# The Ability to Communicate Effectively: Using Portfolios to Assess Engineering Communication

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This paper analyzes the difference between individual student assessment and program assessment, demonstrating the ways in which portfolios can offer important information for outcomes assessment at both levels. I discuss the basic principles of portfolio administration, such as portfolio design/format and portfolio set up, and then discuss ways in which portfolio objectives, including evaluation rubrics, may be developed. Special emphasis is placed on communicating portfolio objectives to students and the efficacy of reflective statements as a way to make the portfolio rating process more efficient. The end result of portfolio assessment is a clearer picture of students' communication skills and valuable feedback for students and professors.

## I. Introduction

At first glance, assessing student learning outcomes in communication effectiveness would seem an easy task. For some engineering departments, good communication is distilled in the instruction to students that they must write and speak "clearly" in order to "communicate effectively." For others, good communication is defined by the department writing manual and can be assessed by counting up the number of grammatical errors in a document. Unfortunately, these two definitions lead students into misapprehensions regarding what constitutes effective engineering communication, how they should develop those skills, and how their skills will be assessed. My issue here is the current state of communication skills development and evaluation that have been inspired by ABET EC 2000. While the national effort to improve students' skills (both in communication and the other objectives areas) are laudable, many engineering programs encounter difficulties with assessment plan development, particularly after deciding to use portfolios to document student learning. The move to portfolios was clearly inspired by ABET documentation that cited portfolios as one means of data collection. In response, engineering programs have attempted to use portfolios for data collection, but often the results are mixed. Faculty complain of increased workloads, students do not see the correlation between course goals and portfolio objectives, and administrators envision portfolios as merely another means of grading student work.

I contend that if portfolios are to be of use to engineering programs, to improve both faculty pedagogy and student learning, then we need to devise a portfolio that meets the needs of engineering education. By this I mean that many of the portfolio models we are working from come from the language arts and education fields; while these portfolios meet the needs of certain faculty and students, they are less applicable to engineering students, faculty, and programs. In designing an engineering portfolio, I believe we can, however, adopt several portfolio principles that seem to be common across disciplines. For the purposes of this paper, I am focusing on documentation of student learning in communication, but I have evidence from the portfolio project at my institution that an engineering portfolio can be used to document student learning in more technical areas, such an engineering practice, experiments, design, and so on.

What follows in this paper is a set of design principles that can assist engineering faculty who wish to explore the possibilities offered by engineering portfolios. Since engineering portfolios at several institutions are still relatively new, the design principles are subject to change; in fact, as more programs experiment with them, I expect that we will be able to share information regarding what works, what does not work, and so on. Engineering portfolios should be based on four principles, a foundation that will ensure that the portfolios function effectively and produce information that is useful to students and faculty. Given my project here, I have related the principles to engineering communication:

- **Defining** engineering communication (or any other learning objective)
- **Identifying** appropriate skills and where in the curriculum they should be developed
- **Correlating** portfolio learning objectives to program and course objectives, and
- **Assessing** student learning so that students, faculty, and programs can benefit and improve.

This paper will address these four principles in order to offer faculty guidance in assessment plan development and maintenance.

## II. Defining Engineering Communication

The call for engineering graduates who possess effective communication skills represents a significant dimension of current industrial and accreditation demands. The call is not, however, new and may be traced to calls for engineering curricular reform from the 1950's'and earlier.[1, 4, 5, 6, 8, 9] Historically, industry has exhibited a recurrent interest in ensuring that the engineers they hire possess communication skills that will serve their technical work. And yet, even the language with which this demand is expressed, for example in EC 2000, creates an inaccurate picture of what constitutes successful writing and speaking. "The ability to communicate effectively" suggests that engineering communication is itself uniform, no matter whether one is writing a report to electrical engineers or giving a presentation to design clients.

Consider the following comparison. Analyze three different articles from three different engineering journals and magazines, for instance, an article on materials failure from *Handbook of Case Histories in Failure Analysis* published by ASM International, a conference paper on the subject of DVD from the IEEE Transactions on Consumer Electronics, and an Student Research Award article in the Doctoral Degree Candidate Category from proceedings of the Society for Biomaterials. The significant differences in engineering communication—word choice, arrangement of information, level of detail, style, and so on—will be apparent even in the articles' abstracts. The elements that constitute effective communication in each discipline are certainly second nature to the engineering practitioner in the field, either the professional or the academic engineer. The conventions are also obvious when one performs the side-by-side comparison. Unfortunately, students are not often asked to adopt this kind of analytical, rhetorical perspective as they develop their communication skills; in addition, since the engineering practitioner takes these conventions for granted, he or she may not highlight these elements that actually constitute "effective communication" for students. In fact, the current trend to incorporate communication tasks into engineering courses, while in itself a positive curricular change, has often taken the form of focus on grammar, mechanics, and punctuation, rather than the critical thinking and audience analysis that underlies truly effective engineering communication.

In order to lay the foundation for successful communication skills development, I would argue, the faculty responsible must first define engineering communication as it is appropriate for the specific discipline and context in which it will be used. Such grounding of communication has been the subject of recent studies in the field of technical communication. Using principles of genre theory and situated learning, Artemeva, Logie, and St-Martin, for example, designed a discipline-specific communication course for engineering students at Carleton University.[2] The major goals of the course are as follows:

> To facilitate the acquisition of rhetorical skills and strategies necessary for students to successfully integrate into their engineering school environment and to facilitate their transition to the workplace. These skills and strategies are acquired through typified writing practices [memos, reports, RFPs] in situated contexts of the engineering discipline, interactions with existing texts, and interactions with relatively experienced writers . . .

Noting that "conventional pedagogical discussions of technical communication often overlook the social forces that affect the engineers' and engineering students' views of rhetoric," faculty defined engineering communication in this course by assuming that disciplinary knowledge in all fields is "negotiated between people rather than passed from one to another." As a result, course components were designed to allow students to "develop an understanding of audience and purpose through the exchange of written and oral feedback, the analysis of existing documents, and audience proximity" in an attempt to "overcome the challenges that teaching writing to engineering students presents." Additionally, the March 1999 issue of IEEE Transactions in Professional Communication focused on the role of engineering genres; according to the editor, the purpose of the special issue is "to locate what is particular to each kind of writing and what skills and knowledge students need in order to be able to communicate effectively within each kind."[3]

I would contend that defining effective communication for an engineering program is a crucial first step in revising a curriculum, developing courses, and creating an assessment plan. Definitions need to be shared by faculty teaching in the program, and so generating them together can establish shared notions of exactly what the program is attempting to develop in its graduates. Essentially, faculty must ask themselves the question, what constitutes effective engineering communication within our discipline? I suggest that the easiest way to answer the question is to ask each faculty member to share a piece of writing that he or she believes is a good example of engineering communication. This may be a piece that the faculty member has written, or an article or report that he or she has encountered in either professional or academic practice. The results of such collecting are often surprising: despite the diverse genres or kinds of writing the faculty may share, these pieces often have more common features than one would initially expect. The exercise of defining engineering communication should demonstrate to participants that they know good communication when they see it and they share a common notion of what constitutes good communication.

The process of defining engineering communication is not an exercise for faculty only. This information must be shared with students, so they too can recognize the elements of effective engineering communication. Students will likely want to know the bottom line: what do you want, may be their question. And they should be told what features should be included in their writing, i.e., standard memo format, appendices that include tabled data in a design report, etc. Faculty should resist, however, allowing students to believe that following a format is the only requirement for producing effective engineering communication. A faculty member's focus should also be on the context in which the writing is completed: who the audience is, what information the audience needs, what constraints the document must follow, what reactions the information may produce, and so on. Student should be allowed to study models of effective engineering communication, and class time should be spent discussing and analyzing the models. Unfortunately, merely instructing the students to "follow the department manual" will ensure that the faculty member receives identical assignments that show minimal engagement by the students in either the written or technical dimension of the assignment.

## III. Identifying Appropriate Skills

Given the promise of engineering portfolios for data collection and evaluation, faculty are often tempted to demand that portfolios do it all. In other words, faculty expect that a student's portfolio will transform him or her into a professional engineering communicator after one course. If the portfolio does not show that the student knows how to handle every communication situation with the appropriate format, audience analysis, and grammar, then the portfolio project is itself a failure. I would argue that such disappointment is a failure on the part of faculty who overestimate what a portfolio can do, rather than an inherent flaw in the portfolio itself.

Like technical skills, communication skills must develop in stages, from the basic understanding of basic principles to the application of those principles to a variety of communication situations. For this reason, faculty should identify the skills set they wish students to develop but also specify the courses and stages in the curriculum where this development will take place. This specification begins with defining engineering communication and then identifying the places within the curriculum where the specific elements of communication will be stressed.

One way to accomplish this identification is via a curriculum map. In the case of Rose-Hulman Institute of Technology, the Curriculum Map project was established in conjunction with the RosE-Portfolio, the electronic portfolio system that we began developing in 1996. Faculty are asked to use an electronic system to record three data points. Using the list of nine objectives that constitute the Institute's student learning outcomes, faculty are asked to respond to the following three questions:

- Is this learning objective a stated goal of your course?
- Are students asked to document their learning regarding this objective during the course?
- Are students given feedback on their work toward this objective during the course?

Analysis of the results of the Curriculum Map reveals exactly where students are provided with opportunities to develop their skills, the classes in which these opportunities occur, when students receive feedback about their work, and so on. The data provided by faculty has also shown us specific gaps in the curriculum. For example, students have the opportunity to work on their communication skills in the freshman and junior year (via the first-year composition course and third-year technical communication course), but there is no consistent opportunity for students to reinforce those skills in their sophomore year. A yearlong gap in communication skills development opportunities contributes to a significant deterioration of the skills base that students established in their first year. We are currently in the process of identifying courses in the sophomore year that could, with minor content revision, provide the necessary reinforcement.

Faculty may also approach the task of identifying skills via course development. Gruber, Larson, Scott, and Neville, for instance, have developed a sequence of four courses that span the four-year engineering program at Northern Arizona University. The purpose of the *Design4Practice* curriculum is to "prepare students for future jobs by emphasizing, throughout their four years in college, engineering attributes considered important by industry."[7] The authors contrast their course sequence to the traditional curriculum, in which professional skills like communication and design are not included until the capstone design course, a point at which a host of skills must be applied simultaneously:

> The new courses [in the *Design4Practice* sequence] are structured around the design cycle to emphasize process over product not only in the technical areas but also in the communicative processes. Instructors use real, hands-on problems to convey technical and professional content to the student and to create a situated-

> learning environment and promote the socialization of learners into a specific discourse community. All courses are taught by cross-disciplinary teams of faculty and industry representatives. In addition, instructors require students to work on both large and small cross-disciplinary teams and integrate and synthesize the technical knowledge learned in traditional courses. Most importantly, students are encouraged to develop managerial and professional skills with an emphasis on verbal communication and technical writing.

Whether the faculty focus on established courses or on the development of a new course sequence, they must plot out specific sets of skills at specific points in the curriculum in order for portfolios to function accurately, efficiently, and effectively.

## IV. Correlating Objectives

Given that engineering portfolios are still in an early stage of development, they can often be misused or misapplied to learning situations. Unfortunately such misuses may ultimately threaten the future of engineering portfolios. If faculty believe that portfolios are merely tacked onto existing courses in order to fulfill the accreditation demands of higher powers, if students believe that portfolios are simply busywork that has nothing to do with learning, then portfolios will never become a part of the engineering education culture. For these reasons, I believe we must demonstrate the efficacy of portfolios to faculty pedagogy and student learning. The way to accomplish this is to correlate portfolio objectives to objectives/goals of an engineering course or program.

First let me define what correlation does **not** mean. Correlation does not mean tacking a portfolio onto an existing course and using it merely as a new means of collecting students' homework. Correlation does not consist of requiring students to place particular materials into a manila folder that then goes into departmental archives never to be unearthed until ABET evaluators appear on the scene. Correlation means ensuring that, for the student, the engineering portfolio is an on-going project, a part of his or her learning experience, a changing artifact that looks different from year to year, and a dynamic object that is useful in the individual's academic and professional life. For the faculty member, the engineering portfolio is a key component of his or her pedagogy, a way of teaching that encourages reflection and critical thinking, and helps the faculty member draw clear relations between classroom practice and engineering applications.

Correlation can take place at two levels. Having followed the earlier stages of defining communication and identifying appropriate skills, then the third stage of correlating objectives will be easy to accomplish. Each faculty member will have shared in defining communication for his or her course and department. The learning objectives for his or her course will have been part of identifying skills and where they will be taught in the curriculum. The work that precedes correlation is thus preparation for establishing what documentation the portfolio should contain, since the evidence in the portfolio will show the student's progress toward a particular set of objectives.

## V. Assessing Student Learning

The fourth stage of engineering portfolio development may discourage faculty from using portfolios. Once again, however, if the initial stages are adhered to, then assessing the contents of the portfolio becomes more manageable. The keys to successful evaluation of portfolios are limiting the scope of what learning the portfolios must document and developing evaluation rubrics accurately assess that learning.

Until recently, models for evaluation rubrics have come primarily from the fields of language arts and secondary education. Experimentation at Colorado School of Mines and Rose-Hulman have provided more specialized rubrics that address the assessment needs of engineering programs. The important thing to remember about rubrics is the need for those who will evaluate portfolio materials to develop rubrics based on models used by other programs, rather than adopting these models unquestioningly. Just as defining engineering communication, for example, brings faculty to a shared sense of how they want their students to communicate, developing assessment rubrics provides comparable benchmarks by which faculty can judge the progress of their students.

Take, for example, the following learning objective. A chemical engineering program identifies oral communication as an important skill for its graduates to possess. Acknowledging that "oral communication" is a broad and vague skill, the faculty in the program further define oral communication as the ability to give effective oral presentations, specifically informal presentations to peers, team members, and immediate supervisors that are typical of chemical engineers working in industrial settings. Then the faculty identify the traits of a successful presentation of this type:

- The presenter provides a summary of the project he or she is working on.
- The presenter reviews the current status of the project.
- The presenter identifies key challenges, difficulties, or concerns that have developed since the last presentation.
- The presenter concludes the presentation, responding to questions for the audience.

The faculty who identify these traits base their rubric on their own experience, the demands of industry, or the standards of professional organizations. They may also begin their discussion with a much longer list of traits. Negotiating the final list helps the faculty gain a sense of what matters most to their department and what they hope to instill in their graduates. Evaluating a student's performance on each trait can then be made on a variety of scales. A yes/no scale will only denote the presence or absence of the trait: The student did begin with a summary/The student did not begin with a summary. Most faculty and programs will require more detailed information. Thus, the rubric may use a three-point scale, but each level must itself be defined to denote exactly what constitutes performance at that level:

| **The presenter provides a summary of the project he or she is working on.** |
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| 1) The presenter provides no summary |
| 2) The presenter's summary is disorganized and does not provide a concise, accurate picture of the project |
| 3) The presenter's summary is brief, well-organized, and provides the audience with key background information, such as project start date, client, links to related projects. |

Using these rubrics produces a number of significant advantages. First, faculty evaluators recognize that the standards by which students will be judged are based on priorities established by the engineering program itself. Rubrics are not, in contrast, imposed on the program. Second, faculty can measure student achievement qualitatively while still retaining quantitative data that are necessary for accreditation and constituency purposes. Third, rubrics can be used in single course as well as across a curriculum. They can also be modified as their efficacy dims or the program's focus changes. Fourth, and perhaps most important, they can be shared with students from the first day of class. Students can see what they will be judged on and how they will be judged. Furthermore, they can participate in the development of these rubrics, contributing their own ideas of how their work should be evaluated.

## VI. Engineering Portfolios and Future Assessment Challenges

What lies ahead for engineering portfolios? The future appears bright, if we can survive the development process. Clearly there is more work to do if engineering portfolios are to gain wider acceptance for assessing engineering education. In addition, more research is needed that demonstrates the benefits of portfolios over other data collection methods. Perhaps the most important transformation must occur within the culture of engineering education itself. Until engineering faculty, programs, and industry commit to this assessment method, engineering portfolios will remain a great idea and not a practical reality.

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