and limited-enrollment Writing Workshops – allowed students and instructors to focus on individualized learning needs in a rigorous curriculum. To support the students' extensive communications activities in the capstone course, WID Program staff designed a series of targeted workshops that launched during the Fall 2003 semester and repeated during the Spring 2004 semester (per above). Workshop topics were developed in response to course requirements, based on discipline-specific writing conventions and writing problems evident in past student work. Topics fall into three general categories:

1. Course assignments / engineering documents (proposals, progress reports, technical reports, posters, extended abstracts)
2. Discipline-specific writing problems (comparing / contrasting abstracts, introductions & conclusions; tone and professional communications; paragraph structure and organizational cues; integrating figures with text)
3. Mechanics and proofreading (review and practice of a variety of grammar rules)

Workshops last ninety minutes each, and enrollment is limited to twenty-two students. Depending upon course enrollment and student demand, workshop topics are offered more than once throughout the semester.

Workshops are scheduled when topics are likely to be of greatest value to students, thus delivery of writing instruction is based upon a just-in-time (JIT) model. For instance, the "proposals" workshops occur two weeks before proposal due dates, and the first workshop on "tone" occurs shortly before the progress report deadline, when students are likely to be struggling for ways to maintain audience confidence in project work that has deviated from an initial plan. In Fall 2003, each student was required to attend five workshops during the course of the semester: those workshops based on the written and oral report for which the student is responsible, and three other workshops of the student's choice. Students may elect to attend more than five depending upon space available. Due to student feedback and course enrollment (ie., eighty-eight students instead of forty-two), the overall number of required workshops was dropped to four in the Spring 2004 semester.

Part of this comprehensive writing program has included the development of extensive instructions for written reports and grading rubrics for oral reports (Table 2 shows the grading criteria for oral progress reports). Within the Capstone course, rubrics serve a dual purpose: clarifying expectations for student work and norming grading standards. On a larger scale, these rubrics are critical in the development of college-wide standards for student communication skills, and thus also critical to the efficacy of programs developed to teach those skills.

1. Title Slide/Outline
  ➢ Were the group, project topic, and sponsor/client identified?
  ➢ Were the subject and focus of the presentation identified?
  ➢ Was an outline provided that detailed the structure of the presentation?
  ➢ Was the presenter professional and engaging in demeanor?

2. Introduction and Background
  ➢ Did the presenter clearly identify the larger context of the project?
  ➢ Did the presenter clearly identify the problem to be solved, the task representing the solution to the problem, and the approach(es) to be used in completing that task?
  ➢ Was the introduction and background readily understandable to the audience?

3. Statement of Goals
  ➢ Were final and intermediate goals specifically identified?
  ➢ Were these goals concrete, realistic, and specific? (i.e., not "research.")
  ➢ Were the goals sequential and spaced at regular intervals, enabling them to serve as "milestones"?
  ➢ Did the goals provide an outline for the Progress Description section?

4. Progress Description
  ➢ Was the progress clearly defined for each goal?
  ➢ Was the current status of each goal clear?
  ➢ Were problems encountered and if so were resolutions clearly and positively described?
  ➢ Were there any changes in the requirements and was it clear how they would effect the outcome of the project?
  ➢ Is the technical detail presented adequate and relevant?

5. Scheduling (Project Plan)
  ➢ Was the project schedule presented and was the current status identified?
  ➢ Were any significant changes to the schedule explained?
  ➢ Was it clear whether the team is on track to complete the project on time?

6. Conclusion/Summary
  ➢ Did the conclusion provide an effective, clear review of the presentation's key points?
  ➢ Has the presenter convinced the audience that the project can be completed on time?
  ➢ Did the presentation end on a positive note?
  ➢ Did the presentation end conclusively, without being abrupt?

7. Time
  ➢ Was the presentation an appropriate and effective length? (approximately ten minutes; or at least between eight and eleven minutes)

8. Quality of Presentation
  ➢ Was the presentation clear and readily understandable?
  ➢ Did the presentation's level of detail demonstrate that the group is capable of completing the project?
  ➢ Did the visual aids enhance the presentation and engage the audience's understanding?
  ➢ Did the presenter interact appropriately with the audience and visual aids? (e.g., using eye contact to connect with the audience or draw attention to slides when appropriate)
  ➢ Did the presenter exhibit professional mannerisms of speech, gesture, and behavior? (e.g., avoiding distracting movements and interruptions in speech; maintaining appropriate volume; appearing relaxed, confident, and knowledgeable, etc.)
  ➢ Were technical details presented accurately?

Table 2: Grading Rubric / Criteria: Oral Progress Reports

The two individual report assignments, one written and one oral, represent 15% of the individual's course grade. Five group-written planning reports are required and reviewed in the cohort meetings. Groups are also responsible for a short initial proposal to bid on project

assignments, a final technical report, a final oral presentation, a conference-style poster, and an extended abstract.

Initial Student Response to the JIT Model for Technical Communications
Table 3 presents the results from surveys administered at the beginning and end of the semester to students in the Fall 2003 capstone course. It should be noted that fall enrollment in the capstone course is typically half that of spring enrollment; there were forty-two students enrolled in Fall 2003. In the surveys, students were asked to state their level of agreement with the given statements where "5" indicated strongly agree; "4", agree; "3", neutral; "2", disagree; and "1", strongly disagree. The total number of responses for each statement is given in the sixth column, N. The "mean" is determined by multiplying the number of responses in each column by the "weight" of that response, e.g., "5" for strongly agree, summing over all the five columns, and dividing by N. The last column is the standard deviation (from the mean) of the responses. With regard to the decreased responses to the statements about specific workshops, it should be noted that the low number of responses reflects the elective nature of these workshops.

On the average, the students agreed that their communication and writing skills had improved by taking the course (4.04/5.0 and 3.95/5.0). Only 4 of the 42 (9.5%) disagreed. Approximately 75% of students agreed or strongly agreed that their skill level increased, 15% of the remaining students indicated no opinion, and 10% disagreed. Data for only six of the elective workshops is shown, since attendance at the other was not sufficient to provide statistically-significant results. For four of the six workshops, there was over a 70% approval rate; at least 70% of the respondents agreed or strongly agreed that these workshops were helpful.

While there is only a marginal increase in the students' "before" and "after" self- assessment of their ability to express themselves clearly, this is not atypical of student attitudes regarding writing. As communications instruction is integrated into existing courses, it is often met with resistance from students who perceive it as extra work. In this case, the capstone course traditionally required very few class meetings; requiring attendance at writing workshops meant these students no longer had the "free" time they were told to expect by prior generations of students. More significantly, the number of students who disagreed or strongly disagreed that they were able to express themselves clearly through writing or speaking at the start of the semester decreased from six in each category to two and one respectively by the end –no students strongly disagreed with either statement. The negative shift in responses to the statement "communication skills are important for engineers" may reflect the professors' ongoing efforts to integrate writing quality into grading rubrics both explicitly and uniformly.

	Beginning of Semester						N	mean	?
	5	4	3	2	1		N	mean	?
Communication skills are important for engineers.	34	6	1		1		42	4.71	0.73
I am able to express my knowledge clearly through writing.	5	22	9	4	2		42	3.57	0.98
I am able to express my knowledge clearly through speaking.	8	16	12	5	1		42	3.60	1.00
Writing helps me organize my knowledge.	8	23	10		1		42	3.88	0.79
I can communicate complicated information to others.	8	19	10	3	2		42	3.67	1.02

	End of the Semester						N	mean	?
	5	4	3	2	1		N	mean	?
Communication skills are important for engineers.	27	13	2				42	4.60	0.58
I am able to express my knowledge clearly through writing.	10	21	7	2			40	3.98	0.79
I am able to express my knowledge clearly through speaking.	12	20	7	1			40	4.08	0.75
Writing helps me organize my knowledge.	9	23	8				40	4.03	0.65
I can communicate complicated information to others.	7	19	13	1			40	3.80	0.75

	5	4	3	2	1		N	mean	?
My communication skills have improved by taking this course.	16	17	5	3	1		42	4.05	1.00
My technical writing skills have improved by taking this course.	14	17	7	3	1		42	3.95	1.00

I found the following workshops helpful:

	5	4	3	2	1		N	mean	?
proposals	7	15	2	6	1		31	3.68	1.12
abstracts, introductions and conclusions	4	15	4	3	1		27	3.67	0.98
progress reports	4	13	10	5	2		34	3.35	1.05
technical reports	2	11	9	2	2		26	3.35	1.00
posters	7	16	4	3	2		32	3.72	1.10
extended abstracts	7	9	6				22	4.05	0.77

Table 3: Results from Two Student Surveys for Fall 2003 in the Capstone Design Course

Implications of the JIT Model for Senior Design Faculty and the College of Engineering
The course instructors are pleased with the demonstrated improvements in the overall communication abilities of the students. Any single cause of these improvements is difficult to identify. WID Initiatives are multi-tiered, involving multiple elements such as writing workshops, tutorials with Writing Consultants, and instructional materials and evaluative tools developed jointly by WID Program staff and course instructors; it is difficult to isolate impact. In addition, the capstone course itself has undergone significant change to support communications skills: instructors have worked to convey the increased emphasis on

communications skills through the course structure, assignments, and discussion in cohort meetings. Based on the fact and nature of the College of Engineering's commitment to communications, it appears that the *combination* of these efforts should be credited for student skill improvement.

However, writing and speaking abilities remain difficult skills to quantify. As is typical in WID Initiatives, writing or speaking is not the primary basis for any course-based evaluation. The WID Program staff and capstone faculty are working to develop indicators of discipline-specific literacy that may be expressed in writing, and integrating these indicators into evaluative rubrics as criteria for grading.

During the Spring 2004 semester, the College of Engineering has supported integrated interventions developed by the WID Program in both the capstone course and a sophomore design course in the Department of Mechanical Engineering. The College has also supported three sections of a new technical communications course that has become a required course in the BSEE and BSCE (computer engineering) curriculum. Three sections are scheduled for Fall 2004.

The College of Engineering Technical Communications Committee will be evaluating the impact of the two course-integrated interventions and the new course. The College has investigated offering as many as seven sections of the technical communications course each semester, should other departments in the College elect to require it in their programs. In addition, the College is considering providing support for two or three additional interventions per department through existing courses that require assignments in oral and written communications.

The role of the WID program is to initiate these interventions and new courses but not to take responsibility for them in the long term. To that end, the College of Engineering is considering establishing a College Writing Center and hiring a "communications coordinator" for the College who will be responsible for maintaining these new programs. WID Program staff would continue to work with the College in an advisory capacity, especially to develop new programs as needs arise. For instance, the College already anticipates augmenting communications instruction at the graduate level.

Conclusions
They are many successful models of the capstone experience[13]. This paper has described an evolving process to improve technical communications instruction in the capstone design course experience for the University of Houston's Departments of Electrical and Computer Engineering, Industrial Engineering, and Mechanical Engineering. There is evidence that these efforts will not end with the capstone course nor be limited to these three departments; rather, there appears to be support for a College-wide communications agenda. A stand-alone technical communications course has been developed and taught according to department-based standards, and the College has expressed support for both such stand-alone technical communications courses for engineers, and for course-integrated interventions in existing classes that require communications components.

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