

## Meeting Two Needs: Teaching Engineering through Writing

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### Abstract

This essay describes the theory behind the use of writing in engineering classes, as well as several strategies for implementing such content-based writing. Despite the widespread use of writing in disparate disciplines across the university, writing is not generally an integral component of “content” courses in engineering. In this essay, I build on recent theories of composition pedagogy to argue that engineering education can be improved through writing. In other words, writing is a powerful tool to help teach students engineering concepts, not just grammar. This essay first outlines the theory and purpose behind the use of writing in content courses such as engineering. It also discusses how such methods improve students’ communication skills, as well as teach them the concepts of the course. Near the end, the essay describes several strategies that use the theories outlined. In this section, I suggest several writing assignments that can be geared specifically toward engineering education, such as freewriting journaling, and discussion board posting.

### Introduction: Rethinking Teaching and Learning

Samuel Florman defines engineering as the “art or science of making practical application of the pure sciences.”<sup>1</sup> By this definition, we can see that students of engineering need to learn at least two disciplines: 1) “the pure sciences” and 2) “practical application” of these sciences. Combine these two necessities with the imperative from nearly every employer that engineers must learn communication skills, and we have quite a wealth of information to teach our students in four (or increasingly five or six) years. In order to meet each of these goals, we must have a concerted, self-reflective teaching strategy.

Here is where James Britton, *et al.* enter the picture, because their study *The Development of Writing Abilities*<sup>2</sup> illuminates students’ learning processes. According to this study, students learn by way of integrating new knowledge with old knowledge. Learning is about processing and analyzing material, not just absorbing it: as Britton says, “Right answers are usually to be achieved by repeating the words of others—the textbook, or the notes, or the dictionary—and they may not make any demands on the

pupil's ability to understand, explain, interpret and generalize for himself."<sup>3</sup> A future engineer who learns that  $v=d/t$ , for example, has not learned how to put this knowledge to "practical use," as Florman says engineers must do. It is not until a student can "understand, explain, interpret, and generalize for himself" that that student can begin to put knowledge to use.

Britton's work is an integral part of the "Writing Across the Curriculum" movement that developed during the 1970s and 1980s. With the publication of Britton's work, along with Janet Emig's essay "Writing as a Mode of Learning,"<sup>4</sup> theorists from across the disciplines began to research and formulate the ways writing can aid students' learning. Learning and language development are difficult to quantify, however, as all teachers know. Theories of grading writing, for instance, range from the very liberal—writing is a type of creative process that cannot be quantified—to the very strict—the use of rubrics that fail essays for a single comma splice or other offensive grammatical error. How do we deal with these difficulties, then? They require a shift in paradigms, I think, as we examine our own teaching along with how students actually learn. Robert Pirsig describes the counterintuitive nature of education in *Zen and the Art of Motorcycle Maintenance*: "the best students always *are* flunking," he writes, "Every good teacher knows that."<sup>5</sup> In other words, sometimes our intuitions may not correctly quantify students' learning abilities or the amount of learning that takes place in the classroom. A truly effective pedagogy may require a shift in focus away from traditional styles.

## **Knowledge and the Writing Process**

There are two reasons to link writing to learning, and I outline those here. First, I examine the link between critical thinking, problem solving, and writing, and then I outline the methodology and results of James Britton and the School Council project.

### **Critical Thinking**

One way to look at the use of writing in any classroom is to view it as a means to promote critical thinking. Nearly every professor can sympathize with the frustration of students who may perform very well on multiple-choice tests but who cannot express the general principles surrounding a given body of knowledge. When instructors assign writing, however, they are not necessarily looking for regurgitation of information. Demonstrating one's ability to repeat information from a lecture is only the first step in truly learning material. In order to be considered knowledge, a student must be able to think critically about the information. As John Bean explains, all instruction seeks to teach students to become critical thinkers.

According to Bean, learning is linked to problem solving, and writing is one effective product of problem solving. Bean quotes John Dewey's progressive view as the basis for most modern theories of education: "'The most significant question which can be asked,' says Dewey, 'about any situation or experience proposed to induce learning is what quality of problem it involves' ... 'Only by wrestling with the conditions of the problem at first hand, seeking and finding his own way out, does [the student] think.'"<sup>6</sup> Critical

thinking is where students begin to form their own ideas, where knowledge becomes a part of the student's consciousness. Bean goes on to explain that writing is a form of critical thinking. Because most writing is thesis-driven, writing is the culmination of a problem, or the solution to a problem. Identifying problems and making arguments is what drives most writing, so it is a way to force students to think critically about course material.

### **Understanding the Writing Process**

The arguments surrounding critical thinking and writing are not quantitatively based, however. Britton and the School Council project are based in statistical methodology derived from psychology that may be more convincing than John Dewey's proposition linking critical thinking, problem solving, and writing.

Britton *et al.* divide the writing process into three stages. The first stage is "conception" (when a writer decides to write and thus chooses a topic), while the second is "incubation," and the third is "production."<sup>7</sup> It is the second stage where much of the learning takes place because it is here that the student begins to think about the subject in terms of his or her previous experience, whether that experience is personal or academic. Thus, it is during the incubation process that the student begins to fully understand the subject. A student's understanding may not be complete until the production stage, however, when the student is forced to process and formalize his or her ideas.

So writing is one way for students to learn material, but it is also a unique way for students to do so, as Janet Emig explains. Emig quotes A. R. Luria from *Speech and the Development of Mental Processes in the Child* who says that written speech "assumes a much slower, repeated mediating process of analysis and synthesis," and it "thus represents a new and powerful instrument of thought."<sup>8</sup> Writing is recursive and allows for revisions of previous understanding, which is the way all learning works, according to Mike Torbe:

Human beings learn by constructing a "model" of the world in the head, by creating, in Kelly's words (Kelly, 1963), "working hypotheses which are about to be put to the test of experience"; and that "world representation" is constantly revised, adapted and extended by being matched against the flux of new or familiar experiences around us.<sup>9</sup>

This learning model may not say much about the role of language in learning, but Torbe goes on to suggest that "language is [the] most explicit and most fully articulated expression" of the process of synthesizing new material with old material.<sup>10</sup> We adapt everything to the model in our heads through language.

Torbe takes this argument further to explain exactly how learning and language work together:

We learn by using language, by talking and by writing; learning is an act of creation which makes and shapes the world of the learner. Learning is not the passive acceptance of other people's ideas and pre-existing

knowledge, but is an activity undertaken by the learner. If that is true then in school learning both students and teachers must use language actively.<sup>11</sup> Accepting this concept about learning radically changes the way we teach. If the goal of all pedagogy is to aid students in learning material, then we must work with the way students learn in the first place.

According to these theories, learning takes place when students place new knowledge in context with their previous knowledge, and this process may mean that the old knowledge is revised to accommodate the new knowledge. One unique way to get students to process and make such revisions is through asking them to write about their knowledge.

Notice that nothing here limits the beauty of the act of education, for watching students learn is one of the joys of being an educator. Knowing how students learn and working with their learning process only serves to maximize those moments when we see students working through problems themselves.

## **Writing in the Engineering Curriculum: Objections and Propositions**

It is a very short distance to begin to discuss the use of writing in engineering courses. Think about the way most engineering curricula treat writing, and the shortfalls are apparent. Freshman students must generally take a year-long treatment of composition and rhetoric or composition and literature, and then one or two more classes in humanities that are generally “writing intensive.” Many engineering curricula now require a technical writing course, which may be geared toward engineers or may be taught by the English department and taken by students from many disciplines. Then engineering faculty assume that communications skills are “taken care of,” and may get furious when students make egregious errors in syntax on their final exams. It has become axiomatic to say that engineers need to learn to communicate in order to be successful, but graduates still have trouble communicating.

Considering the way learning and language work together and that “we learn to write by reading and talking—and by writing,”<sup>12</sup> every professor should be moved to incorporate more writing into the classroom. It should be one part of a comprehensive teaching strategy whose goal is to help students learn material.

The objections to using writing in the classroom are numerous, and I want to briefly address them. There are three main objections to the incorporation of more writing in engineering classes:

- Faculty may be uncomfortable teaching writing.
- Faculty may be uncomfortable evaluating writing.
- Faculty may not wish to devote time to the evaluation of writing.

The first two objections are understandable because engineering faculty are experts in engineering, not necessarily in writing, and their job is to impart engineering knowledge, not writing. In any engineering class, the primary goal should remain teaching the

engineering subject. In a class on thermodynamics, however, writing can be used as a method to help students learn the concepts of thermodynamics. The fact that students will learn to write better through repetition of their writing skills is secondary, or even an added bonus. Therefore, faculty need not be discouraged by their own writing abilities. Even if faculty members are uncomfortable teaching writing, they are experts in engineering, including the *discourse* of engineering. One cannot exist as a faculty member without internalizing and participating in the discourse of his or her field, including the reading and writing of documents. So not only are faculty already experts on the subject of the course, but they are already experts in the writing surrounding that subject. Therefore, faculty already know the rules that govern the discourse, including what is acceptable or valid and what is not. With this combined expertise, faculty can use writing to aid student learning, to help students enter into the engineering discourse as they teach the concepts behind engineering.

The same is true for the second objection. A glance at the literature on evaluating writing shows that writing is difficult to grade,<sup>13</sup> but it also demonstrates that there are many different and effective methods for grading writing. Many of the objections about the evaluation of writing are based on the undergraduate experiences of faculty members whose essay grades appeared to be based on the subjective and idiosyncratic whims of writing instructors. The evaluation, assessment, or grading of writing often *is* subjective and idiosyncratic, and there may be no way around this problem. However, the fact that faculty members are already experts in engineering discourse allows them to make judgments based on what they know is acceptable and not acceptable. If a report would be praised in the engineering community because of its clarity and content, then it should receive a high grade. If a report would be condemned as careless or thoughtless, then it should receive a poor grade. Faculty members already know what determines good writing in their disciplines.

Despite the fact that engineering faculty members are wholly qualified to judge students' writing, faculty may not wish to devote the time into grading student writing. I want to suggest that engineering faculty do not focus on grammar and mechanics, however, because they should be primarily concerned with teaching engineering content. As they write, students will get better at writing, too, but engineering professors do not have to comment on every aspect of a student's writing ability. I sometimes hear faculty members say, "If I assign writing, I have correct every grammatical error," and the truth is that they do not have to do this. It is true that high stakes assignments may sometimes require faculty members to comment on students' writing abilities. A technical report that counts for 10-50% of a student's grade, for example, deserves comments about the student's writing. Even here, however, every error should not be marked. There are also alternatives to high-stakes writing assignments that can still be used effectively in the engineering classroom.

### **Write-to-Learn Assignments in the Engineering Classroom**

If the goal is to teach engineering concepts and only secondarily to teach writing, the stakes may change. In order to help students learn engineering concepts, faculty should

consider what I call “write-to-learn” assignments, low-stakes assignments that do not require much outside preparation by the student or much commenting by the instructor. These assignments are designed to help students process and analyze the concepts of the course. I want to discuss three main ones here: the freewrite, the journal entry, and the discussion board post.

## **Freewriting**

Freewriting goes by many different names, both in composition theory and when professors discuss their teaching. Some call these minute essays, some brainstorming, and some make the term into a bit of a paradox by calling them “focused freewrites.” Freewrites generally have a familiar form, even though they can be used at any point during a class, or sometimes even outside of class (I usually call freewrites done outside of class journals). The purpose of a freewrite is, like all write-to-learn exercises, to ask the student to synthesize material. There is only one rule to freewriting, and that is that the writer should never stop writing. Freewriting exercises must be done continuously, and if the writer runs out of things to say, he or she must keep writing. Wherever the mind goes, so must the pen. I advise my students to write about why they cannot think of anything to say, possibly about their own understanding of the topic.

As the name suggests, the exercise can be completely “free,” where students are asked to write about whatever they are thinking about at the time; some will write about the subject material for the course and some will discuss their private lives. More to the point is to provide a prompt, such as asking students to freewrite for five to ten minutes about the reading done the night before, or even about an assignment that was completed for that class period. The freewrite prompt can be rather general, i.e. “Discuss the importance of Kirchoff’s Current Law.” Or a prompt can provide a list of questions, such as “Discuss the importance of Kirchoff’s Current Law. What has happened since its development that made it so important? Why was the law discovered when it was? Do you find the concepts easy or difficult?” and so on. Although longer question prompts like this are good for getting students to start writing, some students will see a list of questions like they would view them for an exam; in other words, they will attempt to answer each question in order.

Freewrites may also be helpful in the middle of class when a lecture is waning or when students look confused, or at the end of class to discover how much the students have really understood about the class material. If an instructor sees that students are not understanding the material, he or she can revise the lecture on the spot, slow down to answer questions, or even use end-of-class freewrites to explain unclear topics at the beginning of the following class period. If freewrites are used at the beginning of class, they can be used to stimulate class discussion and even to lead into the day’s class material. After students have completed their freewriting, I generally ask them to write down any questions they have about the class material or anything else concerning the course. I can either address these questions individually, or I can address them at the beginning of the following class.

Grading freewrites is probably the easiest part. Because there are no rules about freewriting (except to never stop writing), there is really no way to grade them. I make a mark in my gradebook that the student was there and completed a freewrite, and these marks are used to evaluate the student's "participation" grade. If the student does not even attempt the freewrite, I will sometimes write "unacceptable" on the freewrite, letting the student know that he or she needs to engage the material more directly. Otherwise, I only make a few marks on each student's freewrite, commenting on what they have said, not how they have said it. If the student's ideas are incomprehensible, I tell them that they have to work on clarifying their ideas. Often, a simple "good!" or "ok!" next to memorable sentences or ideas is enough to motivate the student to continue writing.

## **Journaling**

Another method for allowing students to write more about the material of a course is to implement journal writing. A writing journal is a record of thoughts about course material, course reading, or even how outside concepts or a student's life relates to course material. Because journals can be typed and may be more directed than freewrites, they often serve as entries into possible research papers or research projects. Sometimes they act as introductions or parts of the body of a later paper in the class. These journals can be written in response to a prompt, such as "Write a two-page journal entry about the use of microelectronics in everyday life," or they can be a part of a standing requirement where a student must turn in a one or two-page journal every week concerning some part of the course or readings. They should not be summaries of the class, of course, but they should demonstrate that the student has thought about the material by relating it to other forms of knowledge he or she already has, whether this means relating it to a previous course or to his or her own life.

Journals should be more focused, organized, and well-written than freewrites because students complete them outside of class and have an opportunity to revise them. However, grammar and mechanics should not be a major factor in the student's journal grade. Again, the point in requiring such writing assignments is not primarily to teach writing skills. This byproduct should never take the focus from the content of the course, which should remain primary. I grade journal entries based on "depth of response," meaning that what is written in a student's journal must demonstrate critical thinking about the course material. Although I want to add "factual content" to my grading criteria, this is a place for students to think deeply. If they get something wrong, it is then a learning exercise, a place for me to intervene in their private discussion. I also want to include "writing style" here, but I don't, because I won't count off for a run-on sentence or a fragment. What I tell my students is that there is no way for me to judge the depth of the response if the writing is too confusing or because grammar mistakes impede the information from being communicated.

I grade journals with a three-grade scoring guide using words, not letters. Each journal is rated as "Excellent," "Acceptable," or "Unacceptable." See Peter Elbow for a rationale for using words instead of grades, especially with a three-grade system.<sup>14</sup> These words roughly translate into A-C-F, but they tend to be more meaningful than simply putting a

grade on a piece of writing. I also make substantive comments on their journals based on the amount of critical thinking I see in them. Sometimes I tell students to push deeper. Other times, I simply tell them that I like an idea in a specific paragraph or that their explanation of something was confusing. Sometimes I will also mark egregious grammatical mistakes, but I don't generally lower a journal's score because of these "mistakes."

### **Discussion Board Entries**

A variation on the journal entry is the electronic discussion board, bulletin board, or 'blog. For these assignments, the discussion is open to the rest of the class. At the University of Houston, we use Blackboard, which allows for Discussion Board posts, so these assignments are simple to set up. I divide the class into two cohorts, and I make Cohort A post a Discussion Board entry one week. By the following week, Cohort B must reply to one or more of Cohort A's posts, and the groups continue switching with entries and replies throughout the semester. Not only is the "journal" here public, but it is also dialogic. Students must read and respond to other students' writing. The topics can range from anything we have discussed in class to anything in the book to anything about their papers or projects. I don't provide questions and I don't block any entries. In fact, I try to stay out as much as I can. The beauty of discussion boards is that the students become fellow teachers. If a student asks a question about something in class, another student will answer it; if a student gets some information wrong, another student will correct him or her. If no one does this kind of work for me, I have to step in and answer the question, but it generally doesn't come to this. Students are encouraged to post more than the minimum (once every two weeks), but they are not required to do so.

The research on using discussion or bulletin boards in classes is growing, including the *Journal of Asynchronous Learning Networks* devoted to this teaching tool. Such research demonstrates that discussion boards, listservs, and online communities foster active participation inside the classroom because they force students to participate in the same community outside the classroom. Although discussion boards may work beautifully one semester and not so well the next, this problem is no different from the way one class will discuss and interact with the instructor while the next class will remain silent. The challenges range from improper postings, violations of "netiquette," to trying to get students to actively engage the material. These can all act as learning tools, however, so discussion boards should not be discounted on account of them.

Grading discussion board entries is simple. Like journals, I grade them based on the depth of response, but also on the post's appropriateness for the audience and forum. I only grade them as "acceptable" or "unacceptable," though, so no commenting is even necessary. If a student's post is "unacceptable," I send him or her an email stating so, and that student can then post a deeper, more appropriate, or better written entry. Although I don't actually count grammar, I tell students that a poorly written entry cannot be judged on its depth and thus is not acceptable for the audience and forum. Therefore, it is unacceptable. All I have to do is lurk on the outskirts most of the time, enjoying the posts and marking which students participate.



## Conclusion: Using High-Stakes Assignments

High stakes writing assignments also act as write-to-learn assignments. If a student is asked to write a recommendation report on the most appropriate sensors to be used in a specialized application within biomedical engineering, the student should begin by identifying the different types of sensors and researching the applications of sensors, including their positive and negative features. It isn't until the student begins to write about the sensors in order to make a recommendation that the student may realize that more data is needed regarding a particular sensor. When compiling tables and graphs, the student may see that a specific sensor will actually be more appropriate for a given application. It is the act of writing that brings the student to this realization, not necessarily researching or learning about the sensors themselves.

Using low-stakes writing assignments does not preclude other high-stakes writing such as the lab report, the technical report, the evaluation report, specifications, or process descriptions. What low-stakes assignments do is they add writing to the curriculum (something everyone wants, even instructors) without adding overly burdensome grading (something instructors really want). Whereas these high-stakes writing assignments can serve to teach the concepts of the course, they act more like “tests” or “demonstrations.” It is true that a student must understand thermodynamics to write a technical report about a research project in the area, but the same concepts can be taught and reinforced through other low-stakes writing assignments, such as the ones I have noted here.

## References

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<sup>1</sup> Samuel C. Florman, *The Existential Pleasures of Engineering*. New York: St. Martin's, 1976, page x.

<sup>2</sup> James Britton, et al, *The Development of Writing Abiliites (11—18)*. 1975. Urbana, IL: National Council of Teachers of English, 1978.

<sup>3</sup> James Britton, et al, *The Development of Writing Abiliites (11—18)*. 1975. Urbana, IL: National Council of Teachers of English, 1978, page 30.

<sup>4</sup> Janet Emig, “Writing as a Mode of Learning,” *Landmark Essays on Writing Across the Curriculum*. Eds. Charles Bazerman and David Russell. Davis, CA: Hermagoras Press, 1994.

<sup>5</sup> Robert Pirsig, *Zen and the Art of Motorcycle Maintenance*. 1974. New York: Bantam, 1981, page 124.

<sup>6</sup> John C. Bean, *Engaging Ideas: The Professor's Guide to Integrating Writing, Critical Thinking, and Active Learning in the Classroom*. San Francisco: Jossey Bass, 1996, page 2.

<sup>7</sup> James Britton, et al, *The Development of Writing Abiliites (11—18)*. 1975. Urbana, IL: National Council of Teachers of English, 1978, pages 22-32.

<sup>8</sup> Janet Emig, “Writing as a Mode of Learning,” *Landmark Essays on Writing Across the Curriculum*. Eds. Charles Bazerman and David Russell. Davis, CA: Hermagoras Press, 1994, page 95.

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<sup>9</sup> Mike Torbe, "Language Across the Curriculum: Policies and Practice." *Language, the Learner, and the School*. 1969. Portsmouth, NH: Boynton/Cook, 1990, page 136.

<sup>10</sup> Mike Torbe, "Language Across the Curriculum: Policies and Practice." *Language, the Learner, and the School*. 1969. Portsmouth, NH: Boynton/Cook, 1990, page 136.

<sup>11</sup> Mike Torbe, "Language Across the Curriculum: Policies and Practice." *Language, the Learner, and the School*. 1969. Portsmouth, NH: Boynton/Cook, 1990, pages 136-137.

<sup>12</sup> James Britton, et al, *The Development of Writing Abilities (11—18)*. 1975. Urbana, IL: National Council of Teachers of English, 1978, page 32.

<sup>13</sup> See the following works for more information about grading writing: Anson, Chris M., ed. *Writing and Response: Theory, Practice, and Research*. Urbana, IL: National Council of Teachers of English, 1989. Connors, Robert and Cheryl Glenn, eds. *The St. Martin's Guide to Teaching Writing*, 3<sup>rd</sup> ed. New York: St. Martin's, 1995. Cooper, Charles R. and Lee Odell, eds. *Evaluating Writing: Describing, Measuring, Judging*. Urbana, IL: National Council of Teachers of English, 1977. Elbow, Peter. "Grading Student Writing: Making it Simpler, Clearer, Fairer." *Writing to Learn: Strategies for Assigning and Responding to Writing Across the Disciplines*. Eds. Mary Deane Sorcinelli and Peter Elbow. San Francisco, Jossey-Bass, 1997. Sorcinelli, Mary Deane and Peter Elbow, eds. *Writing to Learn: Strategies for Assigning and Responding to Writing Across the Disciplines*. San Francisco, Jossey-Bass, 1997. Straub, Richard. *The Practice of Response: Strategies for Commenting on Student Writing*. Cresskill, NJ: Hampton, 2000. White, Edward M. *Assigning, Responding, Evaluating: A Writing Teacher's Guide*, 3<sup>rd</sup> ed. New York: St. Martin's Press, 1995.

<sup>14</sup> Peter Elbow, "Grading Student Writing: Making it Simpler, Clearer, Fairer." *Writing to Learn: Strategies for Assigning and Responding to Writing Across the Disciplines*.

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