Saving Time, Tempers, and Tears: A Quantified Method of Assessment in Engineering Education

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Abstract

This research addresses a common question asked by engineering educators: "how can I grade the written part of the assignment?" Because ABET guidelines and industry standards are requesting engineering graduates with improved communication and writing skills, it's important to assess these areas competently and consistently. How to do this is another matter. Our research reports the findings of an innovative method of assessment integrated into multiple undergraduate engineering education courses.

Introduction

Our research offers suggestions to engineering educators for improving their confidence and competency in evaluating the written and communicative portions of engineering assignments. Because ABET guidelines and industry standards are demanding engineering graduates with improved communication and writing skills, it is important to assess these areas competently and consistently, and our suggested methods of integrating these ideas involves a fine line between finesse and fearlessness in the classroom. While this paper represents an abbreviated version of our actual research in order to meet ASEE-SE requirements, we are happy to provide examples and supplements of our work upon request.

Goals

Our quest to design a clear, quick, and competent system of evaluating the written and communicative portions of engineering assignments spans a four-year period (1997-2001). It takes place in one large urban and in one state engineering college. The study team is composed of three engineering professors and one technical writing instructor. Prior to this study, the engineering instructors had followed a holistic, "one-size-fits-all", approach to evaluating the writing part of their assignments: put simply, if the technical content was sound and there were not too many grammatical and spelling errors, it received a "B"; if either of these simple criteria wasn't met, the grade was lowered. The technical writing instructor, however, had used a criteria-based system for several years in evaluating student's work in composition and technical writing courses, and suggested an adaptation of a criteria-based system to delineate and specify discrete objectives for each written assignment.

The criteria-based evaluation system was first piloted in the fall 1997 semester in a team-taught introductory civil engineering course (CIVL 1101). The teaching team was composed of one engineering

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instructor and one technical writing instructor, and the instructors identified the following goals before designing the criteria-based evaluated rubric:

- To decrease instructor subjectivity and bias in evaluating written work
- To decrease instructor time spent evaluating written work
- To increase instructor credibility in evaluating written work
- To increase student satisfaction and student understanding of the evaluation process
- To promote greater levels of student-instructor communication about evaluation methods

With these goals in mind, the instructors worked together to review the current course assignments in light of the available models for designing systems of evaluation.

History/Background

In order to understand the difficulty associated with assessing engineering writing, it is important to understand the distinct differences in style between general academic writing and technical writing required in engineering documents. Previous researchers have offered various theories of these discrepancies. Pappas and Hendricks (2000), and Boyd and Hassett (2000) note that students often arrive in engineering classrooms after completing the general education English Composition classes, and many of their previous composition teachers have backgrounds in literature. While English teachers may look for and actively encourage lengthy, expressive situational descriptions in their assignments, this same style of writing is explicitly discouraged in engineering writing assignments. Similarly, Kurtiss (1995) and Miller, et al (1998) agree that all disciplines share a common degree of accepted writing norms with regard to paragraph structure, grammar, and syntax, but some professional disciplines including law, medicine and engineering require a specialized genre of writing customized specifically to reflect field requirements. This is, in effect, where the real problem begins: current engineering education research conducted in these areas acknowledge that writing teachers are trained and experienced in both teaching and evaluating writing, but they cannot and should not be expected to develop a mastery of all discipline-specific technical writing requirements; engineering teachers are trained and experienced in teaching and evaluating content-specific information, but they cannot and should not be expected to know the intricacies of teaching technical writing (Pappas and Hendricks, 2000; Piirto, 1985; Kurtiss, 1995).

In ideal situations, technical writing teachers would work in collaboration with engineering teachers to evaluate engineering writing, but at many institutions, this is not a feasible suggestion, so the question remains regarding the types of evaluation available for engineering writing. Our review of the literature indicates that engineering educators have experimented with different forms of evaluation since the mid-1970's. Much of what is known today in writing evaluation research can be attributed to the early work of Cooper and Odell (1977) who worked to design a system of evaluation for student writing based on objective standards. And while standards are expected to differ from discipline to discipline, Miller, et al. (1998) caution instructors to consider the characteristics of the students and the requirements of the specific genre in defining these standards. A good example of this comes from research studies that suggest engineering students have different responses to teacher comments on their papers. The majority of research studies conducted with students in general English composition classes pay little or no attention to teachers' written comments on graded papers and therefore suggest that writing teachers focus on a few direct questions in combination with a criteria-based system of evaluation (Miller, et. al (1988) and Piirto (1996)). Studies based specifically on engineering students, however, directly contrast these findings, and suggest that engineering students do read and respond to teacher comments. Therefore, they encourage engineering instructors to include these qualitative written comments as supplementary feedback (Miller, et. Al (1988) and Piirto (1996)).

With these findings in mind, two methods of assessing engineering writing today are frequently discussed and encouraged in engineering education literature. One type is called "holistic" writing evaluation, and it is based on the theory that content and technical proficiency of a document should be evaluated together according to pre-established standards. While most proponents of holistic evaluation agree that pre-established standards are essential in any holistic system, a review of several holistic guidelines for evaluation reveals many areas where subjectivity seems unavoidable. For example, Hittleman (1988) uses a 1-4 point scale based on the following definitions: *1*=little or no presence of the characteristic; *2*=some presence of the characteristic; *3*=fairly successful communication; and *4*=a highly mature presence of the characteristic.

Krest (1987) uses a similar system but adds what he calls "loci of control" (LOC) to differentiate between a student's low level of mastery in a particular category and a student with a high level of mastery. While these systems of evaluation offer specified criteria for the students' use before actual writing begins, their intentionally vague specifications may lead to subjectivity in assigning actual point values.

The other system of assessing engineering writing is called a criteria-based system of assessment, a system that has been widely used with great degrees of success in evaluating writing in composition classes since the mid 1980's. While there are many definitions of criteria-based systems that often seem to conflict with each other, for our purposes, we define a criteria-based system as one which specifies a desired characteristic, assigns specific points to that characteristic, shares this information with the student in advance of evaluation, and then evaluates the characteristic based only on the written specification.

While this system is occasionally misunderstood as a type of "writing checklist", most criteria-based systems combine the holistic notion of evaluating separate areas of a document with specific point values for each area and add a more quantifiable way to do this by designing the evaluation instrument to reflect the goals of the particular assignment. For example, an instructor should list the goals of a particular writing assignment before designing the assignment, and then construct the evaluation instrument based on the criteria of the assignment. Points should then be assigned for each criterion, and the evaluation instrument is often presented to the student in the form of a table or matrix.

While there are multiple methods and many examples of criteria-based systems to serve as models, the essential requirements of any potentially successful system should include specific, clear, and discrete criteria specifications that are distributed and discussed with students before any writing begins.

Methodology

Two sections of an introductory civil engineering course at The University of Memphis were selected for the pilot study in the Fall semester of 1997. It is important to note that this type of evaluation relates to a series of group-based design projects where groups of 3-5 students worked together to address a hypothetical client's design needs and present this information in both a technical report and an oral presentation.

A table-based point system was created for the pilot study in fall of 1997, and Figure 1 shows the current criteria point divisions: *40* points were assigned to the technical content portion of the assignment, 30 points were assigned to the technical writing portion of the assignment, *10* points were assigned to oral presentations and *20* points were for miscellaneous items. These divisions were further subcategorized into specific parts of each portion, and available point totals were given. The criteria-based system of evaluation

CIVL 1101 - Civil Engineering Measurements

Report Evaluation #2 Group Name: ____________________

Category	Points	Evaluation
Writing		
Prewriting: Planning sheet, outline, and rough draft	**10**	
Format: All required parts included, pages numbered, figures and tables properly labeled, etc.	**10**	
Readability: Paragraphs and sentence structure, text flow, organization of ideas, correct use of language, use of figures and tables for illustration of ideas, spelling, etc.	**20**	
Content: Use of engineering design concepts, completeness of ideas, support of decisions presented, comprehensiveness of observations and conclusions	**30**	
Focus and Integration: Use of skills and tools developed, implementation of engineering methods, use of resources, ideation, etc.	**10**	
Deliverable		
Oral Presentation	**10**	
Beam Performance*(each beam's strength-to-weight ratio was compared to other beams in the class competition: the group with the highest SWR received 10 points, and the other points were assigned according to rank placement)	**10**	
OVERALL SCORE	**100**	

Figure 1. Evaluation Criteria Rubric for Introductory Engineering Class.

was provided to the students at the beginning of the assignment, and students were given opportunities to ask questions throughout the project.

Evaluation was handled in the following manner: criteria sheets were attached to each final draft, and the writing instructor evaluated the technical writing portions of the assignment, filled in the point totals, and made handwritten qualitative comments on the "comments" portion of the criteria sheet. After this was done, the engineering instructor read the papers and evaluated the remaining content portion by filling in the appropriate point totals and writing comments in a different ink color so the students could easily differentiate between instructors. The remaining oral presentation point totals were determined by averaging point totals from the students, observers, and the instructors.

Papers were returned to students the following lab periods in what the instructors called a “debriefing” session where both instructors met privately with the student groups and discussed the report page by page. Students were given opportunities to ask questions and both instructors responded individually at that time.

Assessment of the Pilot Program

Results and reactions to this new system of evaluation were collected through triangulated measurement devices commonly used in educational research: student surveys, student interviews, and instructor interviews. The initial student surveys from the pilot program reported that students definitely thought that having both a writing expert and an engineering expert evaluating their papers together resulted in increased “fairness” to the students and increased credibility to the final grade itself. The students also requested more specific criteria breakdowns, and the instructors worked together to modify the criteria-based system in response to this request.

Modifications, customization, and extensions of the evaluation system

In response to student and instructor feedback, the pilot criteria-based system was slightly modified for the CIVL 1112 course in the spring semester of 1998, and has been in use for subsequent semesters by the same instructors for the CIVL 1101/1112 course sequence at The University of Memphis. The system has also been expanded at The University of Memphis for use in a sophomore-level programming class, and is being tested currently in a senior-level Applied Fluids Mechanics course at The University of Kentucky. While the criteria changes according to each assignment and each course, the basic concept remains the same: the instructor specifies the desired criteria, assigns point values, gives this information to the students in advance of evaluation, and then evaluates according to the criteria.

The course at the University of Kentucky illustrates an example of a “before/after” change in the evaluation system. Figure 2 show the previous evaluation system used, which was based on a holistic approach. Figure 3 shows the new criteria-based evaluation system for a representative assignment.

Results

A brief summary of the results for the four-year period indicates significant advantages for instructors using a criteria-based system to evaluate writing in two distinct areas: time spent grading and time spent explaining grades to students. While all three engineering instructors expressed some initial reticence about their own qualifications to evaluate writing, they also expressed relief that their relative weightings were remarkable similar to the writing instructor's relative weighting when comparisons were made of the same assignments. The engineering instructors also reported that after the criteria-based system becomes familiar, the time spent reading and evaluating decreases because the time spent is tightly focused on discrete categories. Engineering instructors also reported that discussing grades with students was much easier with this system compared against their previous holistic methods because both students and instructor could look at the criteria and immediately specify an area where improvement was needed.

Students have also reported distinct advantages with this method of assessment: they know what to expect, they have access to the criteria before and during preparation of the assignment, and the system seems fair. A post semester survey of the senior level engineering class including 42 students of 52 students enrolled in

Lab Write-up Requirements

The following structure represents our minimum general requirements for the formal lab report (having these five things is equivalent to a "C"). Any special or additional requirements may be assigned in conjunction with a particular lab. The degree to which you address special requirements of a lab and your ability to expand/develop the 5 areas will determine "B" versus "C" work. Competent writing skills (punctuation, grammar, spelling, etc.) and overall clarity of presentation will determine "A" versus "B" work.

I Introduction

Purpose, objectives, setup if the problem, motivation, etc.

II Theoretical Development of governing principals and equations

Lab-based on what theory or topic, important equations which will be used in the lab. Remember audience...give enough information that a typical engineering student would understand.

III Experimental Methodology

Procedures, equipment, data needs. Give enough information that any person could repeat the experiment.

IV Results

Relates results to objectives, indicates sources of error coupled with an error analysis (quantitative/qualitative), etc.

V Conclusions

What was learned, improvements to procedure, fulfillment of the clients' needs, etc.

Figure 2. Original grading criteria (holistic-based) for senior level fluids course.

the course found the students "liked the criteria-based system of grading (the table) used for the written labs better than the traditional system of assigning a specific number with no comments/breakdown". The average response was *4.10* on the *5.0* scale (with *1* being strongly disagree, *3* being neither agree nor disagree, *5* being strongly agree).

Disadvantages associated with criteria-based evaluation systems include increased time for engineering instructors to work with the writing instructor on the front-end of the assignment to renovate, customize, and design the evaluation criteria. However, the potential long-term advantages appear to outweigh short-term complaints. In fact, all three engineering instructors have extended this system of evaluation to their other engineering courses, and there are plans to extend this system of assessment to additional civil engineering courses in both universities.

Conclusion

Our four years of collected research reveals that the criteria-based evaluation works, students like it, instructors like it, and it fosters greater levels of communication (and hence learning) between the instructor and student. A holistic approach has the advantage of looking at a total picture while combining the evaluation of technical content and delivery style. But our interaction with students has led us to the belief that students want more detailed feedback to target areas of weakness. The criteria-based evaluation allows the students to know what is important in their final product, uniquely identifies potential problem areas, and ultimately saves time for the instructor.

CRITERIA FOR EVALUATION

Group name: ________________________**Group Members:**____

Content Analysis: 60 points/___

	Possible	Score
Introduction/problem statement	10	
Rise in water elevation	5	
Extend of effects upstream	5	
Explanation of the basic procedure	10	
Appendix: Sample calculations, verification	10	
Appendix: explanation of the program procedure, theory, and consistency	10	
Recommendations/Conclusion/link between contract and your company	10	

Presentation of Data: 20 points/___

	Possible	Score
Graph of channel location	5	
Graph of surface location	5	
Graph of normal and critical depths	5	
Accuracy of computations	10	

Technical Writing Proficiency 20 points/___

	Possible	Score
Audience Analysis—"client-friendly focus"	4	
Document Design	4	
Readability: grammar/punctuation/spelling	4	
Clarity of the writing	4	
Link between document and appendices	4	

Oral Presentation Analysis: 50 points/____

	Possible	Score
Time limit 5min (6 min max)	5	
Motivation: Outline of Project - overview of issues	10	
Customization of content to general engineering (non-water resources) audience	10	
Anticipation of client's future needs	5	
Level of interest/enthusiasm	5	
Professional appearance	5	
Quality/use of visuals	10	

TOTALS: Report: 100 points/___ Presentation: 50 points/___

Comments:

Figure 3. Criteria-based evaluation rubric for senior level fluids course.

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