AC 2011-999: ENGINEERING COMMUNICATION ACROSS THE DISCIPLINES: USING ONLINE VIDEO MODULES TO STANDARDIZE INSTRUCTION AND EXPECTATIONS

Laura R. Grossenbacher, University of Wisconsin, Madison

Laura Grossenbacher is Director of the Technical Communication Program in the College of Engineering at the University of Wisconsin-Madison. She holds a Ph.D. in English from the University of Texas at Austin, and has been teaching courses in engineering communication for fifteen years. She has done consulting work in professional engineering writing for private firms (such as HNTB, Inc. and Affiliated Engineers, Inc.) and has taught technical communication as part of the UW-Madison College of Engineering study abroad program in both Toulouse, France, and Hangzhou, China. For the past several years her program has been collaborating with colleagues throughout the College of Engineering to design online modules to improve engineering writing across the curriculum.

Christina Matta, Technical Communication Program, UW-Madison

Dr. Christina Matta teaches in the Technical Communication Program at the University of Wisconsin-Madison, where she teaches introductory and upper-level technical writing classes along with courses in technical presentations and preparing grant proposals. She holds a Ph.D. in History of Science, Technology, and Medicine from the University of Wisconsin-Madison and worked with the Wisconsin Program for Scientific Teaching for six years before joining the Technical Communication Program.

Engineering Communication Across the Disciplines: Using Online Video Modules to Standardize Instruction and Expectations

Abstract

This paper explores the challenges of identifying faculty expectations for engineering communication skills, reinforcing those skills consistently across the curriculum, and assessing learning outcomes in undergraduate students through a series of online communication modules designed for mid- and upper-level engineering courses. The modules, which include learning objectives, instructional videos, interactive quizzes with feedback, and sample grading rubrics, can assist faculty in clarifying their communication expectations and, in turn, emphasize to students the importance of skills transfer between communication and engineering content courses by providing a consistent message across the curriculum. Our paper, therefore, will demonstrate our modules and share assessment strategies with a broader audience of engineering faculty who may face similar challenges, both with integrating communication skills into engineering courses and with developing consistent expectations for student work. We believe our online modules offer teaching materials and direct assessment tools for communication skills that others may find valuable – especially schools preparing for ABET review.

Introduction and problem

Literature on the importance of and challenges inherent in enhancing the communication skills of engineering students has proliferated in the past decade, fueled in part by the emphasis on communication assessment that began in 2000 with the change to ABET accreditation requirements. The National Academy of Engineering[1] claims that current and future engineers will need to communicate well with multiple stakeholders and convincingly shape public opinion; those abilities have become even more critical in the current economy. Many studies rank communication skills as one of the most important job skills, including those by the National Association of Colleges & Employers (NACE), which ranked communication skills first in importance for eight years running.

We therefore assume readers already appreciate the many reasons why engineering educators should be continuously seeking ways to improve students' communication skills. But the challenge today is how best to meet this need: we are looking for the most effective methods for improving the communication skills of engineering students *within* the constraints of an already full College curriculum. In the Technical Communication Program at the University of Wisconsin-Madison, we are seeking ways to better understand and align faculty expectations and communication pedagogy so that over time students perceive reasonable consistencies across multiple courses with different aims. The more we can understand and mutually reinforce good communication practices, the more likely students will ultimately be able to improve.

To address these problems, we have been collaborating with senior design faculty, providing classroom support when possible, holding small focus group discussions with faculty, and trying to develop targeted online learning tools that can be used in engineering design courses. Below we provide some background on the historical problem we have faced with the isolation of our required Technical Communication course from other courses (like senior design) that require writing in our College of Engineering. We outline efforts we have made in the past several years to bridge the gaps between these courses, beginning with identifying common expectations amongst faculty, and then working toward a more consistent communication pedagogy. As part of our effort to achieve consistency, we have been developing some online technical communication modules that can be used to mutually reinforce communication expectations across the College. While these modules are just one piece of a multi-pronged effort to collaborate with different engineering faculty, we believe they are a useful and efficient method for reinforcing some principles; thus, they might be attractive to others who face similar challenges in teaching and reinforcing engineering communication skills.

Communication in Colleges of Engineering: Why the stand alone technical writing course can't really stand alone[2]

We are aware of the multiple models currently used for teaching communication within Colleges of Engineering: at some institutions, English departments are the home for the required writing-intensive courses engineers take. At other institutions, writing instructors work alongside engineering faculty to provide teaching in engineering communication – either in lab courses, or in design courses. At UW-Madison, the Technical Communication Program is housed in and supported by the College of Engineering, and we teach a required, three-credit Technical Communication course that is taken by almost all of the engineering majors in our College (typically in their junior or early senior year). All told, we teach 600 - 700 engineering students per year in this class alone.

Although we are housed in our own College of Engineering, we face challenges similar to those described by other non-engineering faculty or instructors with specific expertise in teaching writing. Even where the writing-across-the-curriculum instructors have developed a fully integrated model for teaching communication within engineering design courses, they articulate concerns we share. Craig, Lerner, and Poe, of the Program in Writing and Humanistic Studies at MIT, have written about these shared challenges; they ask -- how can we help students "move from general academic writing . . . to internalizing the communication-thinking practices of professional engineers?" And how do we work collaboratively with engineering faculty when there is "a perceived split between teaching 'writing' and teaching 'content'"?[3] These questions drive our own efforts to improve the consistency of communication instruction across the engineering curriculum.

Our Technical Communication course is designed to provide instruction in "communication-thinking practices of professional engineers," but it is also (of necessity) a course about *interdisciplinary* technical communication, and that creates challenges for bridging the gap to the usually discipline-oriented senior design course. Because many different engineering majors take our course, we require that they write and speak in such a way that they can be understood by all of the others; the Mechanical Engineers must be able to talk to classmates who are studying Civil and Environmental Engineering, Industrial and Systems Engineering, Engineering Mechanics, Nuclear Engineering, or any other of the eleven undergraduate majors within our college – not including the students from other programs who venture into our class. All students, regardless of their major, must be able to describe their chosen technical projects using the jargon of their field but explaining those concepts well enough that all of those other engineers understand the value of the project; in fact, we hope they can begin to recognize important connections between the different fields of engineering. The most challenging problems facing engineers of the future will require interdisciplinary work – so we feel it is critical that our engineering students be challenged to improve their interdisciplinary communication skills. Students in our course design and develop their own term project over the semester, delivering a memo, a proposal, presentations, a progress report, and a lengthy major technical report – working all along with peers to ensure that their communication is accessible and compelling to those outside of their field. But when students leave our course to move on to more discipline-specific content courses, some of them have difficulty applying the writing skills they have developed to those discipline-specific demands.

The reasons behind this problem with skills transfer between technical writing courses and the engineering "content" courses may be multiple and complex, and the problem is by no means isolated to our College. Richter and Paretti have written about this same problem as being based in "disciplinary egocentrism," meaning that there are "cognitive barriers engineers face" when they move from "interdisciplinary contexts" to more discipline-specific contexts (p.37).[4] Bonk, Imhoff, and Cheng describe the work they have done to integrate writing more effectively in their curriculum, nothing that "true integration of writing into the curricula depends on interrelating courses more fully than just as prerequisites or corequisites"(p. 156).[5] They, like many, have employed the model of bringing writing faculty into their senior design courses to co-teach, effecting a skills transfer through direct instruction. Because budget and time constraints prevent us from working directly within senior design classes, we have been working on less costly methods for improving skills transfer. Our efforts target the development of shared expectations and shared language between our courses and the engineering "content" courses: we think students will begin to see strong relationships between our classes when they see shared patterns of expectations.

Because the problem with skills transfer between courses is to the students' disadvantage, our program has been working to overcome this split between technical writing and "content" proficiency. Our efforts are part of a larger, college-wide initiative that began in 2004 and 2005, when our College deans formed a Task Force of committed administrators and faculty who began holding listening sessions and urging all faculty to address the challenges facing engineers for the future.[6] These discussions at the College level included an emphasis on the importance of improving interdisciplinary work and improving engineering communication skills; these skills received even more attention as we prepared for our ABET re-accreditation visit of 2006. Concurrently, enrollment in the College of Engineering began to climb, resulting in larger class sizes for many faculty teaching senior design. With even more students, design faculty really began to become more concerned about the increased time that they were investing in reading and grading lengthy team-written reports, especially when those reports were poorly written. This confluence of events eventually meant greater faculty interest in collaborating with the Technical Communication Program to develop strategies that would produce better student writing.

As we have pursued these collaborations, the depth of the split between "writing" and "content" courses has become clearer. Some of this split comes from a lack of consistent discourse about writing – in particular, we appreciate faculty who simply admit to us, "I'd like to comment on the writing, but I don't always know why it doesn't work. I just know good writing when I see it." Such faculty recognize both individual issues in student writing and the global problem of supporting effective communication, and usually they want to be part of the solution. Some of our faculty take a very active role in guiding student writing; they spend a great deal of their time commenting on papers, but ever-growing course sizes (and the subsequent rise in the number of teams or students per team) have challenged their ability to devote ample time to working on communication tasks either in or out of class. Faculty therefore want strategies to help students understand the connections between our courses and theirs – an acknowledgement that if students can successfully transfer the skills they are developing in our course, the writing they produce in their engineering courses will clarify rather than obliterate the technical content.

But in senior design courses, where expectations for the design and prototypes alone are multiple and complex, writing may take a backseat to technical competence. Some design faculty (even those with years of experience) tell us that they "just try to ignore the writing and grade the engineering"; others may address problems with the writing, but in the end, "only take points off if the engineering is wrong." Such approaches, though certainly born of necessity given rising class sizes, may contribute to student tendencies to marginalize the importance of good engineering communication and encourage them to hastily prepare their reports without sufficient attention to the writing. Faculty have voiced their frustration in our meetings; their main message is that they require writing in their courses, but they do not have sufficient time to teach it. Some have confided that they do not feel qualified to provide focused instruction in communication skills – an understandable perspective. Unfortunately, given these pressures, the one required technical communication course alone does not provide enough practice that students can easily apply what they have learned in a different context.

The difficulty students have in transferring skills between courses is not unusual to our College, or to communication instruction itself: Marie Paretti, co-director of the Engineering Communication Center and director of a departmental engineering communication program at Virginia Tech, argues that students faced with new learning contexts will often experience lapses in basic skills in which they would otherwise excel, regardless of whether the new context is one specifically focused on communication or engineering content.[7] For example, students who may perform well in an upper-level Thermodynamics course may go on to make basic calculation errors early in their engineering design courses. Paretti calls such lapses a "disjunct in pattern recognition" – that is, students do not immediately see the relevance of the skills that they've developed in a previous course because they are struggling to understand the new context. Understanding how previously learned skills apply to that new context becomes a secondary concern. Of course, some students will see the patterns and leap that skills gap themselves, but a good number of them may need help recognizing the pattern and seeing its relevance in the new context.

Skills transfer of any kind can be complicated by unpredictable enrollment patterns and by student tendencies to compartmentalize their education. The pre-requisites for our upper-level communication course and advising/course plans try to mandate that students enroll in our Technical Communication course in their junior year, so it can be followed with (perhaps) a summer co-op position (where writing or presenting is often required), and then senior-year design courses. This ideal scenario ensures that students will have practice in writing in several different contexts over multiple semesters; our expectation is that students will continue to build on what they have learned in our class through this progression. Some of our students, however, enter the College of Engineering with enough Advanced Placement credits to hold junior status after only one year of coursework on campus; if these students decide to take our course, then there may be a two-year gap before they take a senior design class. If they have not had opportunities to practice their communication skills in the meantime, they may be starting nearly anew in senior design – as seen in exasperated complaints from senior design faculty, who want to know why students who have taken a Technical Communication course still cannot write a coherent, effective design report.

Students faced with a demanding curriculum can forget a lot of instruction in the space of one or two years, and not clearly articulating the explicit connections between courses can exacerbate this problem. We know that students are unlikely to apply what they have learned years or even semesters earlier if faculty do not provide reminders of that past learning or do not emphasize skills acquired in other classes. Our goal, then, has been to work toward a common language and a set of mutual expectations so that engineering faculty can meaningfully require students to implement some of the strategies they have practiced in our courses.

Determining engineering faculty expectations for writing in senior design courses

We began our efforts to provide this common discourse by trying to understand what engineering faculty expect of student writing and presentations in their courses. In Fall 2007 and Spring 2008, we teamed with two senior design faculty to teach linked sections of Technical Communication and senior design – a collaboration that required redesigning our own course, asking students to take these courses back to back, and then trying to help guide the students all year by providing writing support. This collaboration was particularly useful in understanding the skills gap: we found that as well-intentioned as we all were, senior design faculty don't typically use language in their assignments or grading rubrics that emphasize specific communication skills. They might include a criterion such as "project is well justified" in their grading rubric – a criterion we share in our communication courses – but they do not usually break this criterion into component parts.

In contrast, the rubrics in our communication courses are more specific in describing the different criteria we consider necessary for a well justified project – for example, our rubrics would ask for logically ordered and connected ideas, careful analysis of and appreciation for audience needs, credible evidence to support claims, and unified and well developed paragraphs. Such detail may seem superfluous to faculty, but we have found that students respond well to having such specific language in the assignment descriptions and in the grading rubrics. Understanding more precisely what we expect frees students to concentrate on meeting those requirements rather than interpreting them. Students likewise respond well to annotated samples of past projects so they can see where others have successfully demonstrated these desired skills. If a grading rubric indicates only that a document needs to be "well written" and delegates only a small portion of the overall grade to the writing, then students are not held sufficiently accountable for communicating their design effectively. Specifying what we (as instructors) want in our written assignments is key, and students need to understand that weak writing affects how well their engineering ideas and decisions can be understood and implemented.

Given the discontinuities between communication and design courses, we decided to launch a College-wide Faculty survey to develop a firmer and broader understanding of what our engineering faculty expect in good communication. This survey, launched in Spring 2009, specifically targeted senior design faculty and any other faculty who assess student writing in an undergraduate engineering course. We asked our faculty to comment on 17 communication skills – a list we created collaboratively within our program based upon discussions with our Industrial Advisory Board members as well as our own teaching practices. These skills are listed in Table 1, below.

Table 1. Skills included in Spring 2009 faculty survey.

Giving clear, organized, and credible presentations
Creating a well organized document
Communication to a diverse/multidisciplinary audience
Integrating research into a report
Explaining one's design decisions
Creating and integrating effective graphics
Providing clear technical descriptions
Providing logical transitions between ideas
Unifying paragraphs
Providing constructive criticism for peers
Writing or presenting effectively as a team
Listening and participating productively in a team meeting
Thinking critically about political, social, and economic constraints
Thinking critically about ethical ramifications
Writing effective email
Employing audience-appropriate tone and style
Using proper grammar, punctuation, and spelling

We then asked our engineering faculty first to rank how important or useful these skills are for engineering students to master. Forty-one faculty took the survey, and they ranked "giving clear, organized, and credible presentations" and "creating a well-organized document" as the most important skills for engineering students to have. (Figure 1 shows how faculty ranked seven of the 17 skills.)

	Important	Useful	Not very important
Giving clear, organized, and credible presentations	98% (40)	2% (1)	0% (0)
Creating a well-organized document	95% (39)	5% (2)	0% (0)
Communicating to a diverse/interdisciplinary audience	78% (32)	22% (9)	0% (0)
Integrating research into a report	76% (31)	24% (10)	0% (0)
Explaining one's design decisions	85% (35)	12% (5)	2% (1)
Creating and integrating effective graphics	76% (31)	22% (9)	2% (1)
Providing clear technical descriptions	82% (33)	18% (7)	0% (0)

Figure 1. Sample faculty responses to the Spring 2009 College of Engineering Faculty Survey. This question asked faculty to rank the importance of 17 communication skills. (Only seven of those 17 skills are shown here.)

After faculty ranked the usefulness of those skills, we asked them to rank how their students typically perform on the same 17 skills. In other words, we asked them to think about the writing outcomes that they see, and whether students typically exceed, meet, or do not meet their expectations (Figure 2). These results helped us identify which areas may need significant student improvement (according to engineering faculty). For example, faculty ranked "creating a well-organized document" as one of the top two engineering skills, but noted that their students *exceed* expectations only five percent of the time. Furthermore, 53% of the faculty felt their students do *not meet* their expectations for this skill. This result, which is consistent with our own experience, indicated that students need additional training in organizing documents.

	Students exceed my expectations.	Students meet my expectations.	Students do not meet my expectations.	Not applicable in my class.
Giving clear, organized, and credible presentations	12% (5)	51% (21)	17% (7)	20% (8)
Creating a well-organized document	5% (2)	37% (16)	53% (23)	5% (2)
Communicating to a diverse/interdisciplinary audience	0% (0)	39% (16)	22% (9)	39% (16)
Integrating research into a report	2% (1)	38% (16)	38% (16)	21% (9)
Explaining one's design decisions	2% (1)	41% (17)	37% (15)	20% (8)
Creating and integrating effective graphics	17% (7)	39% (16)	34% (14)	10% (4)

Figure 2. A sample from the same Spring 2009 Faculty Survey. In this question, we asked faculty to rank how well their students *typically perform* on the same 17 communication skills.

Once we had our results, we weighed the "importance" of each skill against our faculty's perceptions of student performance on each item to determine what student weaknesses we could help faculty address. Regardless of the importance faculty assigned to these skills, students only rarely exceeded expectations; in addition, weighing the average importance faculty assigned against their average assessments of student performance suggested that all seventeen of these skills are areas in which more instruction is warranted (see Figure 3 for a plot of usefulness against importance for many of the key performance criteria).

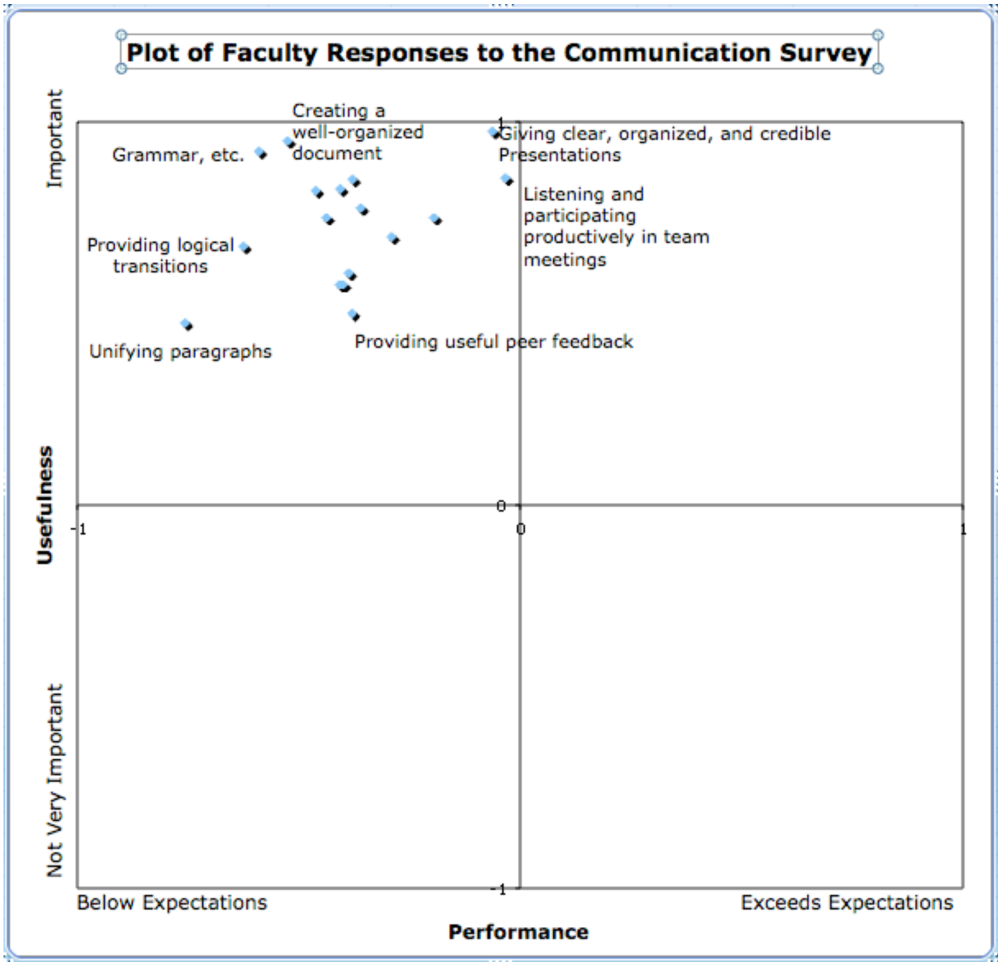


Figure 3. Environmental plot of the importance of these communication skills vs. student performance on these skills. This plot shows the overall average importance of all in relationship to the average assessment of student performance. Even those skills that exceeded expectations for which some faculty show need for improved training. (Created by Thatcher Root, Ph.D.)

The survey results also indicated a certain inconsistency in how engineering faculty conceptualize communication tasks. While faculty believe "creating a well organized document" is **both** very important **and** an area where many student do not meet expectations, they do not rank "providing logical transitions" or "unifying paragraphs" nearly as high in importance. Yet a paper with poor transitions or disunified paragraphs will often mean the paper is not well organized overall. This suggested that we could work on some strategies that would help faculty emphasize what they mean by "well organized document" – to show that emphasizing transitions and unified paragraphs is a more specific way of articulating their expectations.

We are not relying on the Faculty Survey alone to determine areas in which students need help with skills transfer; over the past several years, we have been holding a series of focus groups and meeting individually with faculty. In these sessions, faculty often will come back to issues like "creating effective slides for presentations" and "integrating graphics and equations" as weaknesses that are common in undergraduate writing. Some faculty have pointed out that "writing effective introductions" and "writing executive summaries" – two tasks we did not include in our survey – are also often not handled well by students. These ongoing discussions have helped us identify further weaknesses in communication that could use reinforcement.

Background literature on using online learning modules

Our goal, therefore, is to bridge what we perceive as a skills gap on the part of the student and a time constraint on the part of engineering faculty (meaning, many faculty simply cannot take extra time to teach these skills). Because of the enrollment irregularities that we've described previously, we targeted two groups of students in particular: those who have not taken our Technical Communication course before enrolling in senior design, and those who *have* taken our course, but who may need a "refresher" to complete communication tasks posed in design courses or in their co-ops. To address faculty time constraints, we sought a method of providing communication instruction within the confines of design courses so that faculty did not need to use class time for lectures on writing strategies. For us, that meant designing meaningful online materials.

A significant body of research documents the use of online teaching as a way to address shrinking budgets, time constraints of faculty, increasingly non-traditional schedules of students, and the diversity in student learning styles[8,9]; our question, however, is whether online teaching materials can help us effectively teach and assess some core concepts in *communication*. Instructors in our program (like many) already use course websites as repositories for course readings, presentation slides, lecture notes, online class discussions, and student paper dropboxes, but we felt we needed modules that could be self-regulating, in the sense that instructors would not need to read and respond to student writing (as we already do a great deal of that in our classes). In essence, we wanted videotaped lectures reinforced by online quizzes, to help us ensure students are doing the work – and we wanted quizzes that would not only assess learning but actively teach students concepts, too.

Meaningful quizzes are critical to the value of the modules. Parson *et.al.* have indicated that students can improve test scores in many subjects when they have the option to watch videotaped lectures of core concepts, especially if class time afterward is used for discussion and application of those concepts.[10] Karpicke and Blunt have argued that retrieval of information through testing can be a very powerful way of reinforcing key ideas, and that "the act of reconstructing knowledge itself enhances learning."[11] From our own observations, we know engineering students, in particular, will have heightened awareness of skills that they believe will be on a test. So, we went to work writing quizzes for our online lectures that would provide our students with meaningful learning about communication concepts.

Communication quizzes are being used online in a number of different contexts already. Certainly, English as a Second Language schools have for years been using online tools and quizzes in particular to enhance learning and retention of language, and as Mello indicates, the quizzes can motivate students.[12] More relevant to our concerns is an online communication simulation environment (known as WriteSim TCExam) being developed by Duke University: their effort is to provide simulations of scientific research publications accompanied by quizzes that require students to identify strengths and weaknesses in the texts. This work is designed for biomedical graduate students to improve their identification of problems and thus improve the writing of their own publications. The simulated manuscripts and quizzes help novice researchers learn to identify strengths and weaknesses in scientific writing, with some emphasis on problems of organization and purpose in the texts. This approach requires that students read passages with a variety of typical errors, selecting answers that identify or correct those errors; after answering the questions, students are given immediate feedback that enables them to learn from the test itself.[13] Preliminary assessment of their simulated communication modules demonstrate that students make definite improvement in their own writing after using the modules. While our program is using a Moodle environment, much of what is done in the WriteSim simulation environment can be duplicated in Moodle, and indeed, our approach is very similar, but it is aimed at an undergraduate engineering audience.

Providing a common discourse for the College through online communication modules

With funding provided through our College, we devised web-delivered video modules that can be used across the College of Engineering to reinforce best communication practices and that are flexible enough to serve the needs of multiple courses and faculty members throughout CoE. These modules can provide engineering faculty with the tools they need to make good communication an explicit requirement in their courses *without* adding additional classroom instruction to already full course syllabi. (It should, however, be noted that the modules are short instructional pieces that are not intended to replace the more extensive training provided in a full communication course; these modules are merely supplements, and work best when used as such.)

Based upon our discussions with faculty, we chose the following topics for our modules: Macro-Organizing Technical Documents, Micro-Organizing Technical Documents; Integrating Graphics into Documents; and Designing Slides for Technical Presentations. In addition to these topics, we have also added Writing Introductions to Technical Reports, Argument and Persuasion in Proposal Problem Statements, and Using Equations in Documents. Each module includes a set of learning objectives, so that faculty and students can quickly grasp the purpose of the module; narrated slide presentations of varying lengths; PDF copies of the slides with their accompanying scripts; online quizzes that provide immediate constructive feedback; and sample rubrics that faculty can integrate into their own grading criteria. Because the College of Engineering uses a Moodle-based course management system, the individual components (or the entire module, if desired) can be easily integrated into individual course homepages.

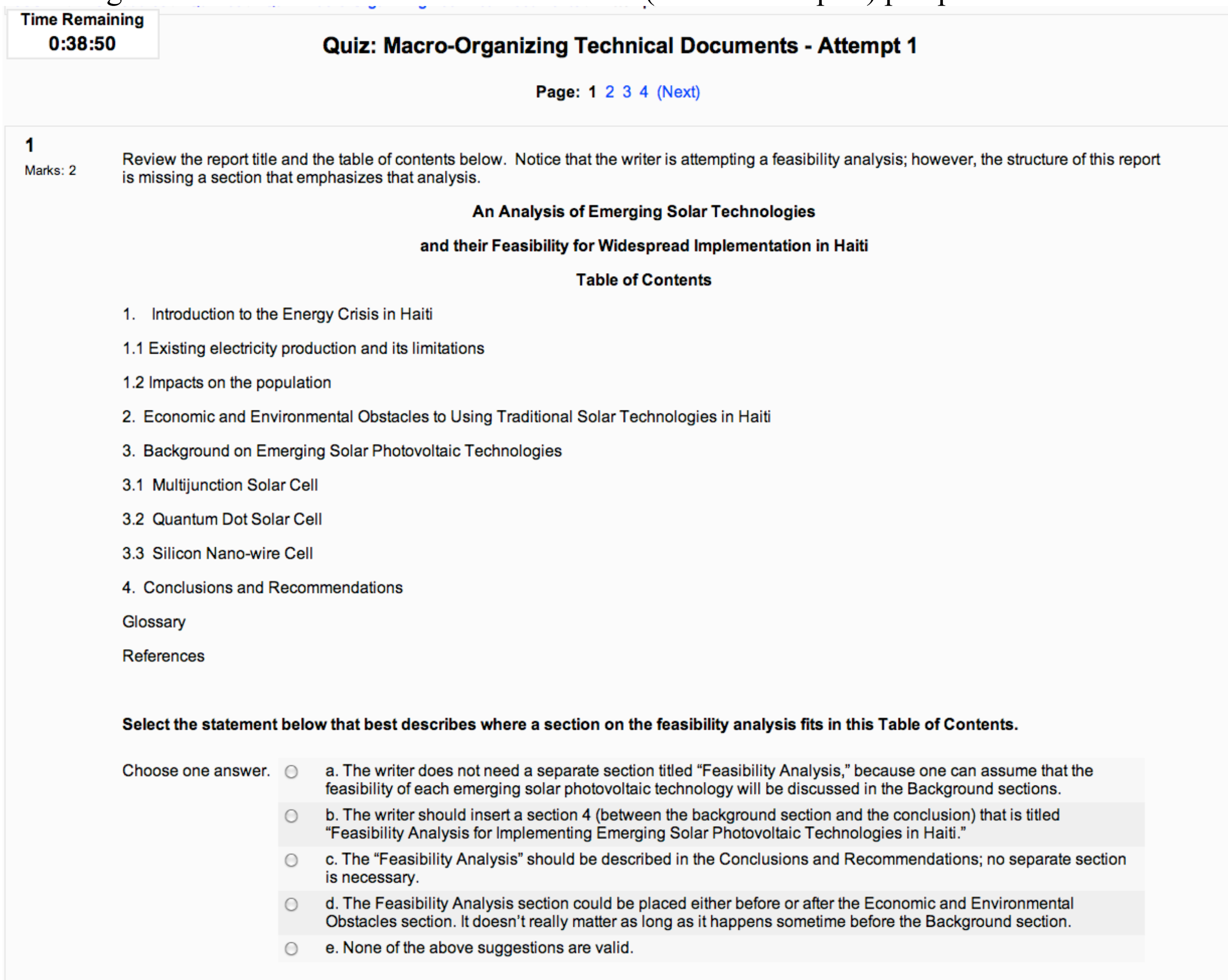
Each narrated slide presentation is between 15 and 30 minutes long, and features an instructional slideshow that both presents basic concepts, as in a more traditional classroom lecture, and analyzes some samples drawn from published work and past student papers. Using both negative and positive examples allows students to compare strengths and weaknesses and to see the principles presented in the module applied to “real” written work. The quizzes then draw upon these examples and use the same concept terms as the learning objectives and the video to promote consistency and skills transfer. The quiz questions are drawn at random from a bank that contains multiple questions for each learning objective, ensuring that students cannot easily share answers with other students in the class (especially useful if they are taking the quiz in a public computer lab). The random questions confer an additional benefit if instructors allow students more than one attempt at the quiz: rotating the questions requires students to apply the feedback they receive to a different writing situation. As a result, students cannot easily avoid the wrong answer the second time. Instead, they must apply their knowledge – supplemented by the reasoning and commentary they received from their first, incorrect answer to a slightly different problem on the same topic. This process helps (but does not entirely) rule out gains in student performance that are the result of crafty quiz-taking skills rather than actual learning gains.

These quizzes serve multiple learning purposes; on the most basic level, they emphasize the importance of the module by assigning a point value to the activity, thus attracting students' attention. The point value assigned to the quizzes helps students understand that this activity, while supplemental, is still important enough to confer credit for satisfactory completion and should be taken seriously. The quizzes are automatically graded and collected in Moodle's gradebook, thus minimizing administrative work for faculty. In this context, the quizzes provide an easy way to judge student competence in the communication tasks targeted in each video.

Second, these quizzes require that students apply the knowledge they learn from the video to the same sort of writing problems they will need to identify and address successfully in their written work. Unlike more traditional multiple choice quizzes that may focus on definitions or generalized applications, we ask students to analyze a piece of writing, then choose an answer that best identifies the problem therein and/or the best solution for the problem. In this approach, students can see concepts such as strong transitions, unifying topic sentences, or carefully framed graphics in the very contexts in which they would appear in a paper, rather than as disembodied, theoretical questions. This context, we believe, enables students to more readily identify in their own papers the situations that call for certain writing strategies.

The Macro-organization video, for example, demonstrates the need for strong, logical connections between individual sections of a technical document. These connections should be evident through carefully crafted transitions in the main text, but they should also be immediately discernable in the Table of Contents. Many readers (particularly in industry) use the section headings listed in the Table of Contents to help them find specific areas of interest in a lengthy document, so it is important that these headings display a logical structure or progression to the sections. Vague or poorly ordered section headings can obscure the document's narrative or mislead the reader about the content of the paper, thus weakening the overall argument.

With this in mind, the Macro-organization quiz includes a question that presents students with a sample Table of Contents for a feasibility analysis, then asks them to decide the best location in the document for the actual analysis (Figure 4). The answers are more than just a list of possible locations, however; instead, they propose different locations *and* a reason for suggesting that location. These reasons reflect some of the common thought processes we have seen as we discuss drafts with our students; often, creating a logical scaffold for a document involves identifying what assumptions the author makes about the audience's expectations. If we ask students to think carefully about why they have chosen to use a particular strategy or approach to ordering their ideas or the sections of a document, they must confront their own assumptions about logic and view their work from the reader's (often non-expert) perspective.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Quiz: Macro-Organizing Technical Documents - Attempt 1

Page: **1** 2 3 4 (Next)

1
Marks: 2

Review the report title and the table of contents below. Notice that the writer is attempting a feasibility analysis; however, the structure of this report is missing a section that emphasizes that analysis.

An Analysis of Emerging Solar Technologies

and their Feasibility for Widespread Implementation in Haiti

Table of Contents

1. Introduction to the Energy Crisis in Haiti

1.1 Existing electricity production and its limitations

1.2 Impacts on the population

2. Economic and Environmental Obstacles to Using Traditional Solar Technologies in Haiti

3. Background on Emerging Solar Photovoltaic Technologies

3.1 Multijunction Solar Cell

3.2 Quantum Dot Solar Cell

3.3 Silicon Nano-wire Cell

4. Conclusions and Recommendations

Glossary

References

Select the statement below that best describes where a section on the feasibility analysis fits in this Table of Contents.

Choose one answer.

a. The writer does not need a separate section titled "Feasibility Analysis," because one can assume that the feasibility of each emerging solar photovoltaic technology will be discussed in the Background sections.

b. The writer should insert a section 4 (between the background section and the conclusion) that is titled "Feasibility Analysis for Implementing Emerging Solar Photovoltaic Technologies in Haiti."

c. The "Feasibility Analysis" should be described in the Conclusions and Recommendations; no separate section is necessary.

d. The Feasibility Analysis section could be placed either before or after the Economic and Environmental Obstacles section. It doesn't really matter as long as it happens sometime before the Background section.

e. None of the above suggestions are valid.

Figure 4. Screenshot from online module quiz. In this example, taken from "Macro-organizing Technical Documents," students must read an existing Table of Contents and choose from five options the best location for a feasibility analysis.

The most important learning purpose the quizzes serve is to provide students with immediate commentary on their solutions to these writing problems. Though the value of multiple-choice questions in encouraging critical thinking has been hotly contested, the quizzes' ability to provide immediate feedback encourages analytical thought. In these quizzes, we ask students to pick the best option from a set of answers with the understanding that the best option in the list may not be the perfect approach for solving the problem at hand. As a result, students cannot easily identify the "right" answer from the list by eliminating the purely ridiculous or picking out the answer that is clearly perfect. Instead, they must think carefully about why any individual answer might be correct *and* about why that same answer might be incorrect. Students must therefore take into consideration the existing text presented in the example, the purpose that text serves, and its specific goals – factors that influence which option best solves the problem posed, even if an absolute ideal is not present. Such critical reasoning is essential not just for success on any subsequent attempts at the quiz, but also for successful use of the strategies presented in the modules in written documents.

We provide this commentary for incorrect and correct responses alike. Students who selected an incorrect answer to the question above would see the following commentary once they have submitted their responses (Figure 5):

Select the statement below that best describes where a section on the feasibility analysis fits in this Table of Contents.

Choose one answer.	○ a. The writer does not need a separate section titled "Feasibility Analysis," because one can assume that the feasibility of each emerging solar photovoltaic technology will be discussed in the Background sections.	
	○ b. The writer should insert a section 4 (between the background section and the conclusion) that is titled "Feasibility Analysis for Implementing Emerging Solar Photovoltaic Technologies in Haiti."	
	⦿ c. The "Feasibility Analysis" should be described in the Conclusions and Recommendations; no separate section is necessary. ✗	Incorrect. While students often combine such analyses with their recommendations, this is not a logically sound practice. Writers need a separate section emphasizing their feasibility analysis, and they would draw conclusions and recommendations AFTER that analysis. That separate section is particularly important because the title of the report announces that this document will do that work.
	○ d. The Feasibility Analysis section could be placed either before or after the Economic and Environmental Obstacles section. It doesn't really matter as long as it happens sometime before the Background section.	
	○ e. None of the above suggestions are valid.	

Figure 5. Quiz feedback for an incorrect answer. The commentary in the right-hand column explains why that answer is correct and gives students some guidelines for choosing the correct answer.

In this example, the commentary explains why the answer is incorrect and gives students some additional guidance to help them select the correct answer. Students who selected the correct answer on the first attempt would receive positive commentary, as seen in Figure 6:

Select the statement below that best describes where a section on the feasibility analysis fits in this Table of Contents.

Choose one answer.

- a. The writer does not need a separate section titled "Feasibility Analysis," because one can assume that the feasibility of each emerging solar photovoltaic technology will be discussed in the Background sections.
- b. The writer should insert a section 4 (between the background section and the conclusion) that is titled "Feasibility Analysis for Implementing Emerging Solar Photovoltaic Technologies in Haiti." ✓

  Correct. We argue in the module that key elements in the report require emphasis. Thus, the writer needs a separate section emphasizing the feasibility analysis -- particularly since the title of the report announces that this document will do that work. Placement of that analysis after the background and before the conclusions shows the most logical approach.
- c. The "Feasibility Analysis" should be described in the Conclusions and Recommendations; no separate section is necessary.
- d. The Feasibility Analysis section could be placed either before or after the Economic and Environmental Obstacles section. It doesn't really matter as long as it happens sometime before the Background section.
- e. None of the above suggestions are valid.

Correct

Figure 6. Quiz feedback for a correct answer. Here, the commentary recalls the material presented in the video and explains why this answer is correct.

This commentary helps students understand *why* their response is correct, not just that it *is* correct – thus providing reasoning that students can use in making decisions about their own writing. In this way, students can learn from the modules even if they selected (or guessed!) the correct answer on the first try: the commentary may add an additional dimension to their understanding of the concepts presented in the video, and students who guessed the correct answer at random will be able to see why that answer is correct. If instructors choose to allow multiple attempts for the quizzes, then students can apply the feedback directly to the writing problem presented in the next attempt. (Rotating the questions and, in some cases, the order of the answers between attempts helps prevent students from simply ruling out that option and guessing a second time.) Under our current settings, students who selected the incorrect answer would not see the correct answer until the quiz is closed to further attempts, discouraging them from providing the answers to other students and from uncritically entering the correct answers on a subsequent attempt (a practice also complicated by the rotating questions).

Providing feedback that includes the correct answer and the explanation of that answer also allowed us to address directly one of the most significant challenges of teaching writing: the common misconception among engineering students that written communication is entirely subjective. Engineering students in particular are often convinced that applying strategies for written communication is entirely subjective, thus giving them a convenient reason to dismiss communication training as unimportant. We therefore sought to demonstrate through these quizzes that even though the application of a specific writing strategy may vary between different genres or purposes, the criteria for strong, persuasive writing themselves can indeed be sufficiently generalized into a solid set of expectations. Offering the rhetorical underpinning for both correct and incorrect answers, we hope, gives students a writing strategy that is general enough to encompass most instances of a certain writing task, regardless of purpose and audience. If the title of a document includes the words "Feasibility Study," to use the example above, then the audience will expect to see a specific reference to an actual assessment of feasibility; in a broader context – that is, beyond the example posed in the quiz – the overall content and organization of a document should explicitly match the audience's expectations as set by the title and table of contents.

Preliminary results of our 2010 video module project

We piloted three of these modules as a required assignment in four sections of our Technical Communication course in Spring 2010 (and have continued to develop them and use them in subsequent semesters): Macro-organization of technical documents, Micro-organization of technical documents, and Integrating graphics into documents. Our data at present are still preliminary, but both quantitative and qualitative results suggest that the modules can help improve student performance in individual sections of an upper-level technical communication class.

This result was evident in our initial assessment of quiz scores in the Micro-organization module. Our assessment involved collecting pre-confidence and performance data across five sections of our course, with 111 quiz attempts from 74 students (though approximately 35 students across these five sections did not take the quiz). Though we had intended that all classes would have access to the individual components of the modules, unexpected technical issues kept us from assessing the results uniformly across all students. As a result, students in the first two sections were to watch the video prior to taking the quiz, but the commentary on responses to the quiz questions was not available. For these two sections, comprising 41 quiz attempts by 27 students, performance on the quizzes was nearly identical between the first and second attempts – averages of 3.66 of 5.0 possible points and 3.67 points respectively.

In the remaining three sections, however, the video was unavailable (due to a file encoding problem). Students in these sections did take the quiz and receive commentary on their responses that they could use towards a second attempt. In these sections, comprising 71 attempts by 47 students, we saw a noticeable improvement in the average quiz scores between students' first and second attempts at the quiz independent of the video: a rise in score from 3.44 of 5.0 points to 4.19. The difference between the student scores in the first set of sections and that of the second set of sections suggests that the constructive commentary on the quiz responses may indeed contribute to an increase in student performance between first and second attempts – even in the absence of the video.

Anecdotal evidence based on student reports submitted in both the Spring 2010 and Fall 2010 semesters likewise indicate that the modules do effectively supplement in-class instruction and guidelines provided through course readings. Modules addressing very specific tasks – such as integrating graphics into documents – provided the most immediate, measurable benefit to students. One author keeps copies of many final technical reports from previous semesters, and is easily able to demonstrate a stark contrast between the reports that were turned in for her class prior to assigning the modules and those submitted in Spring 2010 and Fall 2010. In particular, the students who were required to complete the module and quiz on integrating graphics into documents handled the figures in their papers in a much more consistent and comprehensive way. She estimates that 75% of her students had problems managing figures before 2010, even though she covered the material in class and assigned readings that explained the requirements for using images. In contrast, the students who viewed the graphics module and took the quiz in 2010 simply demonstrate a better understanding of expectations for introducing a figure and writing a useful, meaningful figure title and caption. With very few exceptions, the students in 2010 integrated their graphics more effectively than students in previous semesters – perhaps a sign that the retrieval practice provided by the quiz helped improve student performance, echoing the results of a recent study from Purdue University.[14]

Our results should be considered in light of the fact that the graphics module is, in some respects, a formula that students can follow for integrating graphics effectively, whereas the modules on organizing a paragraph or a document target areas of student achievement that improve best with extended, repeated practice. Even though students who watched the graphics module did provide more specific and focused information in the caption of the graphic itself, they still showed need for further practice in performing more complex tasks, such as providing sufficient framing and context for the graphic in the main text of the document. This conceptual problem suggests that the modules are sufficient on their own only if the task at hand can be easily reduced to a formulaic process – these modules are helpful, but for more complex communication tasks, a larger instructional program is necessary. In other words, there is no getting around the importance of providing useful feedback on student writing.

Conclusions and future directions

Though we are still revising and assessing the modules, preliminary data show that they are effective in providing students with instruction and a consistent language in some tasks common to engineering education. Even so, we do not intend them to replace formal instruction, either in a focused communication course or in courses within individual engineering disciplines; they cannot substitute for the kind of individualized writing instruction that is critical to the writing intensive technical communication course. The modules could be used, however, as a supplement in engineering courses that focus on a technical design project, where faculty have little time to devote to in-class writing instruction. In addition, even with these generalized modules as supplements, faculty must still clearly articulate their expectations for written documents through their assignment descriptions and their grading rubrics; using the same language to refer to these writing tasks across multiple courses will remind students that they are in fact familiar with such tasks and help reinforce the importance of effective communication in engineering.

The very process of creating and revising these modules has been a valuable experience for our technical communication program. Even from the early stages, we surveyed and met with CoE faculty to identify areas in which students need additional communication instruction. We have begun to act more as liaisons to individual faculty members and departments, addressing individual faculty concerns about communication instruction, providing a common language for discussing communication proficiency, and aligning expectations across multiple departments. We feel a good deal of work lies ahead, because our modules can always be made even more useful – but the process of creating them has helped foster a culture of collaboration in our College.

Such a culture of collaboration is especially important for institutions that are preparing for ABET review and are therefore seeking to demonstrate the ways in which their curriculum integrates instruction in communication. As we prepare for our own ABET review, we plan to continue to meet with engineering faculty, improve our modules, and encourage their use in more courses. Our idea is that with more widespread use, we will be able to identify key performance criteria for engineering communication that cut across the College; having a more consistent language for those performance criteria should make outcomes easier to align, assess, and document.

While we began this project as part of our own preparation for ABET, we believe that our modules may help introduce other Engineering colleges develop a consistent set of performance criteria. Towards this end, our Technical Communication modules will be available for general dissemination beyond the UW community beginning in September 2011. Faculty interested in sampling the modules should contact the authors for more information; the complete modules (learning objectives, video, script, quiz, and grading rubric) can be readily imported into any Moodle-based course management system via Zip file, as can individual components of the module. With the exception of the quizzes, each individual component is available as a file for instructors who are using non-Moodle systems; instructors who would like the quizzes in a different format should contact the authors.

Ultimately, integrating these modules into engineering design or content courses can demonstrate to students that faculty consider communication to be paramount in engineering practice, even if instruction in communication does not figure prominently in classroom sessions. The modules cannot replace formal instruction entirely, but they may provide a means of filling critical gaps in instruction for students and faculty alike.

References

[1] National Academy of Engineering, *The Engineer of 2020: Visions of Engineering in the New Century*. Washington, DC: National Academies Press, 2004.

[2] M. Carter, C. Anson, and C. R. Miller. "Assessing Technical Writing in Institutional Contexts: Using Outcomes-Based Assessment for Programmatic Thinking." *Technical Communication Quarterly*. Vol. 12, No.1 (Winter 2003), pp. 101-14.

[3] J. Craig, N. Lerner, and M. Poe. "Innovation Across the Curriculum: Three Case Studies in Teaching Science and Engineering Communication." *IEEE Transactions on Professional Communication*, Vol. 51, No. 3 (September 2008), pp. 280-301.

[4] D. Richter and M. Paretti. "Identifying Barriers to and Outcomes of Interdisciplinarity in the Engineering Classroom." *European Journal of Engineering Education*, Vol. 34, No.1 (March 2009), pp. 29-45.

[5] R. Bonk, P. Imhoff, and A. Cheng. "Integrating Written Communication within Engineering Curricula." *Journal of Professional Issues in Engineering Education and Practice*. Vol. 128. (October 2002), pp. 152-159.

[6] A. Wendt, J. Martin, J. Russell, M. Graham, P. Farrell, P. Peercy, and S. Pfatteicher. "(Re)Designing the College of Engineering at the University of Wisconsin-Madison for 2010 and Beyond." *ASEE Conference Proceedings*, 2006. (Available at http://wwwtemp.asee.org/conferences/paper-search-results.cfm, date last accessed 1/18/2011).

[7] M. Paretti. "Communication in Engineering Design Capstone Courses: Approaches and Challenges." Invited Lecture. College of Engineering, University of Wisconsin-Madison. (October 26, 2010).

[8] D. Laurillard. *Rethinking Pedagogy for a Digital Age – Designing and Delivering e-Learning*. Ed. H. Beetham and R. Sharpe. London: Routledge, 2007.

[9] M.K. Tallent-Runnels, J.A. Thomas, W.Y. Lan, S. Cooper, T.C. Ahern, S.M. Shaw, X. Liu. "Teaching Courses Online: A Review of the Research." *Review of Educational Research* Vol. 76, No. 1 (Spring, 2006), pp. 93-135 (Available at stable URL: http://www.jstor.org/stable/3700584)

[10] H.R. Goldberg and G.M. MKhann. "Student test scores are improved in a virtual learning environment." *Advances in Physiological Education 23*, no. 1 (2000), pp. 59-66.

[11] J. Karpicke, and J. Blunt. "Retrieval Practice Produces More Learning than Elaborative Studying with Concept Mapping." *Science.* (January 2011). (Available at stable DOI: 10.1126/science.1199327).

[12] V. Mello. "Online Quizzes: Are they Worthwhile?" (Conference paper). Fifth Laurels International Conference on Education and Management in English Language Teaching. Sao Paulo, Brazil. (July 1997) (Available at http://iteslf.org/Articles/Mello-Quizzes.html, date last accessed March 7, 2011).

[13] J. Shah, D. Rajgor, M. Vaghasia, A. Pfadtare, P. Shreyasee, E. Carvalho, and R. Pietrobon. "WriteSim TCExam: An open source text simulation environment for training novice researchers in scientific writing." BMC Medical Education. 10: 39 (May 2010). (Available at stable DOI: 10.1186/1472-6920-10-39).

[14] J. Karpicke and J. Blunt. "Retrieval Practice Produces More Learning than Elaborative Studying with Concept Mapping." *Science.* (January 2011). (Available at stable DOI: 10.1126/science.1199327).