AC 2010-2143: IMPROVING TECHNICAL WRITING AMONG ENGINEERING AND TECHNOLOGY STUDENTS

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Improving Technical Writing among Engineering and Technology Students

Abstract

The ability to communicate clearly and effectively is crucial to success in an engineering career. Good writing skills give students a competitive edge in job searches and career advances. It is widely agreed in and out of academia that instruction in writing is an important component of engineering education. Recognizing a serious deficiency in writing skills among today's college graduates has motivated educators to continuously explore effective ways to help students improve their writing skills. In this paper, a novel framework to improve technical writing among engineering and technology students is introduced and analyzed. The framework proposed is currently under development by the School of Engineering and Technology at NATIONAL UNIVERSITY University, a private, non-profit institution dedicated to providing students with quality education. The main idea is to embed a series of tailor-made "signature" writing assignments into both undergraduate and graduate curricula. The framework begins with defining the types of written communications important for students in each program. It then identifies the courses and the appropriate type of writing that may be integrated into the curriculum. Specific signature assignments for each type of written communication have been developed and embedded in course syllabi. These signature assignments follow an IDM (introduce, develop, master) sequence, which makes sure that students can master and get adequate practice in required written communication before they get to their capstone/master's project courses. Rubrics and useful resources such as samples, helpful hints and FAQs are being developed for students to use with each type of writing assignment. We believe that the proposed method would enable our engineering and technology students to significantly improve their technical writing skills. We are certain that these graduates will be able to easily impress their future employers and the general public by their excellent ability to communicate technical information in writing.

Introduction and Background

In general, technical professionals such as engineers and scientists are not typically characterized as having excellent communications skills, including in written communications. Some employer surveys support the validity of this perception through their findings that there is a gap between employers' expectations and the actual capabilities of students/graduates of technical programs when it comes to communication skills[1-3]. The importance of communication skills is amplified by the fact that the competency of technical professionals may often be judged by their communications, meaning that limited skills in writing can have a negative impact on career progression. The Accreditation Board for Engineering and Technology (ABET), the accrediting body for engineering, engineering technology, computer science, applied science and related

programs, has recognized and emphasized the importance of communication skills – including written communications – by requiring that accredited curricula include communication capability as a specific outcome[4].

Educators in technical fields recognize the importance of written communications, and a variety of approaches have been devised and implemented to address the issue. Undergraduate writing courses are almost universally included in general education requirements at colleges and universities. However, these general courses are not perceived to be always sufficient for meeting the needs of students in technical programs. Working with groups of professional engineers in the post-university environment, some research has shown that courses in general writing skills are minimally effective in improving the ability of technical professionals to produce quality, written technical documentation[5]. Frequently, technical programs of study may require special courses or workshops in technical writing; for example, an upper division course specifically teaching technical memo writing has been used effectively in engineering at the University of Arizona[6]. In the United Arab Emirates' Higher Colleges of Technology, a process was implemented whereby the undergraduate writing courses were 'clubbed' together with the introductory level technology courses, and jointly developed and taught by the writing and technology instructors working together. The writing and technical content of students' work were evaluated separately. Qualitative comparisons of reports written in upper level technology courses both before and after this 'clubbing' approach was instituted indicated that this approach was successful in improving students' writing[7]. Other approaches to improving students' writing skills have been proposed. Some "unusual" ones include "reading and writing poetry," "read 'til your eyes bleed" (read from all kinds of sources, and analyze how the writer of each piece was able to achieve his/her objective), and/or organizing small groups to practice writing and constructively critique one another[8]. Simplifying writing styles has been promoted as one means of improving written communication, encouraging the use of shorter sentences and less cumbersome grammatical constructions to achieve reports, memos, and letters that are easier to read and understand[9]. And since the objective of all communication is to elicit understanding, such communications are deemed to be considered better. Such an approach – one that encourages simplicity and informality – may be especially useful as technical professionals document findings and results that need to be communicated to other departments, managers or executives, some or many of whom may not have highly technical backgrounds. All of the above approaches may be used to contribute to improving the ability of students in technical academic programs to communicate effectively through writing.

The School of Engineering and Technology (SOET) at NATIONAL UNIVERSITY University (NU) was established in July 2002, and has attracted a current student body of over 1100 whose profile generally mirrors that of the University itself. NU, the second largest private non-profit university in California, has over 22,000 mainly non-traditional students: students with average age over 30 and heavily weighted with students from traditionally underrepresented groups, including women and minorities. Over 75% of NU students are working on master's degrees; in

SOET the number is around 50%. Most students, whether at the undergraduate or graduate level, are reentering an academic environment after having been out in the working world for some time. It is not uncommon for our students to be a bit rusty in their math skills (to be discussed elsewhere) as well as in their writing skills. In addition to these typical non-traditional students, SOET has recently experienced a significant influx of international students. Most of these international students, primarily from India and China, enter the master's programs at NU after just recently completing undergraduate degrees in their home countries. Many of these international students also need to improve their writing skills. The ability to effectively communicate in writing is included as one of NU's institutional learning objectives (ILOs), making it an objective for all students in all programs at NU. In addition, every program in SOET includes written communication ability as a specific program learning objective (PLO). While writing assignments are not uncommon in many SOET courses, teaching writing has been mainly confined to specific general education and technical writing courses run by the College of Letters and Sciences. The assessment of the ability of SOET students to communicate effectively in writing is most often done through an analysis of the formal documentation accompanying end-of-program capstone projects (undergraduates) or master's projects and theses. Data in some programs have shown an increase in the length of time required for students to complete these end-of-program projects, many times as a result to needing additional time to correct and polish written documentation. Other anecdotal evidence across many SOET programs indicates that students reaching these capstone and master's projects are frequently not fully prepared to professionally document their results in writing. Due to the importance of written communication skills for technical professionals, and the special needs of our students, it was decided that additional measures (besides those already existing, which are similar to some mentioned above) were needed to enable our students to attain levels of written communication skills necessary for achieving success in their professional careers.

SOET's Approach to Improving Writing Skills

Berthouex[10] found that significant improvement in writing skills can be accomplished outside of specific technical writing courses by incorporating more written assignments across a spectrum of engineering courses. Writing assignments linked to design projects have been particularly effective, and the use of writing assignments in more courses provides opportunities for students to progress through practice. Such an approach makes use of existing curricula (no new, writing-specific courses required), and links written communications with engineering curricula and with technical problems and projects, thus providing a clear context for the use of such communications in engineering practice. We decided to implement this additional approach to further improve the writing skills of our students in engineering and technology.

Our initiative was dubbed “Excellence in Engineering Writing,” and was given the shorthand moniker “E^{2}Write”. E^{2}Write was defined to include the following steps to mirror the approach suggested by Berthouex above:

1. Identify the types of written communication skills most needed by students in each individual program.
2. Identify places in each program’s curricula where these particular types of written assignments can best be incorporated.
3. Use an Introduce-develop-master (IDM) methodology for each type of written communication (discussed further below).
4. Embed specific “signature” assignments in course syllabi to ensure implementation of the assignments as determined in steps 1-3 above.
5. Develop resource sets appropriate for each type of assignment, and provide for students to access these resources on an as needed basis.

E^{2}Write was developed in conjunction with the Director of NU’s Writing Center and co-director of the Writing Across the Curriculum Program, Shareen Grogan. The Writing Center is a central resource available to all students where writing consultants work with student writers one-on-one to help them improve their writing skills. The Writing Center is one of the key resources to which students are regularly referred, and is a primary source for identifying and specifying other appropriate components of the resource sets mentioned in step 5.

One of our faculty’s most capable teachers and technical writers, Dr. Peilin Fu, was assigned to lead the E^{2}Write initiative. Implementation details include the following:

Identify the types of written communication skills most needed by students in each individual program.

Dr Fu and Ms. Grogan developed a list of all common, possible types of technical communications (the University of Michigan College of Engineering website provided a good starting place for constructing this list). This list is shown in Table 1.

Technical Communications		Undergraduate Programs	Graduate Programs
Lab report		x	x
Periodic progress report		x	x
Resume and cover letter		x	x
Biographical sketch		x	x
Technical-based business communications	Memo	x	x
	Executive summary	x	x
	Cover letter for a report or proposal	x	x
	Briefing paper	x	x
	Business plan	x	x
	Consultant's report to a client	x	x
	Expert witness's report	x	x
	Test plan	x	x
Short proposal for design project		x	
One or more sections of Technical Report / Proposal	Research question or hypothesis		x
	Thesis sentence		x
	Outline including the main ideas of each section		x
	Abstract		x
	Introduction		x
	Statement of assumptions		x
	Literature review		x
	Method section (or materials & methods plan)		x
	Results and discussion		x
	Annotated bibliography		x
Complete technical report			x
Complete proposal			x
Case study			x
Review of a book, technical article, website, etc.		x	x
Technical description		x	x
Description of a physical or manufacturing process		x	x
Design log books		x	x
Project notebooks or reports		x	x
Poster or ppt presentation		x	x

Table 1: Possible Types of Technical Communications for SOET Programs

Of course, different technical disciplines can require skills in different types of written communications. Construction engineers may require expertise in detailing plans, listing specifications and preparing project bids. Environmental engineers may have greater need for producing analytical reports and for writing memos communicating recommendations. Software

engineers' most important needs in the area of written communications might be for writing user instructions and manuals, and software test procedures and results. Because of these varying needs, the Lead Faculty for each program (i.e., the faculty member responsible for that program's curriculum) was asked to determine the types of written communications most important to emphasize during the major curriculum. Using the list developed previously and shown above in Table 1, and with the leeway to add other types of communications not already explicitly included, each Lead Faculty designated a small subset of technical communications deemed to be most valuable for their program. Some examples of these subsets are shown in Table 2, where CIS, CSC, ENM and WCM stand for BS in Computer Information Systems, BS in Computer Science, MS in Engineering Management and MS in Wireless Communication respectively.

Technical Communications		**Undergraduate Programs**		**Graduate Programs**	
		CIS	**CSC**	**ENM**	**WCM**
Lab report			x		x
Periodic progress report		x	x	x	
Resume and cover letter					
Biographical sketch					
Technical-based business communications	Memo	x			
	Executive summary	x	x		
	Cover letter for a report or proposal				
	Briefing paper	x			x
	Business plan	x			
	Consultant's report to a client	x			
	Expert witness's report				
	Test plan	x	x	x	
Short proposal for design project		x	x		
One or more sections of Technical Report / Proposal	Research question or hypothesis				x
	Thesis sentence				x
	Outline including the main ideas of each section				x
	Abstract				x
	Introduction				x
	Statement of assumptions				x
	Literature review				x
	Method section (or Materials & Methods Plan)				x
	Results & discussion				x
	Annotated bibliography				x
Complete technical report				x	x
Complete proposal					
Case study				x	
Review of a book, technical article, website, etc.			x	x	

Technical description	x	x	x	
Description of a physical or manufacturing process	x			
Design log books	x	x		
Project notebooks or reports	x	x		
Poster or ppt presentation	x	x	x	x

Table 2: Technical Communications chosen by some SOET Programs

Identify places in each program's curricula where these particular types of written assignments can best be incorporated.

Dr. Fu next met with each Lead Faculty and worked collaboratively to identify which major courses in each program were most conducive to writing assignments for each type of communication determined to be important for that discipline. For example, a course on strength of materials might be a good choice for incorporating a writing assignment on documenting test procedures and reporting test results. A course on air pollution control could be an ideal opportunity for writing a report summarizing possible alternatives for a given situation, or a memo to management providing specific recommendations. Many courses include experiments or case studies, which lend themselves perfectly for assignments in writing procedures, analyzing situations, documenting results and outcomes, etc.

Use an introduce-develop-master (IDM) methodology for each type of written communication.

The "introduce-develop-master" methodology is common in mapping how learning objectives will be achieved in the course of a program's curriculum. Specifically, a course (or courses) is identified where a particular learning objective will be introduced, or where students will be expected to comprehend and utilize skills in that objective on an introductory level. Next, subsequent courses are identified where that particular learning objective will be further developed. These courses require that students progress to comprehending or using the capability at an intermediate level. Finally, a course or courses are identified where students will be expected to demonstrate mastery of a particular learning objective. There are no set numbers of courses required for I, D, or M levels in a program. The number is determined by the complexity of the learning objective, the amount of time dedicated to that objective in each specific course, and other related factors. This IDM progression illustrating the relationship between course content and individual learning objectives is typically depicted in IDM maps. Examples of IDM curricular maps developed specifically and solely for the E^2Write initiative are shown in figures 1 through 3.

	WCM 600	WCM 601	WCM 602	WCM 604	WCM 605	WCM 606	WCM 607	WCM 608	WCM 609	WCM 612	WCM 611A	WCM 611B
Lab Report								I	DM			
Briefing paper					ID					M		
One or more sections of Technical Report	I	I										
Complete technical report			I	I		D	D	D	D	M	M	M
Poster /ppt Presentation	I	I	I	D	D	D	D	D	D	M	M	M

Figure 1: Signature writing assignments mapping for MS in Wireless Communication Program

	CIS601	CIS602	CIS603	CIS604	CIS606	CIS607	CIS608	CIS609	CIS620 A	CIS620 B
Periodic progress report									ID	M
Cover letter for a report or proposal	I	D	D	D	D	D	D	D	M	M
Business plan	I			I	D	D	D	D	M	M
Test plan	I		I		I		I	D	D	M
Complete technical report	I	D		D	D	D	D	D		M
Technical description	I	D	D	D	D	D	D	D	D	M
Project notebooks or logbooks									ID	M
Poster /ppt Presentation									ID	M

Figure 2: Signature writing assignments mapping for MS in Information Systems Program

	SEM 601	ENE 601	ENE 604	SEM 604	ENE 605	SEM 606	ENE 607	SEM 608	ENE 608	ENE 609A	ENE 609B
Lab Report		IDM									
Test Plan	IDM	M									
One or more sections of Technical Report			I	I							
Complete technical report					ID	D	D	D	D	M	M
Technical description		IDM									
Poster /ppt presentation			I		I		D		D	M	M

Figure 3: Signature writing assignments mapping for MS in Environmental Engineering Program

Embed specific "signature" assignments in course syllabi to ensure implementation of the assignments as determined in steps 1-3 above.

In order to ensure that the intent of the IDM maps and the overall E^2Write initiative are always implemented fully, applicable course syllabi are individually modified to specifically incorporate writing assignments that match the designated IDM progression. These specified assignments are called "signature assignments." At NU, course syllabi are the fundamental documents controlling course content and course learning objectives (CLOs). (CLOs are appropriately related and linked to the overall PLOs for a program.) The inclusion of a specific writing assignment in a course syllabus ensures that this "signature assignment" will be included every time the course is taught, regardless of instructor or location. This is especially important for multi-campus systems and institutions such as NU that provide both multiple locations and multiple modes of program delivery – such as both "in-class" and "on-line". Instructors are generally free to devise their own approaches to structuring assignments in all aspects except for these specially-designated, required signature assignments.

Develop resource sets appropriate for each type of assignment, and provide for students to access these resources on an 'as needed' basis.

The best resource for students is the personalized assistance they can receive through NU's Writing Center. Through individualized, collaborative instruction, students establish goals and priorities for improving their writing, and work toward the accomplishment of those goals. They may, for example, focus on organization, clarity, sentence structure, APA style, or any

combination of these and other aspects of writing. In addition, there are other types of resources that may be of value for particular assignments. These may include references and guides for particular types of writing, especially since these are readily available online in most cases. Students can also learn by seeing examples of what might designate different levels of achievement in an assignment, such as copies of prior work that has received passing or outstanding marks. And, students can learn how to improve by having access to rubrics used to evaluate assignments. Examples of such evaluation rubrics are shown in figures 4 and 5.

Rubric for Research Papers

Student Name | | I | |

GRADES	**"A" range: Outstanding achievement; significantly exceeds standards** **5 POINTS**	**"B" range: Commendable achievement; exceeds standards for course** **4 POINTS**	**"C" range: Acceptable, solid achievement; meets standards for course.** **3 POINTS**	**"D" range: Marginal achievement; only meets minimum standards (Note: The "D" grade is a passing grade).** **2 POINTS**	**"F" range: Failure to meet minimum standards (Work that is not of "passing quality" should receive grade "F").** **0 POINTS**
(5 possible points for each) **APPROACH TO CONTENT** **Score:**	Unique topic or unique treatment of topic, takes risks with content; fresh approach.	Specific, original focus, content well handled. Significance of content is clearly conveyed.	Retains overall focus, generally solid command of subject matter. Significance is understood.	Topic lacks focus. Significance of content is unclear.	Ignores assignment. Lacks significance.
DEVELOPMENT **Score:**	Sophisticated, exceptional use of examples.	Good use of examples; Sufficient support exists in all key areas.	Subject matter well explored but may show signs of underdevelopment. Competent use of examples.	Some ideas may lack support, elaboration. Lacks sufficient examples, or relevance of examples may be unclear.	The topic has not been developed adequately. Little or no support provided.

GRADES	"A" range: Outstanding achievement; significantly exceeds standards 5 POINTS	"B" range: Commendable achievement; exceeds standards for course 4 POINTS	"C" range: Acceptable, solid achievement; meets standards for course. 3 POINTS	"D" range: Marginal achievement; only meets minimum standards (Note: The "D" grade is a passing grade). 2 POINTS	"F" range: Failure to meet minimum standards (Work that is not of "passing quality" should receive grade "F"). 0 POINTS
ORGANIZATION **Score:**	Original and "fluid" organization; all sentences and paragraphs contribute; sophisticated transitions between paragraphs.	Logical Organization. Has a competent transition between all sentences and paragraphs.	Structure is solid, but an occasional sentence or paragraph may lack focus. Transitions between paragraphs occur but may lack originality.	Organization is difficult to follow. Lacks logical flow of ideas.	Absence of logical structure and organization. Lacks coherence.
INTEGRATION OF RESEARCH (if required) **Score:**	Integration of quotations and citations is sophisticated and highlights the author's argument.	Quotations and citations are integrated into argument to enhance the flow of ideas.	Quotations and citations are integrated into argument. .	Support material may not be clearly incorporated into argument.	Includes plagiarized material (intentional or unintentional).
COMMAND OF ENGLISH LANGUAGE **Score:**	Confidence in use of standard English. Language reflects practiced or refined understanding of syntax and usage.	Conveys a strong understanding of standard English; the writer is clear in his or her attempt to articulate main points, but may demonstrate moments of "flat" or unrefined language	Competent use of language; sentences are solid but may lack development, refinement, style.	Expression is occasionally awkward (problematic sentence structure).	Sentence structure may interfere with meaning. Problems with writing at the college level.

GRADES	"A" range: Outstanding achievement; significantly exceeds standards 5 POINTS	"B" range: Commendable achievement; exceeds standards for course 4 POINTS	"C" range: Acceptable, solid achievement; meets standards for course. 3 POINTS	"D" range: Marginal achievement; only meets minimum standards (Note: The "D" grade is a passing grade). 2 POINTS	"F" range: Failure to meet minimum standards (Work that is not of "passing quality" should receive grade "F"). 0 POINTS
WRITING STYLE/SENTENCE STRUCTURE Score: Total Score:	Sentences vary in structure, very few if any mechanical errors (no serious mechanical errors).	May have a few minor mechanical errors (misplaced commas, pronoun disagreement, etc.), but no serious mechanical errors (fragments, run-ons, comma-splices, etc.).	Occasional minor mechanical errors may occur, but do not impede clear understanding of material. No serious mechanical errors (fragments, run-ons, comma-splices, etc.).	Mechanical errors may at times impede clear understanding of material. May have a few serious mechanical errors, but no recurring serious mechanical errors (fragments, run-ons, comma-splices, etc.)	Recurring mechanical errors. Mechanical errors impede understanding.

***Scales: Sum of Points** A=22.5-25, B=20-22.4, C=17.5-19.9, D=15=17.4, F=14 or below * **Average:** A=4.5-5, B=4-4.4, C=3.5-3.9, D=3-3.4, F=2.9 or below

Figure 4: Rubric for Research Paper

Criterion	Unsatisfactory 0-5.0	Satisfactory 5.1-7.5	Exceptional 7.6-10
Introduction	Did not provide a clear introduction that identified the problem statement.	Provided a clear introduction that identified the problem statement.	Well defined project.
Literature Review	Did not adequately summarize literature (if applicable).	Good summary of literature (if applicable).	Comprehensive literature (if applicable)
Methods	Did not adequately identify key indicators. Did not propose a clear strategy, or proposed an unrealistic strategy of how to solve the problem.	Adequately identified all key indicators. Proposed a clear strategy of how to solve the problem.	Adequately identified all key indicators and provided precise details to support their importance. Proposed a clear strategy and provided a detailed rationale for it.
Chronicle of Activities	Did not provide a clear chronicle of the activities that led to completion.	Provided a clear chronicle of activities that led to completion.	Provided a clear chronicle of activities that led to completion, as well as a brief rationale for each activity.
Mechanics	Paper is poorly written with many spelling and grammatical errors. No pagination.	Paper is written with a few spelling and grammatical errors. Proper pagination is provided	Paper is well written with no spelling and grammatical errors. Proper pagination is provided
Literary Sources	Did not cite sources in the reference section of the paper; None of the sources are literary (if applicable)	Did cite sources in the reference section of the paper; Some of the sources are literary (if applicable).	Did cite sources in the reference section of the paper; Several of the sources are literary (if applicable).

Figure 5: Rubric for Project Report (written part) from SSE 605

Status, Assessment and Plans

SOET's E^{2}Write initiative was conceived during the spring and summer of 2009, and detailed planning and implementation began in late summer. At the current time (December 2009) steps 1 through 3 (above) have been completed, and steps 4 and 5 are in progress. The plan is to complete step 4 for one-third of SOET programs by June 2010, with another third completed by December 2010 and the remaining third fully completed by June 2011. Step 5 is planned for completion by June 2010, although the intent is to continue to add resources on an ongoing basis as new examples of student work become available, new rubrics are developed, etc. All new programs developed in SOET will include the E^{2}Write approach as part of initial program development.

Assessment processes are also currently under development, and may be unique to each program. Dr. Fu is working with each program's Lead Faculty and with our SOET Assessment Committee to develop appropriate assessment plans. Comments, suggestions and recommendations related to this approach for improving writing skills, or to ways for assessing the success of this approach, will certainly be appreciated by the authors.

Anticipating the success of this E^{2}Write initiative, we plan in the future to introduce a similar initiative for helping our students achieve a greater level of excellence in technical presentations. Results obtained through E^{2}Write, and the development of a subsequent presentation skills improvement initiative, will be reported in future presentations and publications.

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