Reinventing *Invention:* Writing across the Curriculum without WAC

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Work for this essay began with a problem that will sound all too familiar to most of us in higher education: It has recently dawned upon administrators and faculty in many departments across our university's curriculum that our students can't write. Or more accurately, enough of our students write poorly enough that we have cause for concern. This concern is usually expressed in the unequivocal if vague resolution that something ought to be done.

But exactly what? And by whom? Our university has no institutionalized way of trying to solve this problem. There is no single writing course that all students are required to take. Indeed, students at our university can avoid taking any writing course at all. Moreover, it is unlikely that our university will undertake any formal writing across the curriculum program. Such a program existed at our university a decade ago; when funding ran out, interest disappeared. It's unlikely that interest will somehow reappear, especially in these days of budgetary constraints.

So what's the best way to respond to the familiar but newly perceived problem of improving students' writing? There is, of course, no magic bullet, no single response that will solve the problem satisfactorily. There's every reason to think that part of the solution lies in providing good writing instruction, both through writing courses and drop-in tutorial work at our school's writing center. However a course in writing (especially if students take only one such course during their college careers) is not adequate to solve the problems we see in

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writing. We will need to complement writing courses with some collaborative efforts between writing faculty and faculty in other disciplines.

There are, we hasten to note, approaches to collaboration we are not recommending. Specifically, we are not advocating projects in which colleagues in other disciplines read student work for content while writing faculty read them for style and mechanics. Nor are we advocating the sort of missionary work in which composition specialists try to persuade colleagues in other departments to change their teaching practice so as to 1) assign types of writing (for example, journals) that composition specialists value or to 2) teach certain stylistic features (using active voice, getting rid of nominalizations), even though there is good reason to believe that these features make writing more readable.

Our Proposal: Informal Collaboration to Teach Invention in All Disciplines

Instead of the preceding approaches, we propose that writing specialists collaborate with faculty in other disciplines in making explicit—and demonstrating to students—the often tacit processes of thinking that are important for a given assignment in a given discipline. In other words, we propose that writing faculty collaborate with their colleagues in understanding and teaching the processes of invention that are fundamental to understanding a given academic subject. As faculty do this, we argue, they can concentrate on the primary business at hand (teaching engineering, for example) while contributing to one aspect of effective writing—the development of well-thought-out claims and arguments.

To illustrate our proposal, we'll analyze excerpts from two design reports created by a team of students in an engineering course, Inventors' Studio. Our goals here are twofold: 1) to demonstrate a form of assessment and response that will help students not only with one aspect of the writing process (figuring out what they want to say) but also with the engineering process (designing a product that can help solve a problem); and 2) to illustrate a model of collaboration that we believe can work in a wide variety of disciplines. We will conclude this article by acknowledging some reservations people may have about our approach and then suggesting both the potential benefits of the procedure we're recommending and our next steps in carrying out our approach.

Understanding *Invention*

Many people equate "good writing" with observing the conventions of Standard Written English and clarity of expression. We do not mean to disparage these qualities in student (or faculty) written work. But our interest in writing comes out of the ancient rhetorical tradition that identifies five arts of the rhetor:

- Invention (for Aristotle, the discovery of persuasive arguments; for modern rhetoric, the formulation and articulation of ideas)
- Arrangement (organization)
- Style (aptness of expression)
- Memory (for the classical rhetor, mnemonic devices that would enable a speaker to speak for a couple of hours without referring to a written text)
- Delivery (the effective use of gesture, body language, and so on).

We have chosen to concentrate on invention for two reasons. First, we acknowledge pragmatic limitations on faculty members' time and energy; confronted with, say, a stack of twenty-five design reports, faculty need to focus their attention on an area that will have the greatest pay off for students' learning. Second, we assume that the most important goal of a writer is to have something worthwhile to say, and the most important obligation of a teacher is to help students understand what they need to do in order to develop their thoughts.

The last several decades have seen a variety of approaches to invention, ranging from the relatively unstructured—freewriting (see, for example, Elbow), mapping (see, for example, Axelrod and Cooper), or journal writing (see, for example, Fulwiler)—to highly structured, systematic approaches represented by the topoi of classical rhetoric (see, for example, Corbett and Connors) or the categories of "critical thinking" described by philosopher Richard Paul or cognitive psychologist Robert Sternberg. All of these approaches to invention assume the existence of discovery processes that can be useful in a wide variety of situations.

We agree that it can be useful to identify generalizable strategies that can guide the conscious aspects of thinking (see Odell, 1995; 1998). But we also recognize that thinking well is a highly contextualized activity (see, for example, Miller and Selzer; Odell 1992). If there are certain basic, widely applicable activities that comprise conscious thought, not all those activities will necessarily be equally important in all situations. Moreover, a given activity may be manifested in quite different ways in different contexts. Consequently, we will approach the topic of invention somewhat inductively, beginning with the Engineering instructor's goals for the course and the assumptions underlying those goals. Then we will show how an understanding of those goals and assumptions allow us to answer two questions:

- What kinds of questions are answered in a given report?
- With respect to questions answered (or not answered), how does this report compare with other reports written for the same course?

Clearly this sort of analysis will not give us insight into the moment-to-moment process by which the two reports were created. Nor can we draw any conclusions about the thinking processes of individual team members, since individual team members often draft different sections of a given report. But we think this sort of analysis makes sense for two reasons. First, answers imply the asking of questions, which indicates an awareness of cognitive dissonance, a basic cognitive activity that can be widely applicable but that varies widely from one context to another. Second, the questions answered in a finished text reflect ways of knowing, patterns of meaning making—in effect, the footprints of significant cognitive activity.

Our analytic approach is based on several assumptions.

- Many of our colleagues have a strong, tacit sense of what it means to think well in their fields, but they often feel frustrated in making that tacit sense explicit and available to students.
- One way to get at that tacit understanding is by closely examining contrastive pairs of student work—examples of A work and examples of C work. (Work that receives Ds or Fs is usually so far off the mark as to make comparison relatively useless.) Often, if not invariably, the A work reflects patterns of thinking—in effect answers to questions—that either are missing from or appear only sporadically in the C papers.

- To discover these patterns of thinking, one must draw not only on the perspective of the writing teacher but also on the disciplinary perspective of the colleague—in the case of this article, an engineer—with whom the writing teacher is working.

Inventors' Studio: An Engineering Perspective

The goal of Inventor's Studio is for students to invent something that will:

- Be patentable
- Provide significant benefits to improve the quality of life
- Be environmentally sound and beneficial to society
- Use existing technology and components in new combinations
- Satisfy a largely unrecognized need

This goal is founded in the instructor's view that the goal of engineering is to improve existing technologies or to create technologies that respond to needs that are not currently being met. This view and the accompanying goals translate directly into the work students are to do in the course and the ways they report on that work.

Here's the advice the Engineering professor routinely gives to his students.

Handout to Students

- **Start with a problem**

  If you start with a problem, that creates a need. And that, in turn, creates an opportunity to create something better.

- **Identify the state of the art (SOTA) in existing solutions**

  If it's a significant problem for a significant number of people, chances are someone's tried to solve it. And even if no one has worked on your specific solutions, they may have—in trying to solve other problems—developed technology that could be used and improved upon in your solution.

  There's an artificial leg I've used as an example. It allowed this person to walk down 70 flights of stairs during the World Trade Center disaster. But it cost $50,000. For one artificial leg. Clearly that puts it out of range of [almost anyone], certainly for people in

Afghanistan who had their leg blown off by a landmine. Or one of the 40 million Americans who don't have health insurance. It's just unaffordable. So you have to ask, "What could be affordable?" Maybe you could design a leg that would allow people to do 80 or 90 percent of what that expensive artificial leg can do at maybe 10 or 20 percent of the cost.

- **Determine what's wrong and what needs to be improved**

  —*Look at it from the user's point of view*

  Become the user. Of course you can do surveys and ask people. That's one way to proceed, and inventors should do it. But you should watch people use the product; you should observe and diagram how people use it.

  Also, think about different sub-groups of users—whether, for example, an artificial limb is for a football injury or for someone who's 80 years old who hurt their ankle. There are different needs for different audiences.

  —*Create specific scenarios*

  I think it was Stephen Sondheim who said, "If you ask me to write a song, I'd have a hard time. But if you asked me to write a song about a cowboy whose girlfriend had left him, and his pick-up broke, and his dog just died, I could write that song."

- **Create something that improves upon SOTA**

  In part, success in creating a design depends on creativity, especially the ability to come up with multiple concepts. But let your creativity be guided by your analysis of what's wrong with existing technology and/or the assumptions on which it is based.

  As you try to improve on SOTA, aim high: determine what would be ideal; think of ways to incorporate new technology to create additional functions and features that will be important to users.

  Once you have a sense of the ideal and of alternatives, assess the alternatives carefully, and work out the details of a product that will let you come as close to the ideal as is feasible, given the constraints under which you must work.

  Test your product, using what you learn from your tests to see how you can refine it further. And in all this, document your work carefully, partly to protect your intellectual property and partly to enable others to replicate your work.

The Design Report: An "A" Paper

Bearing in mind the engineering perspective makes it relatively easy to see why one design report received an A. To put the matter simply, the students who wrote this report did excellent engineering work. As will be apparent in the excerpt presented below, they began by identifying a problem that affects a significant number of people: the immobility caused by injuries to the ankle or foot. They identified several technologies (for example, the "standard crutch") and explained the limitations of each technology.

In an attempt to understand the perspective of people who have injured their ankle or foot, the students interviewed a physical therapist who works with patients who have this sort of injury, trying to identify the characteristics that will matter most to an injured person. For example, they determined that "[t]he bottom of the crutch should act like a foot so the user's gait is not greatly affected." And then they drew on both their knowledge of existing technology and the needs of potential users to identify goals their invention must meet (for example, it must allow users to keep their hands free).

In effect, they answered a series of questions, noted in the margins, below, that are central to the engineering design process.

Student Report	Questions Answered
SOTA Research Ankle and foot injuries are a common mishap in today's world, causing immobility for many people. Currently there are few options to keep the injured leg immobile, the most common being a standard crutch. However, standard crutches have many problems included with them such as: • Change in the gait of the user • Difficult to carry items	*What is the problem?* *For whom is it a problem?* *Why does it seem a significant problem?* *What is an existing technology that tries to solve this problem?*

• Difficult to use on slippery or uneven surfaces • Cumbersome to use for everyday purposes (see pages 35-36 A)	*What are the limitations of that technology?*
One alternative to this type of crutch is the "I Walk Free" crutch, a hands-free crutch that mounts to the thigh of the user and distributes the bulk of the weight over the knee and shin. Though this product is an improvement on the current SOTA, it still has several problems associated with it, such as: • A high cost • The injured foot protrudes behind the user's body (3 more problems listed.)	*What alternative technologies exist?* *What are the limitations of these technologies?*
To investigate the process a person with an injured ankle/foot must go through, we interviewed K… R… a physical therapist from St. Peter's Hospital in Albany. Notes from the interview can be seen on pages 37-38 A and 33-34 R, but the main points touched on in the interview include: • The bottom of the crutch should act like a foot so the user's gait is not greatly affected. (5 other "points" listed.)	*From the perspective of a potential user, what characteristics would a good solution to the problem need to have?*
While the "I Walk Free" crutch is a good start, there is much room for improvement. Ideally, the crutch would be: • Hands-free • Lightweight • Inexpensive (10 more traits listed.)	*From the perspective of a user, how might an existing technology be improved?*

Assessing and Responding to Student Writing

Implicit in the preceding discussion is a way of assessing and responding to the design reports created for Inventors Studio. The report just presented was turned in not quite half way through the semester. It would become the basis for a longer report and oral presentation assigned as the final project for the semester. Consequently, the nature of the response and assessment must have formative value, helping students understand what they need do (continue doing/begin doing/quit doing/do differently) in order to succeed on the semester's final project. This response must not simply help students improve the content of their written work; it must also help guide their engineering processes for the remainder of the semester.

In the case of the students whose work we have just described, it would seem that the main message would be something on the order of the following: Keep doing what you are doing—noting limitations of existing technology, relying on the perspective of the user in order to set goals for one's design, etc. But what about students whose design reports seem less satisfactory? It seemed inappropriate to single out a particular group of students for what amounts to public criticism. Consequently, our second sample represents a certain amount of fabrication on our part; the specific technology described was never mentioned in any of the design reports students turned in for this assignment. But substantively and stylistically, this sample is closely modeled on one of the less successful design reports turned in for this assignment. The qualities it displays are, in our judgment, typical of the less successful reports. As was true for the first example, this sample consists of the first several paragraphs of a longer design report.

The Design Report: A "C" Paper

From one perspective, the following design report is not badly written: it makes extensive use of active voice; organization is made clear by two superordinate terms (*requirements* and *functions*) that forecast the topics to be discussed; the text discusses those topics in the sequence in which they are announced; the piece is coherent (the phrase *another technology* announces a new topic that clearly relates to the topic that precedes it); and the piece displays a good bit of lexical cohesion (for example, the first sentence of paragraph two introduces a new technology and the second sentence begins by referring to this technology).

But this perspective does not help us see why an engineering colleague was not entirely pleased with this work. Nor does it help us tell students what they need to do in order to improve on their subsequent work, which will be based on this report. Granted, this sample answered two important questions (What are the existing technologies? What are their limitations?) that are important from an engineering perspective. But as the following table will show, this report either fails to address other significant questions.

Student Report	Questions Answered
SOTA The state of the art research that we have done so far has been on our concept for a portable way to store and retrieve selections from a student's collection of CDs. From our Concept to Product outline we have split the concept into two categories: requirements and functions. The requirements establish exactly what this design will accomplish. The state of the art research has to do with the way the design functions. During the past few weeks we have concentrated on finding technology that can be used to identify individual music selections within a large collection of CDs. One way of doing this is to create a bar code for each selection on a CD, essentially using a technology that has been very successful on cash registers at supermarkets and discount stores. The problem is that the bar code would have to be visibly imprinted on each selection, a	*Exactly what is the problem? What basis do you have for thinking it is a significant problem*?

process that might degrade the quality of the music at a given point in each selection. Another technology that we considered *was Radio Frequency (RF) Communication. This technology* uses radio frequencies to transmit and receive data. This technology is frequently used in stores such as music stores. At the store exits, there are machines that can recognize an electrical circuit that is imprinted on a tag attached to each item. If this circuit is not deactivated by a clerk when the product is purchased, detection devices installed at the stores exit will sound an alarm….	*What do you know about users of these technologies?What functions matter to them?Given the limits of SOTA and the needs of your users, what are your goals?*

The failure to address the questions we have identified above is quite typical of less successful design reports in this course. But does this failure matter? Does it constitute a significant problem for this assignment and for students' development as engineers? After all, the report talks in some detail about the technology students intended to use. And the students who wrote the report on which Sample #2 is modeled showed some ingenuity in the product they eventually designed and created. However, this report represents a characteristic mistake of inexperienced engineers: they fail to take adequate account of the larger context in which their work exists and the social or institutional goals it must serve. Perhaps equally important, the report gives no indication that the students can do the metacognitive work needed to successfully negotiate the complex process of identifying and guiding their own efforts to solve an ill-defined problem.

From the perspective of the writing teacher, it might be tempting to focus exclusively on the qualities that make this work seem well organized and readable. After all, teachers could do worse than encourage organization and readability. But this sort of response is not enough; it won't help students with the most fundamental task of all writers—formulating and articulating their ideas on a given topic. At some point, someone needs to respond to students in ways that help them carry out the intellectual work at hand. But who should do this? How? At what point in the writing/design process? And is it in fact the case that students should be given this sort of help? Shouldn't tacit procedures be left tacit, to be assimilated as best students are able? Answers to these questions lead us to acknowledge some reservations about the approach we recommend and then to identify what we see as its benefits.

Reservations

One reservation we have in advocating this approach is that it requires faculty to venture out into territory that may be unfamiliar or uncongenial. Writing faculty will routinely find themselves dealing with subject matter about which they know little or nothing. In the design reports, for example, writing faculty are likely to have little ability to judge the appropriateness or the accuracy of some of the calculations students must provide. Moreover, many faculty—in composition/rhetoric and in other disciplines—tend not to be very reflective about the processes of knowing involved in their work. These processes may be so deeply internalized that experts in a given field may find it difficult to articulate these processes or even to recognize that they should do so. Indeed, there are those who feel that tacit knowledge should be left tacit; the more able students will somehow acquire it, and other students' failure to acquire it will enable faculty to recognize these less able students and grade them accordingly.

Even if one accepts the premise that faculty ought to make tacit processes explicit and accessible to students, the effort to do so will take time and patient collaboration between writing faculty and colleagues in other disciplines. Writing faculty may be able to see significant differences between A and C papers. But inevitably they have to confront the question: Are these differences significant from the perspective of the colleague with whom they are working? And writing faculty will have to work with colleagues in other disciplines to negotiate a language that adequately expresses these differences.

As David Kaufer and Richard Young have pointed out, this sort of negotiation is likely to be difficult. Faculty from different disciplines often approach writing with different assumptions—about the types of writing that are appropriate for a given discipline, about the role of writing in the process of invention, and about the nature of the expertise possessed by rhetoric/composition specialists and faculty in other disciplines. Eventually, Kaufer and Young argue, it is possible to bridge these differences, especially if all parties adopt what Kaufer and Young refer to as an interactionist view of expertise, one that allows the generalizable strategies of rhetorical invention to be integrated with the knowledge and meaning-making strategies of a particular academic subject.

But even if we assume that this negotiation is possible, we still must encounter a series of questions: Who should explain the processes of invention that are necessary in a given course? How should they be introduced? Through analysis of exemplary models? Through structured classroom activities that, according to George Hillocks (1993; 1986) are the most effective way of improving students' thinking and writing? And who will monitor students' efforts to engage in the process of invention? Lurking beneath these questions is yet another: Why should I try to teach someone else's subject matter? For writing teachers, this may be an especially vexing question, since it may seem to place them in a service role, one in which they have no specific disciplinary identity. And for colleagues in other disciplines, the work we have described may appear simply to add to an already substantial teaching burden that must be balanced against demands for publication and grant writing.

To begin with the questions about *how* and *who*, our experience suggests that students perceive faculty as the authorities within their respective disciplines. In an engineering course, the word of an engineer carries far more weight than does that of a writing teacher. If colleagues in a given discipline want students to engage in a particular set of invention procedures, they will have to explain those processes—and, better, model them and construct classroom activities that require students to learn them. Moreover, when colleagues in other disciplines read students' papers, they will have to comment on the extent to which students are engaging successfully in those processes. Relegating this work to a writing teacher or to a tutor in the university's writing center sends a clear message to students: "These processes may be important, but they are not important enough to warrant my time and effort." In our experience, students rarely fail to pick up on such messages, to everyone's eventual regret.

Benefits

These reservations notwithstanding, we think our approach entails several benefits. For one thing, it enlarges the definition and value of *writing*. From the perspective we have tried to establish in this article, writing well entails more than observing the conventions of Standard Written English or adopting a graceful, readable style. It entails a process of problem solving that is at the heart of successful engineering. Consequently, it enables engineering faculty to contribute to students' writing ability while at the same time engaging them in the essential business of an engineering course—devising, testing, and explaining a product (or process) that solves a significant problem. Further, it provides faculty—in engineering and in rhetoric/composition—a means of monitoring and guiding the design process. The questions that must be answered in the written report are also questions that the instructor can repeatedly pose to students as they work on their designs and as they submit interim reports. By making such questions a routine part of the work of the course, the engineering faculty member (or for that matter, a writing center tutor) can use those questions in assessing students' interim work, whether in written reports or in the designs themselves.

At least as important, from the perspective of a composition/rhetoric specialist, this approach gives provides new impetus to the study of rhetorical invention. Our experience affirms Dorothy Winsor's notion that rhetorical invention and invention in engineering are closely related processes. This affirmation, in turn, raises a series of questions: Can we find evidence that some form of rhetorical invention is equally important in, say, doing philosophy or biology? If so what forms does that invention take? What are the questions students need to learn to ask in these various academic contexts? To what extent do these forms of invention lead scholars to revise (affirm/abandon/add to) the processes of invention identified in classical or contemporary rhetoric? In short, the sort of collaboration we propose may provide service to colleagues in other disciplines. But it also engages writing faculty in questions that are fundamental to scholarship in their area. As scholars answer such questions as these, we believe they will be, in effect, reinventing invention—and in the process making a concrete, practical response to the vague, campus-wide notion that "something ought to be done" to improve the quality of students' writing. The approach we have described in this article is not the single magic bullet that will solve all the problems one finds in students' writing. But it's not a bad beginning.

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