Using the *Challenger* and *Columbia* Disasters to Discuss Technical Communication and Professional Ethics: A Multifaceted Approach

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Abstract – This paper describes the use of the space shuttle *Challenger* and *Columbia* disasters as case studies for technical communication and professional ethics in a required junior/senior-level engineering communication course at Mississippi State University. Students in this course have traditionally read background material, watched documentaries, and discussed technical documentation on both disasters as part of the course's standard curriculum. Over the years, student response to these experiences became enthusiastic enough that course instructors decided to transform the shuttle-disaster case studies into higher-stakes writing and speaking assignments focusing on various shuttle-disaster-related topics. This recent transformation has thus far shown significant benefits, particularly the development of more comprehensive responses to ABET's "Criterion 3." The paper discusses these benefits, provides an overview of the assignments' components, explains the relevant grading methods, and analyzes applicable student feedback on these assignments.

Keywords: engineering ethics, technical writing, technical communication, ABET "a-k," program assessment

INTRODUCTION

Professional ethics is one of the most important concepts with which engineering students must become familiar. Almost any student, instructor, or employer would generally agree that professionals should conduct themselves in an "ethical" manner, and one of the more infamous ABET criteria is "Criterion 3. Program Outcomes and Assessment," item "f" of which declares the need for students to acquire "an understanding of professional and ethical responsibility" [ABET, 2]. The concept of ethics, however, is also notoriously difficult to teach and measure effectively; straightforward lectures on ethics, for instance, with little room for authentic student engagement might interest some students, but most are likely bored by field-specific stories inevitably culminating in morals that are already adequately conveyed by numerous professional societies' ethical codes. How, then, can engineering schools provide their students with substantive, ethics-relevant experiences and content that both engage students in active learning and allow schools to measure their success with ethics education against stated program objectives and outcomes?

Faculty in the Bagley College of Engineering (BCOE) at Mississippi State University have developed an ethics-intensive assignment sequence as part of GE 3513 Technical Writing, the junior/senior-level technical-communication course required of undergraduates from all engineering departments. This sequence incorporates case studies based on the *Challenger* and *Columbia* shuttle disasters and has thus far proven effective in keeping students interested in discussions and applications of ethics while also improving their writing and speaking abilities and measuring the extent of both outcomes. The rest of this paper provides an overview of the assignments' components and benefits, discusses grading methods relevant to the ethics assignments, and analyzes student feedback on these assignments.

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OVERVIEW OF THE *CHALLENGER* AND *COLUMBIA* CASE-STUDY ASSIGNMENTS

The usefulness of the *Challenger* and *Columbia*-disaster case studies stems from their technological and organizational complexity as well as their general familiarity for students. While *Challenger*'s and *Columbia*'s technical design flaws are not especially difficult to understand, the organizational factors that perpetuated these disasters tend to be more problematic because (a) engineering students are typically more interested in technical rather than organizational matters, and (b) classroom settings often do not provide faculty and students with the context necessary to comprehend ethical dilemmas in their realistic natural habitats. This latter point can be particularly difficult: many engineering schools still expose their students to ethical issues via brief, low-stakes coursework designed to fit into courses already devoted to standard core topics. And although such "wedging" may be justifiable, it is this very act that relegates ethics coursework to the type of clinical, either/or exercises bemoaned by Lynch and Kline, who argue for a higher degree of specificity, more writing, and the addition of role-playing in standard "prepackaged" ethics coursework [Lynch and Kline, 212-213]. In fact, Lynch and Kline posit that this lack of context is the chief problem with exposing ethics to undergraduates in meaningful ways: "Getting engineers to act ethically in well-structured but idealized cases may be less important than improving their ability to identify ethically problematic issues in a poorly structured problem field within an institutionally and culturally constrained set of tacit assumptions" [Lynch and Kline, 209].

Through their required technical-communication course, BCOE undergraduates have long been exposed to the ethical dilemmas posed by the *Challenger* disaster (and, since 2003, the *Columbia* disaster), but until recently this exposure, as in many other engineering schools, took the form of low-stakes, in-class projects; more specifically, students would read an overview of each disaster [Boisjoly, Langewiesche] and in teams answer a series of questions (shown in Figure 1 below) intended to stimulate class discussions on professional ethics, whistleblowing, effective communication, and numerous other relevant topics.

Figure 1. Discussion Questions on *Challenger* Memos

The *Challenger* Memos

NOTE: This assignment assumes you've read Roger Boisjoly's narrative (links I-VII) on the Online Ethics Center web site (http://www.onlineethics.org/moral/boisjoly/RB-intro.html).

In your project teams, read and discuss the Miller, Boisjoly, Russell, Thompson, and Kilminster *Challenger* memos (distributed in class). Be prepared to analyze and discuss your assigned memo for the rest of the class, ultimately telling us whether you think the memo is an example of effective technical communication. In arriving at this conclusion, take the following ideas into account:

1. *Readers*: who were the short- and long-term readers?
2. *Context*: in what sort of political/social/cultural/professional environment were these memos written?
3. *Chains of command*: what were the writers' limitations on both recommending actions to others AND taking actions themselves?
4. *TC basics*: how sound are the memos' diction, sentence & paragraph structure, overall document design, grammar, clarity, etc.?

Although students consistently participated in class discussions and routinely reported on evaluations that the shuttle-disaster projects were valuable parts of the course, the instructors knew the value of these assignments was overly limited: because the shuttle projects were two out of 10 other in-class projects assigned in addition to three major technical documents and three presentations, there simply was not enough time to cover the institutional and cultural contexts necessary for an adequate understanding of the constraints within which the critical *Challenger* and *Columbia* decisions were made. Harkening back to Lynch and Kline's assertion above, it is these contexts and constraints in which the true value of ethics coursework resides – not the (un)ethical decisions themselves but the professional's responsibility to identify situations requiring critical decisions in the first place along with the day-to-day environment in which such decisions must invariably be made.

To counter this problem of identification and context, BCOE engineering-communication faculty fused the shuttle-disaster projects with the major assignments in the course, literally devoting the majority of the semester to discussion and analysis of *Challenger* and *Columbia*. Far from replacing existing content, however, the shuttle/ethics content became a means of edifying such traditional technical-communication concerns as elements of professional writing style, targeting various audiences, effective use of graphics, and even the dangers of grammatical/mechanical mistakes. The next few subsections discuss these edifying assignment modifications in detail.

Using *Challenger* as a Basis for the Course's Major Documents

The *Challenger* disaster became the core subject for all of the course's major documents. Whereas previous semesters required students to submit papers of varying genres (technical memos, lab reports, proposals, instruction manuals), the newly modified assignments transformed into three iterations of one long document that would take the form of a scholarly journal article. Figure 2 below shows excerpts from the assignment information prompt for the fall 2006 semester (in this and all other figures, certain font sizes, spacing, and text highlighting have been altered from their original form to fit the constraints of this paper).

Figure 2. Fall 2006 Assignment Prompts for the *Challenger* Journal Article

> Write a journal paper according to ASEE *Journal of Engineering Education* (*JEE*) guidelines that analyzes any **five** *Challenger*-related technical documents written prior to *Challenger*'s destruction. You may choose which documents you analyze (including the memos I distribute in class), but the documents you analyze must have been written by personnel at NASA or at any of their contractors; journalistic pieces and pieces written by people outside the shuttle program are not acceptable for this topic. Your analysis should examine a broad range of elements about the documents themselves: the professional context in which they were written; the technical content they contain and its soundness; the documents' clarity and precision for relevant and varying levels of readers; the documents' design/spatial organization; their grammatical/mechanical soundness; and, of course, their conformity to established modes of professional ethical conduct. Your paper should not merely be a summary of the documents you intend to analyze or of events preceding and following the *Challenger* disaster. Rather, your discussion should focus on appropriate elements of technical communication and professional ethics.
>
> *What does "ethical" mean?* For the purposes of this assignment, focus on professional ethics as defined in our textbooks (*TC* chapters 1 and 2, *HTW* "ethics in writing," pp. 178-180); as defined by different professional/technical organizations (The Online Ethics Center for Engineering and Science at http://www.onlineethics.org/; the National Society of Professional Engineers at http://www.nspe.org/ethics/home.asp); and as described in the ethics books cited in this assignment description.
>
> This writing assignment is comprised of three different iterations: **Paper 1** consists of the first two sections of your overall document (the final draft of paper 3). This paper should include your completed **Abstract** and **Introduction** sections (roughly two pages typed and double spaced). **Paper 2** consists of all subsequent sections in your article, from the first body paragraph to the **Conclusion** section (rough minimum of 10 pages). This paper should be a working draft of the final version you will submit for paper 3. **Paper 3** is the full article, which must include papers 1 and 2 as well as a **References** section and any other front or back matter that may enhance your reader's understanding of your document (12-15 pages).

As with all major GE 3513 writing assignments, the three iterations of the paper were submitted in two drafts each: a first draft (required to be at least half the length of the iteration's final draft) peer-reviewed in class by instructor-assigned teams, and a final draft submitted seven to ten days after the workshop in electronic form both as an e-mailed Word file or PDF and as an uploaded file at Turnitin.com, a website whose "Educational Suite" includes tools for plagiarism detection and prevention.

Although fall 2006 offered students only one shuttle-disaster topic, in other semesters students have chosen from several topics on both *Challenger* and *Columbia*, as Figure 3 below shows.

Figure 3. Alternate Shuttle/Ethics-Based Topics from Previous Semesters

> 1. Risk assessment is a subjective study. Engineers and managers often have conflicting notions of "acceptable risk." Describe the ways in which the engineers and management differed in their assessment of risk before the *Challenger* or *Columbia* disasters, and discuss the ethical and communication ramifications of these conflicting views.
>
> 2. While many organizations have official policies detailing ethics and communication standards, these policies are not always practiced. In the wake of the *Columbia* disaster, tales of two very different NASA environments emerged. Discuss the conflict between NASA management's assertion that NASA is a "Badgeless Society" and the engineers' perception that their concerns were unimportant to management, and detail the connections between this conflict and the disaster.
>
> 3. Focusing on ethics (or the lack of), compare management's and engineers' actions preceding either the *Challenger* or the *Columbia* disasters to the actions of people involved in another real-life disaster within your own field where people were hurt or killed.

4. Respond to James Oberg's characterization of the NASA space culture that led to the *Columbia* disaster as "broken," meaning that NASA officials placed greater emphasis on the business of space flight than on the safety of the individuals involved. If you agree that the NASA culture was indeed "broken," thus contributing to the disaster, identify specific ethical lapses by NASA managers and/or engineers. Then study the current NASA culture, answering the question, "Has it improved?" If you disagree with Oberg's characterization, then defend NASA's actions preceding the *Columbia* disaster and respond to those who criticize NASA's traditionally "Faster, Better, Cheaper" approach to space flight as unethical.

As part of the paper-writing process, course instructors provide students with a multitude of resources. The most significant of these resources are the *Challenger* memos [Rogers Commission] that form the basis for several class discussions and, in fact, serve as the main documents the majority of students choose to analyze for their papers (no doubt because of the class discussions!). Another crucial set of resources are documentaries: *"A Major Malfunction…": The Story Behind the Space Shuttle* Challenger *Disaster* [Maier] and the National Geographic Channel's docudrama Challenger*: The Untold Story* [Everett] both describe the history behind *Challenger* and the events that followed in detail. The Maier documentary is particularly useful because it gives students a tremendous amount of context that even pre-disaster documentation simply cannot provide (via NASA newsreels, early shuttle-program propaganda, interviews with key NASA and contractor personnel, footage of Rogers Commission testimony following the disaster, and so on). Figure 4 below shows the other main resources students can use for the paper process.

Figure 4. Fall 2006 Assignment Resources for the *Challenger* Journal Article

http://www.onlineethics.org/moral/boisjoly/RB-intro.html (plus all related, embedded links): a good background on the *Challenger* situation from an engineering perspective

Report to the President by the Presidential Commission on the Space Shuttle Challenger *Accident*: all five volumes available for onsite use in McCain 202A; incomplete online version available at http://science.ksc.nasa.gov/shuttle/missions/51-l/docs/rogers-commission/table-of-contents.html

http://www.hq.nasa.gov/office/pao/History/transcript.html: the actual transcript of the *Challenger* crew as recorded during the 73-second launch sequence; note the chilling last two lines

http://science.ksc.nasa.gov/shuttle/missions/51-l/docs/rogers-commission/Appendix-F.txt: a series of personal observations by Richard Feynman, the late Caltech physicist and member of the Rogers Commission

Edward Tufte, *Visual Explanations: Images and Quantities, Evidence and Narrative*: available for onsite use in McCain 202A; contains a detailed section on *Challenger* and, in particular, on the pre- and post-disaster engineering charts used to discuss the O-ring problem

Paul Dombrowski, *Ethics in Technical Communication*; 1 copy available for onsite use in McCain 202A

Mike Martin and Roland Schinzinger, *Ethics in Engineering*, 3rd ed.; 3 copies available for onsite use in McCain 202A

JEE guidelines: http://www.asee.org/about/publications/jee/guide.cfm

Search the MSU library's online catalog (http://nt.library.msstate.edu/content/templates/?a=656&z=184) for other books on engineering ethics and on the *Challenger* disaster.

http://www.engr.msstate.edu/current_students/technical_communications_program/tcp/Shackouls_TCP_Documentation_Guidelines.pdf: Shackouls TCP Documentation Style (required for GE 3513)

Using *Columbia* as a Basis for the First Presentation

The *Columbia* disaster, meanwhile, became fodder for the course's first presentation, which specifically involved analyzing and redesigning P. Parker, et al.'s presentation "Orbiter Assessment of STS-107 ET Bipod Insulation Ramp Impact" from January 23, 2003 (given nine days before *Columbia*'s disintegration) [Parker et al.]. Students create and give this presentation in multidisciplinary project teams into which their instructor divides them during the semester's second week. Figure 5 below shows excerpts from the assignment information prompt for the fall 2006 semester.

Figure 5. Fall 2006 Assignment Prompts for the *Columbia* Slide-Redesign Presentation

For presentation 1, your team will evaluate and redesign the *Columbia* engineering presentation available at http://www.nasa.gov/pdf/2203main_COL_debris_boeing_030123.pdf. (Edward Tufte's article "PowerPoint Does Rocket Science" discusses two slides from this presentation, "Review of Test Data Indicates Conservatism for Tile Penetration" and "Summary and Conclusion"). Specifically, your team should analyze the strengths and weaknesses of the presentation slides based on your knowledge of the *Columbia* disaster and its causes; evaluate the appropriateness of the engineering methodology behind the slides, eventually concluding why this presentation was not more effective; and redesign the slides based on sound, ethical engineering-communication principles **WITHOUT** using your hindsight knowledge of *Columbia*'s eventual fate (i.e., redesign as if you do not know that *Columbia* is going to disintegrate) and **WITHOUT** using any technical information that would have been unavailable to those directly involved with *Columbia*. Your presentation should not merely be a summary of the events leading up to the *Columbia* disaster or of the aftermath. Rather, your presentation should focus on the causes of the disaster, the relevant strengths and weaknesses of the slides, and the ways in which you can improve the slides using sound communication principles. In general, you should devote an equal amount of time and slides to each portion of this topic (i.e., discussion and slides on evaluation, discussion and slides on your redesign).

You are free to modify the layout and design of the slides in the *Columbia* presentation – including adding, deleting, or relocating whole slides and specific information – as long as you do not drastically change the content's original meaning or violate the "non-hindsight" rule described above. If you need to add details to which you do not have access, simply put a description of these details in square brackets in the appropriate location on the slide, like so: [A specific explanation of the Crater method should go here.]

NOTE: In his article, Tufte analyzes, evaluates, and harshly criticizes the two slides in question. While you may certainly read his points and make use of them in your presentation, such use should be limited to the same type of support provided by all well-used research materials – in other words, **you may not let Tufte's analysis do your work for you**. Be very careful to avoid this potential problem.

Although GE 3513 devotes several class meetings to discussion of and practice with the elements of effective technical presentations – from sufficient content preparation and non-distracting slide visuals to consistent eye contact and appropriate body language – the time constraints of an already-busy semester simply do not permit the type of iterative presentation process employed with the written assignments. Therefore, students are expected to prepare and practice outside of class and give their presentations in only one official draft. (Students can, however, take advantage of the BCOE's technical-communication assistants, available to help with all manner of communication-related coursework.)

As with the paper process, the presentation process is attended by a host of relevant resources. Students gain the bulk of their background knowledge on *Columbia* from the *Atlantic Monthly* article "*Columbia*'s Last Flight: The inside story of the investigation – and the catastrophe it laid bare" [Langewiesche]. Another valuable resource is the National Geographic Channel's one-hour exposé *Seconds from Disaster:* Columbia's *Last Flight* [Bennett], though this program is unfortunately more basic and less penetrating than its longer *Challenger* counterpart. The other major resource students use is Edward Tufte's article "PowerPoint Does Rocket Science" [Tufte], in which he dissects two slides from the "Orbiter Assessment" presentation mentioned above while simultaneously skewering the deficiencies of PowerPoint software and its all-too common misuses in this failed presentation (note also the warning to students in Figure 5 above that they not co-opt Tufte's analysis as their own). Figure 6 below shows other resources students are encouraged to use for their *Columbia* presentation.

Figure 5. Fall 2006 Assignment Resources for the *Columbia* Presentation

http://caib.nasa.gov/news/report/default.html: the full *Columbia* Accident Investigation Board report online – this series of PDFs is absolutely gigantic, so below are a few specific sections that may be useful to you on this assignment:

- http://caib.nasa.gov/news/report/pdf/vol2/part12.pdf - Impact Modeling Report
- http://caib.nasa.gov/news/report/pdf/vol2/part13.pdf - STS-107 In-Flight Options Assessment
- http://caib.nasa.gov/news/report/pdf/vol3/part02.pdf - STS-107 Image Analysis Team Final Report (see especially the Executive Summary)
- http://caib.nasa.gov/news/report/pdf/vol5/book2/part12.pdf - Crew Survivability Report

- http://caib.nasa.gov/news/report/pdf/vol2/part08.pdf - Debris Transport Analysis (some of this information seems directly related to the information in the *Columbia* presentation on which you're working)

http://www.thesmokinggun.com/archive/nasaemail1.html: a series of NASA e-mails from people who apparently knew catastrophe was possible before *Columbia* tried to reenter Earth's atmosphere

GRADING METHODS FOR THE *CHALLENGER/COLUMBIA* ASSIGNMENTS

In evaluating student writing, BCOE engineering-communication faculty use a holistic grading method [Pappas and Hendricks, Brocato and Picone] that involves criteria-based rubrics for each iteration of the paper. For the iterative assignments discussed here, each iteration has its own rubric, so each successive version must build on the previous ones. Figure 6 below shows the grading rubric for paper 3, the culminating assignment that includes revised versions of papers 1 and 2.

Figure 6. Fall 2006 Grading Rubric for the *Challenger* Journal Article (Third Iteration)

D/60-69 out of 100 (Has a chance of working):

- Attempts to focus consistently on a specific purpose beginning in abstract and intro, emphasized within the body, and reiterated in the conclusion
- Largely adheres to *JEE* guidelines (title & name header; bold, left-justified headings) and length requirements
- Focuses on the provided topic
- Attempts adequate and focused use of sources to support major points *without plagiarizing or creating the appearance thereof*
- Contains no factual inaccuracies
- Does not destroy reader's confidence with numerous grammatical/mechanical errors

C/70-79 out of 100 (Is likely to work, with some difficulties):

- Achieves some sense of purpose for each section (i.e., the sections do what they're supposed to do)
- Introduces the paper well: funnel shape, context leading to specific thesis
- Successfully attempts some substantive discussion of major points/assertions
- Attempts purposeful inclusion of technical details (tang & clevis movement, o-ring erosion, etc.) to support/fill out a point or to establish a clearly defined pattern of behavior
- Includes at least one purposeful, well-integrated graphic (cited if applicable)
- Attempts to summarize major points (abstract); attempts to include essential intro elements
- Attempts Shackouls TCP documentation style in text and references (if applicable)
- Has few grammatical/mechanical errors (especially serious ones – see **B** below)

B/80-89 out of 100 (Is under control of reader, facts, structure, language):

- Attempts to cultivate a suitable writing style: few choppy sentences, appropriate transitions between ideas/sentences/paragraphs, appropriate diction & formality
- Consists mostly of well-organized paragraphs: topic sentences, support via logic and source info
- Announces paper's significant points and correct focus in abstract
- Is mostly successful in discussing major points/assertions
- Uses sources appropriately overall
- Avoids heavy moralizing or other excessive emotional appeals
- Has very few grammatical/mechanical errors, especially serious ones (subject-verb agreement, sentence fragment, comma splice, misspellings, incomprehensibly mixed constructions, etc.)

A/90-100 out of 100 (Is clear, efficient, convincing, and a pleasure to read):

- Contains all necessary components for each section
- Contains thoroughly developed ideas and meaningful discussion
- Concludes with an appropriate summing up of points and final statement of author's position
- Has no notable problems with use of sources
- Has no problems with *JEE* formatting guidelines
- Takes obvious care of readers; tone, design, writing style, use of graphics & sources (if applicable) largely beyond reproach
- Has very few grammatical/mechanical errors, especially serious ones

Because grading rubrics are tantamount to answer keys for tests, students are not allowed free access to individual assignment rubrics (instructors will show students specific items on the rubrics during one-on-one conferences). However, one of the course's first in-class projects involves writing a brief technical report in teams and then *grading* the completed report in teams, during which instructors provide a rubric specific to the in-class report's subject matter so that students can grade the report coherently. In this way, students learn about the grading process used for their documents and the rationale used both in creating the rubrics and in the grading process itself.

BENEFITS AND DRAWBACKS OF THE NEWLY MODIFIED ASSIGNMENTS

Thus far, the higher-stakes *Challenger* and *Columbia* assignments show several identifiable benefits and drawbacks. As stated above, students in general are fascinated by both shuttle disasters and have little trouble working themselves into a state of righteous indignation over the very idea that Morton Thiokol management (in a simplistic interpretation of *Challenger*'s denouement) would place profit before safety by overriding their engineers' opinion not to launch, or that NASA manager Linda Ham would capriciously cancel a request for satellite imagery of *Columbia*'s potentially damaged wing simply because the requesters failed to ask her permission first. While such emotional reactions are clearly inappropriate in pure form for technical papers, this sort of student enthusiasm, coupled with the myriad other disaster-related details that comprise class discussions, can make for first-rate subject matter. Moreover, the complexity of this subject matter is near-perfect for a technical-communication classroom full of engineering students that, in the BCOE's case along with that of many other schools, is run by non-engineering instructors; the result is that *Challenger* and *Columbia* tend to offer enough nuts-and-bolts technical material to satisfy nuts-and-bolts engineering students while also offering enough non-technical writing-related material to satisfy more communication-oriented faculty. Both camps, meanwhile, find the disasters' organizational and ethical issues meaningful, particularly when these issues cross paths with technology to generate one of the most important questions in this scenario: how do engineers communicate with non-engineers (or senior engineers who now fill administrative roles) in ways that are comprehensible, thorough, persuasive, and ethical given specific institutional and cultural pressures?

One drawback of these assignments is the length of time classes spend discussing the shuttle disasters. While instructors tend to enjoy having a full semester to cover *Challenger* and *Columbia* minutiae (especially if they themselves are intrigued by the subject), students can get burned out by the routine, even though most of them acknowledge and appreciate the fact that their assignment topics are the interactive subject of nearly every class meeting. This development is also related to another, more substantive drawback: the potential for a distorted view of authentic ethical situations in industry and academia. No sentient person would deny that these two shuttle disasters are "authentic," but their dire status as literal life-and-death cases along with their high-profile nature can make students question their practicality, particularly if these students plan on working at what they view as small firms that only take on relatively small projects. (Indeed, as one student put it when his class shifted topics to something less inherently risky, "Thank goodness – no more life and death for a while.")

STUDENT FEEDBACK AND CONCLUSIONS

Tables 1 through 3 below contain quantitative and qualitative data relevant to this study. First, Table 1 shows the combined paper-assignment averages for the semesters in question.

Table 1. Comparison of Student Paper Averages[1] from Fall 2005-Fall 2006 (all are out of 100 possible points)

Fall 2005 (41 students total)	*Spring 2006 (50 students total)*	*Summer 2006 (37 students total)*	*Fall 2006 (25 students total)*
81	**84**	**89**	**82**

[1]These averages consist of three iterative document grades per student derived using the rubric in Figure 6 above.

Although the paper averages obviously increased over the calendar year, the improvements are unremarkable overall. Fall 2005 and fall 2006, for instance, are separated by one point, which is statistically insignificant (in GE 3513, semester-to-semester averages routinely fluctuate in this manner). Even the large increase of five points in summer 2006 is easily if anecdotally explained: in the eight years GE 3513 has been taught, every group of summer students has outscored their fall and spring colleagues. Thus, a relatively high average of 89 out of 100 is standard for a summer semester and likely not indicative of improved overall student performance.

Next, Table 2 below shows responses to two questions relevant to this study from the standard university course-evaluation form. This form contains two parts: (1) a standardized, ten-item, Likert-scale survey (the scale is explained below), and (2) two open-ended questions, “What did you like most about this course?” and “What improvements would you suggest?,” with space for written responses; relevant responses from these questions are listed in Table 3 below.

Table 2. Summarized Responses to Two Study-Relevant Items from Fall 2005 and Spring 2006 Course Evaluations

Questions	*Fall 2005 (41 students enrolled)* [1]					*Spring 2006 (50 students enrolled)*				
The instructor makes the material interesting and holds the attention of the class.	SD[2]	D	NAND	A	SA	SD	D	NAND	A	SA
	0	**2**	**3**	**18**	**17**	**0**	**0**	**3**	**22**	**24**
The instructor makes the material relevant to my course of study.	SD	D	NAND	A	SA	SD	D	NAND	A	SA
	1	**2**	**4**	**23**	**8**	**0**	**0**	**5**	**18**	**26**

[1]Discrepancies between the total responses and the total students enrolled indicate students who did not respond to certain questions. [2]KEY: SD = Strongly Disagree; D = Disagree; NAND = Neither Agree Nor Disagree; A = Agree; SA = Strongly Agree

Although the students’ overwhelmingly positive responses to these two questions portend well for the concept of using space-shuttle scenarios to teach and document ethics, one contributing factor must be reiterated for the latter question: GE 3513 is an **engineering** communication course, with content specifically designed to be relevant to engineering students’ courses of study. Hence, most responses to these two questions over the last eight years have been positive regardless of any space-shuttle-based content. Nevertheless, these responses clearly show that students in these two semesters found the *Challenger/Columbia* content interesting and relevant, an obviously desirable condition for instructors seeking to create a healthy learning environment.

Unfortunately for this study, Mississippi State University thoroughly redesigned its course-evaluation form for the fall 2006 semester, and the new form has no questions truly equivalent to those discussed above; thus, quantitative student responses from fall 2006 have no bearing on this study. Similarly, Mississippi State does not even administer standard evaluation forms for summer courses, so GE 3513 instructors distribute their own qualitative course questionnaire, relevant responses from which appear in the “Summer 2006” row below.

Table 3. Summary of Relevant Written Student Comments from Recent Course Evaluations

Fall 2005	If I have to watch another space shuttle video, I’m gonna [sic] blow my head off.			I enjoyed the *Challenger* disaster paper.			
Spring 2006	[…] I don’t understand why we have to write on the *Columbia* if I have no aerospace background.			I loved doing the *Columbia* paper and researching *Challenger*.			
Summer 2006	They [paper assignments] required an enormous amount of work, but they taught me a lot about formal technical reports. Plus, I’m really glad that I know about the *Challenger* now (I knew <u>nothing</u> about it before this class).	The first presentation [redesigning the *Columbia* presentation] was a little boring because we were already writing a long paper on shuttles.	I did not like this presentation [*Columbia*] because I felt like too much time was being spent on such a small topic.	[…] many classes involved a lot of *Challenger* information, which wasn’t necessary for people not writing on that subject. [1]	Wished I could have written about design and not about ethichs [sic]	I felt the provided topic [*Challenger*] strayed from the essence of the class. The class lectures discussed issues with technical writing, but the paper seemed almost like a literary analysis or persuasion paper.	Interesting topic that applied to everyone
Fall 2006	I felt that each of the assignments we worked on helped with technical communication.			I think that the paper assignments were suitable.			

[1]To encourage active undergraduate researchers, GE 3513 instructors also allow students to write documents of equivalent scope on appropriate research-based topics, though no more than 10% of a given semester’s students typically choose the research option.

Of the 13 study-relevant comments shown above, seven criticize the space-shuttle content, and six praise either the content or the assignments in general, though even one of these (the first comment for summer 2006) concedes that the papers were "an enormous amount of work." Perhaps more importantly, each semester's responses only represent 4% to 20% of all students, meaning the vast majority of students involved had no opinion about *Challenger/Columbia* content or chose not express it. Therefore, generalizations about such content based on qualitative data would surely be premature.

Clearly, students are not vigorously opposed to using the *Challenger* and *Columbia* scenarios as fodder for course writing assignments. Though some of their written comments convey dislikes about certain elements of the assignments, these dislikes are generally consistent with negative feedback from past semesters – topic A is less interesting than topic B, too much time was spent on topic A instead of topic B, the assignments are too time-consuming, and so on.

USING THIS PROJECT FOR PROGRAM ASSESSMENT

The major benefit of using *Challenger/Columbia* as described in this paper is **documentation for assessment**. The students followed in the spring, summer, and fall 2006 semesters, for example, provided over 100 researched, journal-format papers on the professional ethical concerns surrounding the *Challenger* or *Columbia* disasters. Since every engineering undergraduate at Mississippi State eventually takes GE 3513, every engineering undergraduate also eventually participates in the ethics-based, critical-thinking experiences described here. The electronic documentation of these experiences, meanwhile, becomes an invaluable assessment tool, since the multifaceted nature of this assignment means it addresses five of ABET's famous "a-k" criteria [ABET, 2]:

"(d) an ability to function on multidisciplinary teams" – In the current iteration of the project, students work in multidisciplinary teams (often six to eight different engineering majors represented per class) for most of the semester to redesign a *Columbia*-related presentation, as described in Figure 5 above.

"(f) an understanding of professional and ethical responsibility" – Although *Columbia* is still a fairly recent and somewhat unfamiliar phenomenon for many students, the *Challenger* disaster has become one of the most commonly cited examples of lapsed professional ethics in modern history, and in this project students examine numerous ethical issues from numerous perspectives: the responsibility of engineers at NASA and Morton Thiokol, Inc. (MTI) to communicate thorough, accurate information about o-ring design flaws in an urgent manner to appropriate supervisors; the responsibility of NASA and MTI management to process the engineers' information without allowing that information to be unduly tainted by economic or scheduling pressures; the responsibility of MTI to withdraw a design they eventually knew to be faulty regardless of financial loss; the responsibility (if any) of those most fervently against the launch to work outside the official chain of command to stop the launch if necessary; and so on.

"(g) an ability to communicate effectively" – By the time students complete this project, they have written a paper to journal specifications that argues a specific thesis and supports it with relevant research. This paper is revised through three iterations with two drafts per iteration, one of which is peer reviewed. Their audience is one of the most important they will encounter in their professional careers: an educated lay audience, intelligent readers who possess no specialized knowledge of the topic at hand. This audience is the same for their shuttle-related presentation, where the student teams critique the original presentation slides and then present their redesign, incorporating sound technical-communication practices but eschewing hindsight – in other words, students cannot redesign as if they know *Columbia*'s fate but must instead read *Columbia* history thoroughly and analyze situational details to create a believable but still technically effective presentation.

"(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context" – One of the most enlightening aspects of in-class shuttle discussions involves the impact the space shuttle "industry" can have on entire communities and economies – how, for example, MTI's securing of the solid rocket booster contract affected the state of Utah but also how this situation ultimately affected *Challenger*'s fate by requiring initially unassembled (and therefore more risk-susceptible) rockets, since assembled rockets were supposedly too heavy to transport via rail from Utah to Florida. Concerns like these help prevent students from seeing the complex *Challenger* and *Columbia* scenarios in simplified, pure right-and-wrong terms.

"(j) a knowledge of contemporary issues" – The *Columbia* disaster can certainly be classified as a contemporary issue because it happened so recently, but its intricate causes and even more intricate post-disaster investigation force students to think about broader, contemporary **corporate** issues, such as the difficulties of navigating complex chains of command or communicating with multiple supervisors who happen to have opposing agendas, all the while balancing science, economics, and ethics in the quest to implement and oversee successful engineering designs.

FUTURE WORK

Future work for this shuttle/ethics project includes devising an instrument for specifically assessing the project's effectiveness both quantitatively and qualitatively each semester (to be used along with the standard university form); addressing valid student concerns about workload and the amount of time devoted to project topics; and compiling more data from earlier in GE 3513's history to compare current data with student grades and course evaluations stemming from coursework that did not use *Challenger* or *Columbia* in substantive, high-stakes assignments. These additions will help fuel further publications and presentations on this project.

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