

## **2006-614: EXPLAINING THE NUMBERS: USING QUALITATIVE DATA TO ENHANCE COMMUNICATION INSTRUCTION IN THE ENGINEERING CLASSROOM**

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# Explaining the Numbers: Using Qualitative Data to Enhance Communication Instruction in the Engineering Classroom

## Abstract

In 1959, C.P. Snow articulated the notion of “the two cultures,” specifically, the bifurcation between the sciences and humanities and the impact this had on solving the world’s problems. Disciplinary cultures are evidenced through rites, norms, language, and customs. In particular, disciplines can be characterized by their theoretical and methodological worldviews. While sciences like engineering are positivist with respect to research orientation, humanities, and in particular, communication, is multifaceted including the post-positivist, interpretive, critical, and postmodern research orientations. This difference can present a paradox when representatives from engineering (science) and communication (humanities) work together to improve and assess engineering education

The Center for Engineering Leadership at the University of Utah represents the mixing of disciplinary cultures, such that representatives from the College of Engineering and the College of Humanities work together in and out of the classroom. This college-wide program exists to improve undergraduate engineering education through equipping students with the requisite professional skills to be effective in the workplace, thus responding to the call put forth by ABET’s EC 2000. Our integrated approach embeds speaking, writing, and teamwork instruction within the engineering curriculum. Curricular advancements such as these must be continually assessed both at the macro and micro level. Although recent claims have been made for the use of qualitative inquiry in assessment practices, we argue that qualitative research is still underutilized as a course assessment tool in engineering classrooms.

The authors analyzed and compared both qualitative and quantitative course evaluation data from a mechanical engineering course in order to demonstrate that qualitative data gathering techniques facilitate a deeper and broader understanding of students’ experiences in the classroom. A comparison of the results shows how students’ qualitative explanations of their experiences both validates and enhances the numerical ranking of satisfaction with multiple course attributes. A deeper understanding of students’ experiences gives educators the opportunity to make important curricular changes. This research speaks to issues of multi-method assessment tools in engineering, as well as the broader implications of students’ experiences with writing, speaking and teamwork instruction.

## Introduction

With the advent of ABET’s EC 2000, much focus has been placed on equipping engineering students with the necessary professional skills to be effective in the workplace.<sup>1-3</sup> As such, engineering educators highlight unique approaches to teaching students how to write (and speak) effectively.<sup>4-6</sup> A few key themes characterize this research. First, most attempts to train students in “technical communication” have prioritized writing over speaking. Second, most approaches to communication skill development include an emphasis on either integrating writing and speaking into an introductory and/or capstone engineering course or offering a Technical Communication course specifically for engineering students. Third, research in this area often

highlights previous attempts to incorporate or develop writing assignments using a writing-in-the-disciplines approach while relying on industry representatives and/or alumni to provide discipline-specific, genre-based knowledge. While these approaches to teaching technical communication to engineering students do meet the objectives of EC 2000, we argue that they do not go far enough. That is, in order for engineering students to be professionally as well as technically competent, they must be prepared to not only write professional documents and prepare professional presentations, they must also learn about interpersonal communication in order to be productive organizational members.

### **CLEAR Approach**

The University of Utah's CLEAR Approach (Communication, Leadership, Ethics, and Research) to improving engineering education involves collaboration between the Colleges of Humanities and Engineering. Our goal is to prepare engineering undergraduates to occupy positions of leadership in organizations through improving their oral and written communication, teamwork skills, and ethical understanding. Our college-wide program is integrated in that students learn these professional skills in their required, core engineering courses. Further, our program is developmental in that students are exposed to basic level skills in the freshman year and gradually progress to sophisticated skills at the senior level. In other words, rather than teach students formal and informal communication skills in a required technical communication course, we teach students through and about communication in their engineering courses. This not only enables students to learn discipline-specific knowledge, it also facilitates learning of engineering material through speaking and writing about current engineering topics. The advantages of this program are numerous, including: 1) improving students' communication (oral, written, and interpersonal) and thus, satisfying ABET's call for improved undergraduate engineering education; 2) enhancing students' learning of the engineering material; 3) teaching students about the discipline of engineering and the communication conventions associated with it; 4) demonstrating the interconnectedness of communication and engineering; 5) socializing students (i.e. preparing them to be engineering professionals); and 6) fostering relationships across colleges.

This college-wide initiative is made possible through a grant from the William and Flora Hewlett Foundation, as well as contributions from both colleges. The structure is such that graduate students from Communication and the University Writing program work with engineering faculty to (re)design curriculum, lecture, provide individual assistance to students, and provide evaluations of students' communication performance. This partnership is effective because both engineering and communication expertise is represented. Although the exact structure varies from department to department dependent upon the uniqueness of the curriculum, all departments utilize this integrated approach and partner with College of Humanities representatives to teach students communication while teaching engineering. This instills that engineering and communication are inextricably linked. In other words, to be a "good" engineer, you must know more than technical information and computer programs. We teach students that in addition to the technical competencies required, they must also know how to communicate effectively.

We also believe that in order for collaborative relationships between the sciences and humanities (such as the relationship CLEAR has with members of the College of Engineering) to be effective, there must be a collaboration between (sometimes) competing paradigms.

### **Research Norms in Engineering Education Research**

As stated above, scientific disciplines such as engineering typically stem from a positivistic paradigm which highlights a belief that objective truth exists outside of humans, objectivity, a separation of the researcher from the researched, and standardization and reproducibility of research procedures.<sup>7</sup> Disciplines in the humanities are often multi-paradigmatic and may include post-positivistic orientations, interpretive/constructivist, postmodern and/or critical.<sup>8</sup> There is not adequate space in this document for a thorough background exploration of each paradigm. We will focus on the interpretive paradigm because the ideologies underpinning this research will allow us to understand students' experiences. These underpinnings are: (1) reality is socially constructed via communication between social actors; (2) there can be no separation from the researcher and the researched since knowledge is dependent on social activity and interpretation, therefore researcher bias is expected; (3) qualitative methods of inquiry such as open-ended questions and observation are preferred ways to understand how social actors make sense of their world.<sup>9</sup>

A search of the Journal of Engineering Education on the topics of qualitative research and qualitative methods resulted in approximately 16 articles. Several themes emerged upon review of these articles: (1) most studies that included a qualitative component also utilized a mixed method approach with quantitative data gathering and analysis techniques; e.g. 10-12 (2) several studies that employed qualitative methods were designed with the purpose of understanding the impact of gender on engineering students and faculty members; 13-17 (3) most qualitative research was conducted in the past 5 years; e.g. 10-14, 17-24 and (4) only two studies addressed curriculum or programmatic assessment.<sup>19,25</sup> Clearly, the dominant research paradigm in the field of engineering education is quantitative. Arguably, data that are measurable and quantifiable yield results and pedagogical understandings that are generalizable in the traditional sense. These data also provide findings that are not easily contested, especially in the face of skeptics. However, in 2004, a "how to" workshop was offered at the annual meeting of ASEE, demonstrating the increasing relevance of qualitative research to developing a rich understanding of engineering education concepts.

### **Qualitative Inquiry and CLEAR Assessment**

As stated above the CLEAR Program is unique in that our goal is to integrate communication concepts into already existing engineering classes. This externally funded, progressive program, then, has many constituents. It is important that we are meeting the needs of industry by better equipping students for their future as organizational members. We must heed the calls put forth by ABET and demonstrate that students are learning to communicate effectively and work on multidisciplinary teams. More locally, we must demonstrate the communication competence of students as a result of this integration, in contrast to the separate writing or communication course. And of course, we must listen to the faculty we work with and the students whom we teach. Assessment, then is very important, whether it be at the programmatic, curricular, or

course level. Because we are interested in learning more than the association between variables or the average satisfaction rating with instructors and instruction, qualitative research becomes especially salient. We argue that a mix between quantitative and qualitative course assessment techniques is necessary for educators to understand engineering students' experiences. Several assumptions about interaction and learning guide this perspective.

Our philosophy of teaching and learning centers on constructivism and situated learning.<sup>26-28</sup> At a basic level, we believe that learning is an active process. That is, students are actively engaged in the construction of knowledge through the sharing, using, and testing of ideas and skills. Learning is essentially the co-creation of meaning. Several principles of learning guide constructivist thinking. First, learning is an active process whereby the learner is engaged with the world, rather than a passive acceptor of knowledge that exists "out there." Second, people "learn to learn" as they learn. That is, as meanings are constructed, students are better able to give meanings to other sensory inputs that fit similar patterns. Third, the action of meaning making happens in the mind. Fourth, learning involves language, such that language facilitates learning. Learning is a social activity, whereby learning is tied to connections with others including family, friends, peers, teachers, casual acquaintances, etc. Thus, interaction with others and the application of knowledge are integral. Sixth, learning is contextual. Information is not learned in isolation. We learn in relationship to what we already know, as well as our beliefs, values, etc. Seventh, one needs knowledge in order to learn. In order to assimilate new knowledge, one needs a structure of developed knowledge on which to build. So, in essence, the more one knows, the more one can learn. In order to teach, then, one must consider the learner's previous knowledge. Perhaps one of the most important principles to remember is that learning takes time. Learners need time to ponder ideas, use, and revisit them. Learning is the product of repeated exposure and thought. Finally, motivation is essential for learning. That is, learners need to know why something is being learned; that is, they need to know the ways in which knowledge can be used.

Situated learning essentially builds on the constructivist principle of contextualized knowledge. In other words, drawing from Brown, Collins, and Duguid (1989), knowledge cannot be extracted from the situations in which it is learned and used.<sup>29</sup> On the contrary, learning must be contextualized, or situated such that knowledge is related to real world experiences. In this way, knowledge is understood through use. Further, through using knowledge, one's view of the world changes and the culture in which the knowledge is used becomes internalized. The internalization of culture occurs through an apprenticeship approach to learning. This approach involves the creation of real world contexts so that students can learn to use knowledge (tools, ideas, skills) the way that practitioners use knowledge; in essence this learning involves entering the community of practice and its culture. Through enculturation, learners move from the periphery of the community to the core, as they co-create and use knowledge. The benefits of situated learning include the following: 1) students learn about the conditions for applying knowledge; 2) students are more likely to engage in invention and problem-solving; 3) students can see the implications of knowledge; 4) students are supported in structuring knowledge in ways appropriate to later use as a result of working with that knowledge in context. These are the types of experiences the CLEAR approach attempts to foster with the integrated nature of the program.

Given these assumptions about learning, an interpretive, qualitative approach to data gathering and analysis surrounding students' experiences in the classroom becomes especially relevant. At the core of the interpretive paradigm is the centrality of meaning in action. In other words, the aim of this approach is the explication of subjective, consensual meanings that constitute social reality,<sup>30</sup> in this case the reality of the classroom experience. The goal of interpretation is to discover the ways people understand their own experiences. As such, subjectivism is embraced and emphasis is placed on individuals' understandings of events.

Since this perspective assumes that classrooms are interlocked actions of a collectivity and that communication is the means by which classroom reality and events are produced and sustained, the interpretive approach affords us with the necessary tools to fully understand the subjective nature of the experiences of communication instruction and learning. The goal is to show how particular realities (in this case, the realities of the engineering classroom) are socially produced and maintained through talk and other daily activities. Through retrospective sense-making processes, students share their experiences of learning communication and explain the meanings and significance of this instruction.

For the purpose of this paper (to demonstrate the richness of information gathered as a result of employing a qualitative approach to assessment), we will highlight one specific department and compare and contrast the assessment data gathered through the use of both quantitative and qualitative data gathering and analysis techniques over two semesters in two separate courses. Course evaluation data included both closed ended/forced choice items and open ended questions which required students to provide their opinions and thoughts regarding both the effectiveness and usefulness of the instruction they received, as well as the reasons why.

### **CLEAR and Mechanical Engineering**

We chose to examine course evaluations in Mechanical Engineering because it is currently one of the most advanced CLEAR departments and the communication integration in is solidified and endorsed by the undergraduate curriculum committee, as well as the faculty members. The four-year plan is summarized in Table 1. Communication instruction takes place in three required, core Mechanical Engineering courses, as well as throughout the junior level lab sequence. The oral and written communication and teamwork instruction varies from course to course and builds on the professional competencies learned in the previous years. The freshman course exposes students to the engineering design process. Students work in teams to complete a competitive design project through several specific assignments. Specifically, teams write several memos, one conceptual design description, and one final design review. In addition, they prepare and deliver two design presentations. The emphasis at this level is on description and information; that is, the communication learning objectives are for student teams to be able to describe their design through informative writing and speaking. Students are also taught how to work in teams at a basic level with attention to team roles and norms and group cohesiveness.

	Speaking	Writing	Teamwork
Freshman Year: Description and Information	ME 1000 Design Presentations	ME 1000 Memos, Mechanism Descriptions, Design Reviews	ME 1000 Cohesiveness, roles, norms, and responsibilities
Sophomore Year: Persuasion	ME 2000 Oral Proposals	ME 2000 Written Proposals	ME 2000 Team productivity
Junior Year: Presentation/Style/Form	ME 3200/3210 Poster Presentations	ME 3200,3210, 3300, 3500, 3600, 3700 Lab Memos	ME 3200/3210 Negotiation and conflict resolution techniques
Senior: Evaluation and Feedback	ME 4000/4010 Update Presentations	ME 3910 Design Project Proposals ME 4000/4010 update memos	ME 4000 Critical listening and feedback

Table 1. CLEAR Mechanical Engineering Four-Year Plan

The sophomore course builds on the principles learned at the freshman level, as students move from description and information to persuasion. Student teams complete a semester long project in which they are asked to develop a new manufacturing process or product to help a stagnating business acquire new profits. The students “pitch” this idea to management through a proposal and oral presentation. Further, students receive more sophisticated instruction in team dynamics with a specific focus on team productivity.

The junior level lab sequence consists of four courses and the emphasis at this level is on improving student writing. Several lab memos are completed in these courses and time is devoted to one-on-one attention with students. Finally, the senior design sequence is a three semester progression. The first course in the sequence consists of lectures and assignments culminating in the team project proposal, a formal written document outlining the capstone project. Students receive instruction in resumes and cover letters, as they have to apply to be on a project. Because many of the projects require large sums of money to complete, students often need to make presentations to university organizations as well as external funding agencies. Thus, students learn how to prepare and deliver a fundraising presentation to assist them as they try to secure funds for their projects. With the project selected and the proposal completed, students progress to the second semester in the sequence, which consists of working on their team project, while learning about the conceptual design phase and prototyping. With respect to communication instruction, teams write an update memo and present an oral project update about once a month. Further, they learn the importance of critical listening, evaluation, and feedback, as they are required to provide oral and written feedback to other teams upon completion of their presentations. Finally, the third course in the senior design sequence consists of the construction, testing and optimization of the proposed design. Students continue to write update memos and also prepare a poster presentation and final report.

In sum, Mechanical Engineering students work in teams, speak, and write throughout their undergraduate career as they complete design, manufacturing, and lab assignments. With the assistance of communication instructors, students learn how to prepare and deliver effective

formal presentations, how to produce quality documents through appreciating writing as a process, and how to navigate various teamwork issues including roles and norms, team contracts, conflict management, time management, and the provision of critical feedback. Although the effectiveness of this 4-year plan is known anecdotally, detailed assessment data is required for continued support of this program. As such, the remainder of this paper will demonstrate the importance of qualitative data to providing a clear picture of program effectiveness from the students' points of view.

### **Course Evaluation Data**

The data for this project consist of course evaluations from the freshman and sophomore courses from two different semesters. Specifically, the format of the course evaluations changed from Spring semester 2004 to Fall semester 2004. The Spring 2004 course evaluations in both classes consisted of primarily forced choice items with only a few open ended questions (see appendices A and B). The Fall 2004 course evaluations in both classes consisted of only open ended questions that were very specific (see appendices C and D). It is important to note that although the students in ME 1000 and ME 2000 were different across semesters the engineering professor, the communication instructors and the assignments and curriculum in each class were the same.

### **Quantitative Data Summary ME 1000 and 2000 Spring 2004**

The quantitative course evaluation data for the freshman (N = 41) and sophomore (N=35) classes is summarized in tables 2-6. The results from ME 1000 indicate that overall, the lectures and consultations facilitated understanding of presentation basics and helped students learn how to prepare and deliver an effective oral presentation (see table 2). In addition, the following statements summarize the course evaluation data:

- The oral communication instructor encouraged students to develop their presentation skills and provided valuable feedback most of the time
- The oral presentations were appropriately integrated with course material some of the time
- The oral communication instructor demonstrated above average knowledge of presentation skills for engineers
- The oral communication instructor was almost always available for office hours
- Students think that oral communication skills are very important to engineers

In short, students had an average to slightly above average experience learning oral communication skills in the freshman course. That is, the quality/usefulness/effectiveness of the instruction was average or slightly above average.

Item	Mean	Mode
The oral communication instructor's lecture effectively assisted me in understanding how to organize and develop a presentation.	3.68	3.00
The oral communication instructor's lecture effectively assisted me in understanding how to deliver a presentation.	3.61	3.00
The oral communication instructor encouraged me to develop my oral communication skills.	3.83	4.00
I learned how to communicate orally from the oral communication lecture in class.	3.24	3.00
I learned how to communicate orally from the individual and/or team meetings with the oral communication instructor.	3.39	4.00
The oral presentations were appropriately integrated with course material.	3.71	3.00
Feedback from the oral communication instructor was valuable.	3.59	4.00
The oral communication instructor demonstrated knowledge of presentation skills for mechanical engineers.	3.59	4.00
The oral communication instructor was available for office hours.	4.11	5.00
I think oral communication skills are important to engineers.	4.66	5.00

Table 2. ME 1000 Results Oral Communication Instruction – Spring 04

In addition, the students perceptions regarding the writing instruction in ME 1000 can be summarized as average (see table 3). Overall, the lectures and consultations were of average usefulness to the students in terms of facilitating understanding of how to organize and write technical documents (memos, design descriptions, design reviews) and in helping students learn how to write in general. More specifically, the following statements summarize the writing course evaluation data:

- The writing instructor encouraged students to develop their writing skills some to most of the time.
- Students applied feedback they received from the writing instructor most of the time.
- The writing exercises were appropriately integrated with course material most of the time.
- The writing instructor demonstrated an above average knowledge of writing skills for mechanical engineers
- The writing instructor was almost always available for office hours.
- Students think that writing skills are very important to engineers.

In short, students had an average to slightly above average experience learning writing in this course. That is, as was the case with the oral communication instruction, students found the quality/usefulness/effectiveness of the writing instruction to be average to slightly above average.

Item	Mean	Mode
The writing instructor's lecture effectively assisted me in understanding how to organize a memo.	3.49	3.00
The writing instructor's lecture effectively assisted me in understanding how to write a memo.	3.59	4.00
The writing instructor's lecture effectively assisted me in understanding how to organize a design proposal.	3.46	3.00
The writing instructor's lecture effectively assisted me in understanding how to write a design proposal	3.24	3.00
The writing instructor's lecture effectively assisted me in understanding how to organize a design review.	3.41	3.00
The writing instructor's lecture effectively assisted me in understanding how to write a design review.	3.30	3.00
I applied feedback to subsequent writing assignments/drafts.	3.54	4.00
The writing instructor encouraged me to develop my writing skills.	3.44	4.00
I learned how to communicate in writing from the writing lectures.	3.05	3.00
I learned how to communicate in writing from individuals and/or team meetings with the writing instructor.	2.98	3.00
The writing exercises were appropriately integrated with course material.	3.71	4.00
The writing instructor demonstrated knowledge of writing skills for mechanical engineers.	3.54	4.00
The writing instructor was available for office hours.	3.92	5.00
I think writing skills are important to engineers.	4.51	5.00

Table 3. ME 1000 Results Written Communication Instruction – Spring 04

Finally, with respect to teamwork instruction, students perceived their experience learning about teams to be of average usefulness (see table 4). That is, the exercises and lectures were of average usefulness to students in terms of understanding team dynamics, communicating with teammates, and completing team projects. The following statements summarize students' perceptions regarding specific issues:

- The teamwork exercises and lectures were appropriately integrated with course material some of the time.
- The teamwork instructor demonstrated an above average knowledge of teamwork for engineers
- Students think that teamwork is important to engineers

Item	Mean	Mode
The teamwork instructor's lecture effectively assisted me in understanding team dynamics.	3.34	3.00
I learned how to communicate with my team through the teamwork lectures and exercises.	3.13	3.00
The in-class teamwork exercises and lectures were appropriately integrated with course material.	3.40	3.00
The in-class teamwork exercises and lectures helped me to navigate working with my team mates on oral and written projects.	3.30	3.00
The in-class teamwork exercises and lectures helped me to navigate working with my team mates on the design project.	2.93	3.00
The teamwork instructor demonstrated knowledge of teamwork skills for mechanical engineers.	3.63	4.00
I think teamwork skills are important to engineers.	4.48	5.00

Table 4. ME 1000 Results Teamwork Instruction – Spring 04

One final interpretation can be made through analyzing this data. When comparing students' responses across the categories of instruction (speaking, writing, and teaming), we can conclude that the lectures and consultations regarding communication were of average usefulness and that students had an average to slightly above average experience learning principles of effective communication. However, students had a slightly better experience learning speaking than writing or teamwork.

The students' perceptions regarding the communication instruction in the sophomore course are similar to the freshmen's perspectives. Like ME 1000, students found the lectures and consultations regarding oral communication to be of average usefulness (see table 5). Specifically, the lectures and consultations were of average usefulness in terms of facilitating understanding of persuasive presentations and helping students learn how to prepare and deliver a persuasive presentation. Additionally, the following statements summarize students' perceptions regarding oral communication instruction in this course:

- The oral presentations were appropriately integrated with course material some of the time
- The oral communication instructor demonstrated average knowledge of presentation skills for engineers
- The oral communication instructor was available for office hours some of the time
- Students think that oral communication skills are very important to engineers

In short, students had an average experience learning oral communication skills in this course. That is, the quality/usefulness/effectiveness of the instruction was average.

Item	Mean	Mode
The oral communication instructor's lecture effectively assisted me in understanding how to develop a persuasive presentation.	3.49	4.00
The oral communication instructor's lecture effectively assisted me in understanding how to deliver a persuasive presentation.	3.31	4.00
The oral communication instructor encouraged me to develop my oral communication skills.	3.17	3.00
I learned how to communicate orally from the oral communication lecture in class.	2.80	3.00
I learned how to better communicate orally from the individual and/or team meetings	2.94	3.00
The oral presentations were integrated with course material.	3.31	4.00
Feedback from the oral communication instructor was valuable	3.49	4.00
The oral communication instructor demonstrated knowledge of presentation skills for mechanical engineers.	3.34	3.00
The oral communication instructor was available for office hours.	3.43	3.00
I think oral communication skills are important to engineers.	4.60	5.00

Table 5. ME 2000 Results Oral Communication Instruction – Spring 04

The students' perceptions regarding the writing instruction in this course was similar to the speaking instruction, although the averages were slightly lower (see table 6).

Item	Mean	Mode
The writing instructor's lecture and peer review facilitation effectively assisted me in understanding how to organize a proposal.	3.00	3.00
The writing instructor's lecture and peer review facilitation effectively assisted me in understanding how to write a proposal.	2.89	3.00
The writing instructor's feedback on my review draft was helpful.	2.97	3.00
I applied feedback to subsequent writing assignments.	3.40	3.00
The writing instructor encouraged me to develop my writing skills.	2.86	3.00
I learned how to communicate in writing from the writing lectures in class.	2.69	3.00
The writing exercises were appropriately integrated with course material.	2.80	3.00
The writing instructor demonstrated knowledge of writing skills for mechanical engineers.	2.89	3.00
The writing instructor was available for office hours.	3.13	4.00
I think writing skills are important to engineers.	4.23	5.00

Table 6. ME 2000 Results Written Communication Instruction – Spring 04

The following statements summarize the writing instruction students received:

- The writing instructor's lectures were of average usefulness to students in terms of facilitating understanding of organizing and writing proposals

- The writing instructor encouraged students to develop their writing skills and provided helpful feedback some of the time
- Students applied feedback they received from the writing instructor some of the time.
- The writing exercises were appropriately integrated with course material some of the time.
- The writing instructor demonstrated an average knowledge of writing skills for mechanical engineers
- The writing instructor was available for office hours some to most of the time
- Students think that writing skills are very important to engineers

In short, students had an average or slightly below average experience learning writing in this course. Finally, through comparing students' experiences in the two courses, we can conclude that overall, students had a slightly better experience learning communication skills in ME 1000 as compared to ME 2000.

Although this data is useful and provides a general assessment of the effectiveness of communication instruction from the students' points of view, we can not move beyond the data to draw inferences about what aspect of instruction in particular made the instruction effective or ineffective. Thus, open-ended questions are necessary to further interpret the quantitative data and in turn, modify the instruction to improve the courses when necessary. The remainder of this paper will highlight the value added of the qualitative data to making sense of the predominantly quantitative course evaluations and will also illustrate the differences in understanding that can be achieved when distributing a completely qualitative course evaluation.

### **Qualitative Course Evaluation Methods**

As noted earlier instructors from the CLEAR program changed the course evaluations for ME 1000 and ME 2000 in the fall of 2004 to a qualitative/open-ended format (See Appendixes C and D). We analyzed the course evaluations by first typing the responses in chronological order for each question. For example, response number 10 came from the same student for each question. Once we had a transcript or "data" we performed a close reading of both ME 1000 and ME 2000 transcripts. This method is in line with a grounded theory analysis outlined by Strauss and Glaser in 1967.<sup>31</sup> Cresswell<sup>32</sup> stated "The intent of a grounded theory study is to generate or discover a theory, an abstract analytical schema of a phenomenon that relates to a particular situation. This situation is one in which individuals interact, take actions, or engage in a process in response to a phenomenon."

The data in a grounded theory study is typically textual<sup>33</sup> and analysis of the data is systematic and follows a standard format. The format consists of open coding, axial coding and selective coding.<sup>32</sup> During the open coding phase researchers form initial categories of information about the phenomenon being studied by segmenting information. This stage begins with a line-by-line analysis of the text in which it is read deeply a minimum of five times. A question the researcher must address as this stage is "what categories does the textual passage suggest?"<sup>33</sup> In this particular analysis the category that initially emerged was that of "a model". What we mean by this is that through deep reading of this text it was clear that students were asking repeatedly for a model or template for how to do communication.

It is important to note that until a researcher is ready to write their final analysis the codes and categories are meant to be fluid and open. This openness works to insure that a researcher does not rush to theoretical judgments before exploring multiple avenues presented in the text. Therefore, during the second stage, or the axial coding stage a researcher re-reads the text and tries to assemble the data in a new way. During this stage in analysis the categories and their subsequent meanings are typically unclear. Therefore, the researcher designs ways to select words and themes that can be grouped together. In this stage we grouped responses that had the words “model”, “how to”, “examples”, “format”, or “template” as indicators of “model responses.” We also recognized that there were themes that kept emerging that went against the category of the model that we developed. These responses were iterative and suggested that students experienced communication as a process. We formed the initial category of “iterative responses” and used phrases such as “practice”, “revise”, “rework” to group responses together in this category. Therefore, at the end of this two-stage process we had two well-developed categories which included “Model Responses” and “Iterative Responses”. The breakdowns of responses in each category are outlined in Tables 7 and 8 below:

ME 1000	
420 Possible Responses	14 questions, 30 respondents
149 blank responses	
271 actual responses	
69 model responses	25% (as evidenced by words such as model, examples, template, how-to or format).
14 iterative responses	5% (as evidenced by words such as practice, revise, process, re-write).
Remaining feedback	70% (generally, wanted more feedback, or they were general critiques or praise of communication instructors or field).

Table 7. ME 1000 Qualitative Results – Fall 2004

ME 2000	
216 Possible Responses	9 questions, 24 respondents
38 blank responses	
178 actual responses	
39 model responses	22% (as evidenced by words such as model, examples, template, how-to or format).
9 iterative responses	5% (as evidenced by words such as practice, revise, process, re-write).
Remaining feedback	73% (generally, wanted more feedback, or they were general critiques or praise of communication instructors or field).

Table 8. ME 2000 Qualitative Results – Fall 2004

Once this stage was completed the initial story started to take shape and we had a system for how to group data together. However, we still needed to explore the data further by entering the selective coding stage. This is where a researcher identifies a story line and writes a story that integrates the categories in the axial coding model. We noted that the conflict between understanding that communication is a process that requires practice and revision to master and

the notion that one can develop communication skills by following a model kept emerging. Therefore, this became the backdrop for our theory explained below.

## Qualitative Results

The interesting findings from this data are that students' qualitative responses asked for examples or models (basic templates for "how to" speak, write or work on a team for a successful (i.e. "A" grade) end result. What we know is that models were given, including specific handouts of memos and the communication instructor's actual presentation with power point slides (in itself, an example). Students wanted a model or template for how to do communication effectively. They did not see the process of learning communication techniques as iterative where students must *perform* the activity repeatedly to progress. In other words students learn to write well by going through the process of writing and revising documents. They learn to speak by practicing presentations and taking many opportunities to publicly speak. Students learn to work as members of a team by going through the constant negotiations and communication necessary to coordinate activities. Instead, the student's qualitative responses to the course suggested that they thought if they had more examples of speaking and writing that they would themselves be able to master writing, speaking and teamwork skills.

Unfortunately for students there is not a model for how to perform communication activities well that will *teach* them how to write, speak or to be an effective team member. A model can give students an idea of what a proper report, presentation or healthy team looks like; not *how* to write, speak or be an effective team member. What we are talking about is a difference between knowing *that* and knowing *how*. For example, knowing *that* a memo has headings and clearly delineated paragraphs and knowing *how* to critically organize thoughts and information to write an effective memo.

We propose that in order to help students understand the iterative learning process of writing, speaking and work on a team that we compare the process of learning and performing communication activities to the process that these students invoke when they work on engineering design. Specifically, we believe we can make the comparison that when students work on a design project they do not rely on a handout or example to get the results they desire. Yes, they rely on past scientist's work and formulas to help develop their designs; but they do not use these past achievements as a type of "instruction sheet" or step-by-step guide. Instead engineers use an iterative process for design. They go through drafts, trial and error periods and revisions until the design is complete.

If engineering students begin to understand that the processes they go through to communicate with others is the same process they go through when they design something they may put more weight on practice, be more inclined to make small improvements and recognize that not getting it right on the first try is not failure; but an opportunity to progress. The goal is to keep working on the skill or design.

## **Importance of Qualitative Research to Program Assessment**

We have used a comparison of qualitative and quantitative course evaluations from two mechanical engineering classes to show that the information gathered from qualitative data evaluations gives instructors depth and direction that is often lacking in quantitative data assessments. For example, if we were to examine the information found in the quantitative course evaluations we would know that students experienced learning writing, speaking and teamwork skills as average or slightly above average. While this is useful information to know, it begs the questions (1) why aren't students more satisfied? (2) What specifically worked/didn't work for them? (3) How can our program improve curriculum development to increase students' satisfaction?

In comparison, examining the qualitative data gave us insight into how students experienced communication instruction. It also allowed us to develop a theory (namely that students don't view the process of learning effective communication skills in the same manner they see the process of design) that we can now work from. In the future we can begin to explain communication processes as parallel to the design process in an attempt to guide students toward a better way of learning.

In summary, we stress the importance of using a mixed method approach for course assessment in order to give both the depth and breadth necessary for understanding students' experiences.

Appendix A: ME 1000 Course Evaluation Spring 2004

Center for Engineering Leadership Evaluation Form  
ME 1000 Spring Semester 2004

Please use the following scale and fill in the appropriate number beside each item below.

- 5 – Always true
- 4 – Frequently true
- 3 – Sometimes true
- 2 – Rarely true
- 1 – Not at all true

Oral Communication

\_\_\_\_\_ The oral communication instructor's lecture effectively assisted me in understanding how to organize and develop a presentation.

\_\_\_\_\_ The oral communication instructor's lecture effectively assisted me in understanding how to deliver a presentation.

\_\_\_\_\_ The oral communication instructor encouraged me to develop my speaking skills.

\_\_\_\_\_ I learned how to communicate orally from the oral communication lecture in class.

\_\_\_\_\_ I learned how to communicate orally from the individual/team consultations with the oral communication instructor.

\_\_\_\_\_ The oral presentations were appropriately integrated with course material.

\_\_\_\_\_ Feedback from the oral communication instructor was valuable.

\_\_\_\_\_ The oral communication instructor demonstrated knowledge of presentation skills for mechanical engineers.

\_\_\_\_\_ The oral communication instructor was available for office hours.

\_\_\_\_\_ I think oral communication skills are important to engineers.

Written Communication

\_\_\_\_\_ The writing instructor's lecture effectively assisted me in better understanding how to organize a memo.

\_\_\_\_\_ The writing instructor's lecture effectively assisted me in understanding how to write a memo.

\_\_\_\_\_ The writing instructor's lecture effectively assisted me in understanding how to organize a design description.

\_\_\_\_\_ The writing instructor's lecture effectively assisted me in understanding how to write a design description.

\_\_\_\_\_ The writing instructor's lecture effectively assisted me in understanding how to organize a design review.

\_\_\_\_\_ The writing instructor's lecture effectively assisted me in understanding how to write a design review.

\_\_\_\_\_ I applied feedback to subsequent writing assignments/drafts.

\_\_\_\_\_ The writing instructor encouraged me to develop my writing skills.

\_\_\_\_\_ I learned how to communicate in writing from the written communication lectures.

\_\_\_\_\_ I learned how to communicate in writing from the individual/team consultations with the writing instructor.

\_\_\_\_\_ The writing exercises were appropriately integrated with course material.

\_\_\_\_\_ The writing instructor demonstrated knowledge of writing skills for mechanical engineers.

\_\_\_\_\_ The writing instructor was available for office hours.

\_\_\_\_\_ I think writing skills are important to engineers.

### Teamwork

\_\_\_\_\_ The teamwork instructor's lecture effectively assisted me in understanding team dynamics.

\_\_\_\_\_ I learned how to communicate with my team through the teamwork lectures and exercises.

\_\_\_\_\_ The in-class teamwork exercises and lectures were appropriately integrated with course material.

\_\_\_\_\_ The in-class teamwork exercises and lectures helped me to navigate working with my teammates on oral and written assignments.

\_\_\_\_\_ The in-class teamwork exercises and lectures helped me to navigate working with my teammates on the design project.

\_\_\_\_\_ The teamwork instructor demonstrated knowledge of teamwork skills for mechanical engineers.

\_\_\_\_\_ I think teamwork skills are important to engineers.

Appendix B: ME 2000 Course Evaluation Spring 2004

Center for Engineering Leadership Evaluation Form  
ME 2000 Spring Semester 2004

Please use the following scale and fill in the appropriate number beside each item below.

- 5 – Always true
- 4 – Frequently true
- 3 – Sometimes true
- 2 – Rarely true
- 1 – Not at all true

Oral Communication

\_\_\_\_\_ The oral communication instructor's lecture effectively assisted me in understanding how to develop a persuasive presentation.

\_\_\_\_\_ The oral communication instructor's lecture effectively assisted me in understanding how to deliver a persuasive presentation.

\_\_\_\_\_ The oral communication instructor encouraged me to develop my speaking skills.

\_\_\_\_\_ I learned how to communicate orally from the oral communication lecture in class.

\_\_\_\_\_ I learned how to communicate orally from the individual/team consultations.

\_\_\_\_\_ The oral presentations were appropriately integrated with course material.

\_\_\_\_\_ Feedback from the oral communication instructor was valuable.

\_\_\_\_\_ The oral communication instructor demonstrated knowledge of presentation skills for mechanical engineers.

\_\_\_\_\_ The oral communication instructor was available for office hours.

\_\_\_\_\_ I think oral communication skills are important to engineers.

Written Communication

\_\_\_\_\_ The writing instructor's lecture and peer review session effectively assisted me in understanding how to organize a proposal.

\_\_\_\_\_ The writing instructor's lecture and peer review session effectively assisted me in understanding how to write a proposal.

\_\_\_\_\_ The writing instructor's feedback on my review draft was helpful.

\_\_\_\_\_ I applied feedback to subsequent writing assignments/drafts.

\_\_\_\_\_ The writing instructor encouraged me to develop my writing skills.

\_\_\_\_\_ I learned how to communicate in writing from the written communication lectures in class.

\_\_\_\_\_ The writing exercises were appropriately integrated with course material.

\_\_\_\_\_ The writing instructor demonstrated knowledge of writing skills for mechanical engineers.

\_\_\_\_\_ The writing instructor was available for office hours.

\_\_\_\_\_ I think writing skills are important for engineers.

Appendix C: ME 1000 Course Evaluation Fall 2004

Center for Engineering Leadership Evaluation Form  
ME 2000 Fall Semester 2004

Oral Communication

Give two examples of how the oral communication instructor's lecture helped you to develop and deliver a presentation.

What other information could have been presented that would have helped you to develop and deliver a presentation?

Give two examples of how you applied feedback from your first presentation as you developed and delivered your second presentation.

What are two ways you see yourself using the oral communication skills you learned in this class in your academic and professional life?

Written Communication

Give two examples of how the writing instructor's lecture helped you to develop and write a mechanism description.

What other information could have been presented that would have helped you to write as a team?

Give two examples of how you applied feedback about the written mechanism description as you revised the final draft.

What are two ways you see yourself using the writing skills you learned in this class in your academic and professional life.

Teamwork

Give two examples of how the teamwork instructor's lecture helped you to develop a working agreement.

What other information could have been presented that could help you to increase team effectiveness?

Give two examples of how you used information presented in the lecture on conflict resolution and individual team skills development in your own team participation.

What are two ways you see yourself using the team skills learned in this class in your academic and professional life.

## General

Ideally, with what other learning opportunities would you like the communication instructors to provide you?

Explain what communication means to you. What do you see as the relationship between engineering and communication?

Appendix D: ME 2000 Course Evaluation Fall 2004

Center for Engineering Leadership Evaluation Form  
ME 2000 Fall Semester 2004

Oral Communication

Give two examples of how the oral communication instructor's lecture helped you to develop a persuasive presentation.

What other information could have been presented that would have helped you to deliver a persuasive presentation?

Give two examples of how you applied feedback from your first individual presentation to your second team presentation.

What are two ways you see yourself using the oral communication skills you learned in this class in your professional life?

Written Communication

Give two examples of how the writing instructor's lecture helped you to develop a persuasive proposal.

What other information could have been presented that would have helped you to write as a team?

Give two examples of how you applied feedback from the writing instructor as you revised your proposal.

What are two ways you see yourself using the writing skills you learned in class in your professional life?

General

Ideally, with what other learning opportunities would you like the communication instructors to provide you?

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