Holistic Grading in Science and Engineering

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ABSTRACT

A description of holistic grading for oral and written individual and team-prepared work in science and engineering courses, and guidelines for its implementation in the classroom are presented. Anecdotal evidence of the effectiveness of the methodology is reported.

I. INTRODUCTION

As writing and communication skills become more necessary for most entry-level engineering positions, engineering schools must now assure that they graduate engineers who can meet new workplace standards. In this regard, two tasks face engineering departments: 1) how to raise the level of writing and communications ability of their students and 2) how to increase faculty members’ ability to grade writing and communications effectively. These tasks are required both to satisfy the needs of industry and to satisfy the new ABET Engineering Criteria 2000.1

Furthermore, both industry and ABET are increasingly emphasizing the need for engineering graduates to work in a team environment. Engineering schools are responding by requiring that students perform an increasing amount of their laboratory and/or design work in teams. Heretofore, the majority of engineering faculty members have not had the instructional tools either to teach or evaluate teamwork.

How engineering schools respond to industry may be strongly influenced by the ABET “a-k guidelines” which, in part, focus on teaching students to communicate technical information. These guidelines are a mandate for engineering schools to become more interdisciplinary, and to teach and evaluate skills never before considered essential to the study or practice of engineering. Many engineering schools have, if fact, added some instruction in writing and oral presentations to their curricula (e.g., the program at Virginia Tech2) and other programs cited therein), while others have added team projects. However, problems remain: Who will teach writing and oral presentation skills, and who will grade the students’ work in these areas? How will we teach teamwork, and how will we assign individual grades for work performed in teams?

The overriding issue is a simple one: understanding technical material is largely useless unless one can effectively communicate it within and across disciplines. The problem is not that engineering faculty members fail to value good writing and speaking; the problem is that they are not trained to teach or evaluate these subjects. This article is not a crash course in writing and speaking, but it does set some clear “holistic” standards for effective writing and oral presentations, and offers a method for evaluating writing and public speaking that follows the standards outlined by ABET and the characteristics of effective industry-modeled communications.

We suggest that “holistic grading,” a methodology used primarily in the humanities, has potential for solving these dilemmas in engineering.4 Holistic grading examines a document or presentation as a whole rather than considering technical content and writing style (including grammar and mechanics) as separate entities. In particular, holistic grading does not follow the usual formula for deducting points for various grammatical or stylistic errors. Rather, it defines standards for various grades against which the entire document or presentation is judged. In particular, an effective written document or oral presentation must be evaluated in the context of the purpose for which it is intended, and the degree of success with which it satisfies this purpose. Engineering faculty may be more comfortable with and adept at grading along such workplace standards.

The objective of our present work is to present a holistic assessment and grading methodology that is relevant to the workplace for which we are preparing our students, as well as efficient for faculty and fair to students.

II. GOOD WRITING VS. GOOD COMMUNICATIONS

Academia has long been led to evaluate student writing according to standards set by English departments. While these standards represent “academic” English usage and style, and certainly set the highest standard for written communications, they do not always accurately reflect workplace needs and the standards for workplace writing. Workplace standards mandate clear and concise communications that meet the needs of a particular situation, rather than adhere to the rules and conventions of academic English. This practice is especially true as employers are increasingly providing employees with personal computers (rather than secretaries) and requiring them to perform their own typing and editing. If a written document does its job of communicating clearly to an intended audience, no one minds too much if there are some stylistic or grammatical shortcomings, especially if the extra effort required to “make the document perfect” decreases productivity with no increase in understanding. While this approach does not hold true for high-level

1. In developing our methodology, we have been strongly influenced by the pioneering work of Edward White (E. M. White, Teaching and Assessing Writing, San Francisco: Jossey-Bass, 1991.)

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communications in any field, day-to-day communications (especially the increasing use of e-mail) require no more than an unambiguous understanding of what the author is communicating.

Different writing styles are appropriate for different purposes; we have known this, at least intuitively, for a long time. A most recent example are the writing standards, or lack thereof, applied to e-mail communications. Few individuals complain about the apparent conversational standards that apply to this sort of writing—almost anything seems acceptable. On the other hand, articles for publication, research proposals, and technical presentations at society meetings are subject to the strictest academic standards. Between these two extremes is the most prevalent and necessary form of workplace communication—everyday business communications, both oral and written. In these communications, clarity and efficiency are the order of the day. In such applications, workplace needs value good communications over good writing.

Ultimately, the writing standards suggested here do not seek to undermine academic English standards or instruction. Quite the contrary, learning to communicate clearly and concisely in writing tends to improve academic writing skills. It is our experience that both students and faculty, most of whom have long been separated from their formal training in English, relate well to the holistic writing guidelines defined in the following section. What both groups seem to need and want are objective standards that allow assessment by example.

### III. Holistic Guidelines

Although engineers sometimes are unable to communicate the rationale for an evaluation, most recognize a well-written document or a well-crafted oral presentation when they see or hear it. Our guidelines are designed to help them define and apply what they already understand. The philosophy behind holistic guidelines is simple: Judge the technical content and the writing style as integral components. As all engineering faculty members have experienced, a grading methodology by which a certain number of points are deducted for various types of grammatical or stylistic errors, coupled with a similar approach to the technical content, rarely works. Writing and technical content cannot be separated into simple additive (linearly independent) parts. A poorly written document is both stylistically inferior and technically inadequate. The linear independence implied by standard grading practices fails to incorporate the significant cross-correlations and mutual dependencies of technical content and writing style.

Holistic grading guidelines, both for written documents and for oral presentations, avoid such grading problems. In the holistic methodology, descriptive standards of expectations for various workplace-defined types of communicative presentations are defined. At first sight, one might conclude that it would be necessary to prepare a guideline or standard for each of the many possible communicative tasks students may encounter. Of course, this becomes prohibitively complex and bureaucratic. Instead, we define general guidelines (rather than absolute standards) that the user should apply subjectively to the assignment at hand. In this manner, we have found that, with careful definition, a single guideline may be prepared that covers all written work, while a second may be used for oral presentations. Guidelines, both for writing and oral presentations by individuals and teams, are shown in Appendices A and B, respectively. The guidelines for grading individual and collaborative writing (Appendix A) are self-explanatory; the “A” section represents characteristics of excellent communication in industry. Decreasing letter grades describe increasingly less effective documents. Note that the grammar rules and regulations many faculty members (and students) despise are absent, and are replaced by practical communication qualities. In short, if a document communicates well what it intends (without too much work being required of the reader), it may not be considered particularly good writing, but it is good communication.

Industry guidelines for effective public speaking and oral presentations (Appendix B) are more in concert with academia, for there are fewer and less restrictive rules applied to speaking than to writing. This fact does not suggest that excellent presentations are easier to create than effective written documents, or that there are few standards for excellence in presentation style. Speaking in front of others requires not only skill, but also style. A presentation style that works well in front of an academic or industrial audience and communicates technical information well (without placing too many demands on the audience) can be considered effective, whether or not it strictly adheres to the conventions of “good public speaking.” Unfortunately, as with writing, some faculty members ignore all but gross errors in oral presentation style in favor of evaluating content alone, but most academicians know what a spirited and informed presentation looks like and reward it accordingly.

Our holistic guidelines that define the qualities of either a written document or an oral presentation have been well received by students and faculty members alike. Contrary to expectations, we have found that the uncertainty (subjectivity) associated with application of the guidelines is not a problem for our students. They have come to realize that this subjectivity represents the real workplace—readers or members of the audience judge the student’s work differently because each listener/reader applies his or her own definition of excellence.

Electronic copies of the holistic guidelines described in Appendices A and B, as well as an electronic copy of the oral presentation checksheet presented in Appendix C are available on-line at http://www.mse.vt.edu/faculty/hendricks/writing_guidelines/.

### IV. Implementing and Assessing Holistic Guidelines

The holistic assessment methodologies presented here have been developed during six years of trial and error, and have only recently been formalized as offered in the appendices to this paper. We have learned that integrating such a grading system into our curriculum and using the guidelines presented here require care and time. At times, students have been uncomfortable with the uncertainty of the new evaluation methodologies, and want and demand both adequate feedback concerning their work and a rationale for a grade assignment. Although there are numerous similarities among our holistic guidelines for written, oral, and team-prepared

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*We have been gratified by both the interest and the constructive feedback from our students as the process evolved. The final format of the oral presentation evaluation form presented in Appendix C has been heavily influenced by their participation in the development process.*
work, subtle differences, if not properly accounted for, can make the difference between success and failure.

In implementing holistic guidelines, we have found that, for written work, it is essential that the instructor still liberally mark the document both with criticism and praise. This approach is in contrast to some recent efforts in which attempts have been made to create evaluatory writing checksheets. Although the checksheet approach is convenient for faculty to implement, the primary shortcoming of this methodology is its failure to provide adequate feedback to the student so that she or he may take corrective action. Thus, there is no grading checksheet offered in association with our holistic writing guidelines.

The holistic evaluation of oral presentations provides a different set of problems. Since there is no equivalent of the written document on which the instructor may provide feedback, we have employed two alternatives: immediate oral feedback (from both the class and the instructor) following the presentation and written feedback. Again, as with the evaluation of written work, we have found that the checksheet approach, although convenient and attuned to numerical grades, does not provide adequate feedback by which students may improve their presentation skills, nor does it provide sufficient rationale for the grade awarded for the work*. In collaboration with our students, we have designed a standardized written evaluation form that both reminds the grader of the holistic standards for oral presentations described in Appendix B and provides adequate space for written comments, both positive and negative, on the various items being evaluated. This form is presented in Appendix C.

To help students learn skills that will enable them to perform well in the workplace, as well as to help insure that engineering programs satisfy ABET 2000 criteria, engineering schools are encouraging or requiring students to work in teams in capstone senior research or design courses, and in some laboratory classes. While some colleges have had students work in teams for quite some time, faculty members are becoming more serious about the topic. The responsibility again falls on engineering faculty to evaluate team projects fairly and effectively. While the guidelines presented here do not instruct faculty on how to organize teams or teach teamwork skills, they do offer characteristics of effective collaborative work and provide a means to evaluate such work. Although in the workplace a team effort stands or falls by itself, independent of the contribution of the individual members, in academia there is a need to adjust the grade awarded for a team project based on individual performance. We have devised a methodology by which we scale the performance of each student by a subjectively determined multiplicative factor that varies between about 0.85 and 1.10. This scale factor is determined by an individual appraisal that takes into account important measures of performance such as attitude, commitment, and participation. We have found that when couched in these terms, such subjective evaluations are both expected by and acceptable to students.

To this point, we have only discussed how holistic grading can be used to assess student performance. Perhaps as important, we must also address the question of the effectiveness of holistic grading as an assessment instrument. Since the implementation of our holistic grading scheme, we have observed consistently improved written and oral work and have, therefore, been able to raise our standards for what is considered acceptable work. In addition to our subjective observations, which have been confirmed by our teaching colleagues, our industrial review panel has also documented this improvement. This panel, which has three times independently evaluated our students' communication portfolios since 1996, has determined that “All papers meet, and most papers exceed, the requirements for entry-level engineers in the industrial workplace.”

V. Conclusion

Many colleges and universities have determined that an effective way to improve writing and communication skills is through writing across the curriculum programs, of which the program in our department is but one example. In this paper, we have suggested holistic grading as a viable way to assess effectively the quality of student work performed in such programs for scientists and engineers. For such a grading scheme to be successful, however, faculty must learn how to grade holistically, and students must be convinced of the efficacy and fairness of the approach. Clearly, holistic grading as described in this paper addresses only part of the problem. The remaining question—how does one teach holistically—is a subject for another paper.

REFERENCES


APPENDIX A

Holistic Guidelines for Grading Individual and Collaborative Writing

A—General writing and content considerations: Excellent work overall. Obviously well conceived and descriptive. Technical objectives are clearly and convincingly stated; relevant and numerous sources of background material clearly frame and introduce the subject. Technical content themes are logically stated and organized, and clearly support the overall objective. Data and descriptions are clearly separated from interpretations. Content is detailed and suggestive. Conclusions are well supported by data. The overall presentation shows a high level of understanding and perspective. Easy to read, smooth, highly organized; exhibits a clear sense of unity and purpose, and paragraph and topical transition. Contains no major and few minor grammatical or stylistic errors. Graphics are highly informative, appropriately placed, clearly and uniformly designed, and easy to interpret.

Collaborative considerations: Clearly identifiable uniform purpose, approach, and mastery of topic. Complete and consistent level of detail and specificity. Excellent, attractive, and uniform document design and layout (including white space, consistent headings, and type size and font). Uniform collaborative writing style and transitions from section to section or topic to topic.

*Such a numerical check sheet was used in the earliest courses in which our methodology was tried, but with strong negative student feedback.
Graphs are completely consistent in style, size, placement, purpose, detail, and overall quality.

B—General writing and content considerations: Paper presents content clearly and displays a firm grasp of the technical material but without the sharp focus and perspective of an “A” paper. Technical material is presented logically with perhaps a few minor lapses in clarity and transition, but is still well organized, thoughtfully conceived, and avoids generalizations on the topic. Most parts of the paper are clearly written and adequately detailed; some sections may be awkward but not unclear. Successful effort is evident throughout the paper. Some “B” papers are more successful in presentation and weaker in content; others are opposite. No major grammatical errors; some minor grammatical errors, but none that disrupt the style and easy reading of the paper. Graphics are informative, uniform, intelligible, and support the content of the paper.

Collaborative considerations: Clearly identifiable uniform purpose and approach. Technical understanding of the topic and material is strong but not masterful. Mostly detailed and specific, but may have a few uneven or general passages. Highly attractive and uniform document design and layout (including white space, consistent headings, and type size), but may have some small inconsistencies or overlooked design details. Clearly identifiable writing style but shows evidence of multiple writers. Shows evidence of effective collaborative revision. Strong, but not flawless, transitions from section to section or topic to topic. Graphics are mostly consistent in style, placement, purpose, detail, and overall quality.

C—General writing and content considerations: Displays a reasonable grasp of the technical content but little independent or original thought. Wholly extracted sections of content from text or handouts. Some general grasp of how this contribution fits into the framework of experimentation or theory. Treatment of the topic may be general and lack detail. Some lapses in clarity and focus; perspective is mostly observational. May contain errors in technical content. Technical content only casually supports conclusions. Adequately organized. Some major grammatical errors, or frequent and annoying minor grammatical errors. Writing style may be uneven: reading may be slow or confusing at times. Graphics may not clearly support content objectives as in an “A” or “B” paper or may be ornamental.

Collaborative considerations: Identifiable uniform purpose and approach, but with some obvious lapses. Technical understanding of topic and material evident but uneven from section to section. Some good detail, but may be overly general and exhibit only moderate technical control over and understanding of the material. Document design and layout understandable but with some obvious inconsistencies or overlooked design details. Writing style often uneven, but individual sections are still mostly readable and clear; obvious evidence of multiple writers and weak collaborative revision. Transitions from section to section or topic to topic adequate, but may be confusing at times. Graphics may be inconsistent in style, placement, purpose, detail, and overall quality.

D—General writing and content considerations: No vision or thought evident. Weak or superficial grasp of technical content. No identifiable effort in the description or analysis of technical content. Gross technical errors. Little or no perspective or detail on topic except sweeping generalizations derived from others’ work. Poor writing style, frequent major and minor grammatical errors. Poorly organized. May be reasonably well written but require rereading at times. Graphics are poorly designed, absent, ornamental, or offer no support of the content of the paper.

Collaborative considerations: Lacks uniform purpose and approach, with obvious inconsistencies in content and writing style. Technical understanding of the topic may be uneven or confusing from section to section. Document design and layout casual—indicating little collaborative effort. Writing style is largely uneven from section to section; individual sections weak and show complete lack of revision. Weak transitions from section to section or topic to topic. Graphics absent or largely inconsistent in style, placement, purpose, detail, and overall quality.

F—General writing and content considerations: No evidence of technical unity or understanding of technical content. Little understanding of even general technical concepts. May be completely off topic or lack identifiable focus. Paper may be entirely unreadable or have frequent glaring writing style weaknesses and major grammatical errors. May display a flagrant lack of concern for, or misunderstanding of, technical content and writing style. Graphics may be absent, poorly designed, irrelevant, or unintelligible.

Collaborative considerations: Absence of identifiable collaborative technical or writing effort. No uniform purpose and approach. Document design and layout serendipitous. Writing style difficult to read, uneven; some sections may be incomprehensible and show complete lack of collaborative revision. Transitions from section to section or topic to topic are absent. Graphics haphazardly styled and placed, with no attention to uniform purpose, detail, and overall quality.

APPENDIX B

Holistic Guidelines for Individual and Team Oral Presentations

A—General presentation and content considerations: The presenter commands a complete mastery of the material and how it is presented. Excellent synthesis and organization of material and presentation. Presenter is aware of the relative importance of each specific topic to the general theme, and appropriate time is spent on each topic. Presenter is obviously comfortable in front of the audience; physical gestures, vocal quality, and eye contact indicate an easy familiarity with the material (humor may occasionally punctuate the presentation). Visuals also indicate a mastery of the material; they are clear, easy to read and understand, and present concepts in alternative ways. Visuals are not ornamental; they follow the oral presentation accurately and provide the audience with a “visual map” of the presentation. The presenter is dressed and groomed appropriately for the presentation.

Collaborative considerations: Superior and easily understood synthesis of individually presented technical material. Logical transitions of technical material from one presenter to another. Clear evidence that all presenters understand the material being presented, and how his or her material fits into the larger scheme. Overall presentation is natural; team members move about naturally and display confident movement, eye contact, hand gestures, and interaction with other team members. Team members are dressed in a similar business style.

B—General presentation and content considerations: Presenter shows significant control and understanding of the technical material, its importance to the general theme, and its organization and presentation. A clear synthesis of the material and presentation is obvious, but the presenter may not grasp some finer detail in the material or may not spend sufficient time on critical topics. The
presentation is mostly comfortable in front of the audience, but brief lapses in clarity in the technical material or organization may occur. Gestures may seem a bit mechanical or rehearsed at times. Vocal quality is strong, but the presenter may experience short lapses in continuity or express some temporary awkwardness. Visuals are, for the most part, thoughtful, easily read, and relate clearly to the material, but some visuals may seem to repeat material clearly expressed verbally. The presentation is only adequately timed, and the presenter may have to rush to conclude or take questions. The presenter is dressed appropriately for the presentation.

Collaborative considerations: Audience understands well the general topic and individual topics presented. Transitions among topics effective, some unevenness may occur, but it does not affect the clarity of the presentation. All team members appear to understand all the topics presented but may lack a working understanding of the more sophisticated implications. Overall presentation attractive, eye contact is good, but some movement may be stiff or seem practiced at times. All team members are dressed in appropriate business attire.

C—General presentation and content considerations: The presenter shows erratic control over the presentation or understanding of the technical material, requiring the audience to work to bring meaning to the presentation. Lack of preparation (technical or presentation) is obvious in the on and off synthesis of the material and organization of the presentation. Time spent on important technical topics may be brief, or the presentation may be too general overall (or concentrate on too few important points). The presenter lacks the preparation or ability to make the audience understand and feel entirely comfortable with the presentation: little hand or body movement, occasional lack of eye contact (or too much time looking at the visuals), or intermittent problems with vocal quality (tone, volume, inflection) may make the audience feel that more preparation was needed. Visuals seem somewhat general or basic (or ornamental), or sometimes unrelated in nature to specifics in the presentation (other than the title, outline, and lists): visuals tend to support the material but offer no fresh perspective or added understanding of the material. Some visual representations may be difficult to read; other important visuals may be left out or depicted erroneously. The presentation is paced unevenly, and the presenter may exhibit some trouble concluding adequately or taking questions. The presenter may be dressed too casually for the presentation.

Collaborative considerations: Little team effort or preparation evident. Weak synthesis of individual presentations; presenters lack a clear understanding of how individual topics fit the general theme. Audience may have to work to understand the presentation. Transitions from presenter to presenter may be choppy, only generally logical, and/or fail to support effectively the audience fully understanding the technical material. Overall presentation is poorly paced. Presenters move about awkwardly or not at all; they show little evidence of preparation. The presentation appears to be a group of rather undynamic individual presentations rather than a team effort. Occasionally good individual eye contact and movement. Some team members may be underdressed.

D—General presentation and content considerations: The presenter demonstrates only a superficial understanding of the material and little effective control over the presentation. The presenter may focus on an obviously general interpretation of the material or concentrate on a few specific points he or she understands. The audience must work hard to understand the technical material and may be uncomfortable with the presenter’s own lack of understanding, organization, or ability to communicate with the audience. Audience members may simply give up on the presentation or “drift off” until the presentation is over. It is obvious that little thought or time went into preparing and organizing the technical material, or practicing the presentation. The presenter’s movements may be few or none; vocal quality may be poor or strangely exaggerated (to compensate for having little to offer the audience). Little or no eye contact (or the presenter may look mostly at the visuals). The audience is likely to reflect the presenter’s nervousness. Visuals are poor and hard to understand; beyond the title, outline, and lists, there may be no significant visuals. The presenter may not adequately discuss some visuals, and visuals may be ornamental or too small to see. The presenter has no control over the pace of the presentation and may have to end abruptly or be asked to step down. The presenter may be dressed too casually for the presentation.

Collaborative considerations: Very limited team effort. No synthesis of effort in technical material or presentation style. Pacing poor. Transitions in technical content are largely undetectable. No evidence of practice or coordination among team members; weak individual presentations. Presentation is chaotic and almost uncontrolled. Visuals poorly designed, ornamental, unrelated to the topic, or absent. No coordination in dress style; some members may be dressed inappropriately for a professional presentation.

E—General presentation and content considerations: The presenter exhibits an obvious, if not total, lack of control over and concern for the organization, presentation, and mastery of the technical material. No detectable preparation of the technical material or the presentation is evident. The presenter may overcompensate the dramatic aspects of the presentation to detract from the lack of preparation or failure to master the technical material. The presenter may focus on one or two general points that are easy to explain. Visuals are poorly conceived and constructed, hard to read, or simply nonexistent. Little or no movement or hand movement, or eye contact (the presenter may stare at the visuals). Visuals may fail to relate to any significant parts of the technical work. The pace of the presentation is entirely uneven. The presenter is likely to be dressed inappropriately for the presentation.

Collaborative considerations: No team effort evident in technical material, presentation style, or synthesis of effort. Transitions absent. Visuals poor, unrelated, ornamental, or absent. Very poor individual efforts. Audience may be unclear on even the general topic of the presentation. Difficult or embarrassing to sit through.

APPENDIX C

Evaluation of Individual and Group Oral Presentations

<table>
<thead>
<tr>
<th>Presenters</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technical Content:</strong></td>
<td>Excellent</td>
</tr>
<tr>
<td><strong>Reminders:</strong></td>
<td>topic mastery, including technical correctness; completeness of analysis and interpretation of data; clarity of purpose and approach; scientific tone/language; appropriate level of detail; appropriate use of statistical analysis and visualization of results.</td>
</tr>
<tr>
<td><strong>Strengths:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Weaknesses:</strong></td>
<td></td>
</tr>
</tbody>
</table>

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Organization: Excellent Good Fair
Reminders: effective introduction (including problem statement) and conclusion; clear technical transitions among major topics in the body, skill handling questions, clock mastery.
Strengths:____________________________________________________
Weaknesses:____________________________________________________

Presentation Criteria: Excellent Good Fair
Reminders: eye contact, hand/body movement, overall vocal quality, and appropriate dress.
Strengths:____________________________________________________
Weaknesses:____________________________________________________

Visuals/Graphics: Excellent Good Fair
Reminders: clear, easy to read and interpret, relevance to topic, presents new information or enriches orally stated information; timing, technical correctness, and appropriate and aesthetic design and layout.
Strengths:____________________________________________________
Weaknesses:____________________________________________________

Group Criteria: Excellent Good Fair
Reminders: synthesis of material among presenters, consistent level of detail, transitions from speaker to speaker, overall group dynamic.
Strengths:____________________________________________________
Weaknesses:____________________________________________________

Overall Evaluation: Excellent Very Good Good Fair Poor
Strengths:____________________________________________________
Weaknesses:____________________________________________________
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