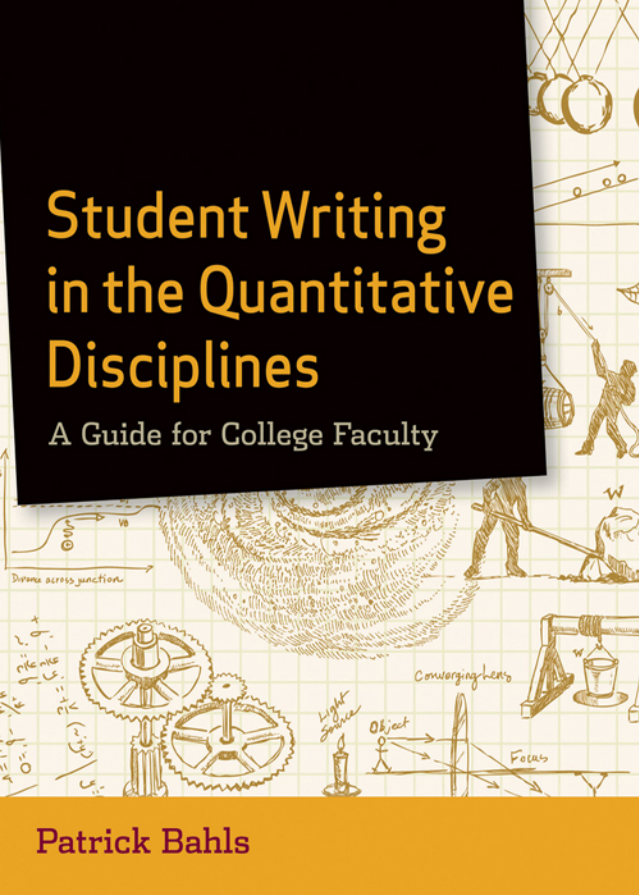


A Guide for College Faculty

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Student Writing in the Quantitative Disciplines

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Patrick Bahls

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FACULTY**

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To Maggie

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P R E F A C E

“I got into math because I don’t like to write!”

Do your students say this whenever you ask them to write more than a few simple lines of computation? Do they revolt when you encourage them to contextualize their computations or to justify them or explain them in qualitative terms? Do they insist that it doesn’t really matter how they got to the right answer, as long as they got there in the end, so it makes no difference that they can’t explain their reasoning once they are done?

I write this book for college faculty in mathematics, statistics, physics, engineering, economics, chemistry, computer science . . . in any subject, really, in which quantitative reasoning is central and in which writing has traditionally played a secondary role. I write this book to help faculty in these quantitative disciplines see how writing figures prominently in the learning process and to learn how to more meaningfully incorporate writing into even the most purely mathematical of college courses. I write this book to help these faculty enable their students not only to become better writers in their disciplines but also to use writing as a tool for learning and for examining and analyzing new ideas.

I write as an instructor who deals daily with students’ resistance to writing. Not a semester goes by without a handful of the first-year college students in my calculus classes declaring their distaste for writing, generally midway through the course’s first major writing assignment. They say it honestly, and without

malice or guilt. They say it like I should take pity on them and knowing how they feel excuse them from writing for the rest of the semester. Students enter their math classes expecting to write very little, if at all. For most of them, math courses focus on formulas and computations. Math to them is numbers, a smattering of symbols, some assorted “thuses” and “therefores,” and that’s exactly how students like it. Few students have ever been asked to write in complete sentences in their math classes, and from their perspective this is a good thing. As a consequence, students don’t recognize what writing in mathematics looks like, in part because many of us have a hard time describing it, let alone explaining why it is important.

Nevertheless, writing has a place in every course, even in courses with quantitative content, in which numbers typically take center stage. Even in math, well-structured writing assignments help students learn how to communicate clearly what they have learned. Even in disciplines like math, statistics, physics, engineering, economics, chemistry, and computer science, reflective writing helps students focus on the learning experience itself. Writing helps students in these areas organize and clarify their thoughts. It helps them discover others’ ideas and develop their own. It helps them gain a sense of authorship and take charge of their own learning.

This book is written for instructors in any discipline that offers courses with heavy quantitative content, courses in which students regularly make claims like “I got into this major because I don’t like to write” or “I won’t need to write much for what I plan to do.” This book will help you respond to these claims by showing students what a powerful learning tool writing can be, in any field. The following chapters answer many of the questions you may have regarding the role of writing in quantitative disciplines:

- How can writing help me meet my course learning goals?
- How can I convince my students that writing is worthwhile?
- How can I design assignments that will help my students become better writers?
- How can I respond to the writing my students create for these assignments?
- Where can I go to learn more about writing and how to teach it?
- How can I do all of the above without adding hours to the time it takes me to prepare for class?

This last question is a crucial one. Rest assured that I include a number of strategies to help you incorporate writing into your courses in ways that are both effective and efficient. Indeed, some simple writing activities take only a minute or two of class time for your students to complete them, and no more than ten or twelve minutes outside of class for you to respond. Lengthier assignments, naturally, take more time both for you and for your students, but there are ways of making even the most involved projects more manageable and worth the time they take.

Your students will have questions and concerns of their own, and this book will help you respond to them confidently:

- Why do I have to write in this class? Aren't I just supposed to find the right answer?
- You're not an English teacher. What do you know about teaching writing?
- I'm not used to writing like this. What am I supposed to say in this paper?
- I'm not here to learn writing. I'm here to solve problems.

This last objection is one of the hardest to address, particularly because many of us find it easy to sympathize with the students who voice it. Our disciplines are very content oriented, and many of us struggle to find the time to teach our students everything our syllabi say we are supposed to. Given all of the content we have to cover, when can we find time to help our students with their writing? How can we make sure that even while we're helping students become better writers, we're still helping them master disciplinary ideas?

It is clear that time spent on writing is time not spent on something else. If over the course of a semester you take two or three hours of class time for writing instruction, peer review, or other writing-related activities, you take two or three hours of class time away from direct treatment of course content. Particularly in highly regimented lower-level courses, this might mean you will have to consider a few sections of material with less depth than you would have otherwise or that you will have to skip one or two sections altogether.

However, as I hope to show you in this book, writing in the disciplines is worth a few hours' sacrifice, and in fact writing need not distract your students from learning the content of your course. To the contrary, effective writing assignments will help your students contextualize course content as they assemble disparate ideas from your discipline and discover new ideas of their own. These assignments will assist your students in answering the questions "How?"

and “Why?” rather than simply “What?” Put another way, writing and written assignments do not replace the content with which courses in the quantitative disciplines are concerned; rather, they complement that content and give it context and richness. Seen in this way, writing is not so much an end but a means. It is a lens through which course content can be viewed, giving that content greater depth and clarity.

A WRITING AUTOBIOGRAPHY

I begin by saying a bit about my own experience with incorporating writing in my math courses. The following brief history points out some of the missteps I’ve made and the pitfalls I’ve fallen into as I have learned more about teaching students to write in my own discipline. Because the rest of this book offers a variety of ways to avoid those, I say little about that here. The message I’d most like you to take from this history is that learning to teach writing takes time. You can’t expect to do it perfectly right away.

My attempts at including writing in my mathematics courses began several years ago in graduate school. My early efforts to involve writing in these courses were clumsy. As these efforts became more focused and purposeful, I became acutely aware of the need for a more comprehensive treatment of both the theory and practice of writing in the quantitative disciplines. In the following pages I offer an overview of the journey I have taken, and an outline for this book, which in many ways is a record of that journey.

Why Use Writing in the Mathematics Classroom? . . . Why Not?

In the fall of 1999 I began my second year of graduate school at Vanderbilt University. Before that I had been a teaching assistant with limited course duties, but in fall 1999 I was given full responsibility for the design and delivery of a first-semester course in calculus. I felt I was ready for the job. I had spent the past few years developing a number of teaching techniques I hoped to put to work in my courses, and I’d finally been given a chance to use them. I was excited to find out how well they would work.

Among those techniques was the use of writing. As a person who’s always used writing to organize my thoughts, I knew there had to be a place for writing in the mathematics classroom. I’m embarrassed to admit that with no formal training

in writing instruction, this was about *all* that I knew about teaching writing. I was naïve, but I earnestly wanted to succeed.

My first writing assignment, given roughly halfway into that first calculus course, was a simple one: “Select a mathematical topic of interest to you and write a five- to ten-page paper about it.” I gave my students minimal direction and few format restrictions, as I thought that this would free them to be creative. I asked for no rough drafts, as I had only rarely been asked for such drafts when I had written papers as an undergraduate. I assumed that my students had come to my class as fully formed writers who needed no further guidance. If they were strong writers they would write well, and if they were weak writers they would write poorly.

The students did most of their work on their own and only rarely consulted with me. Near the end of the term I collected their papers. Having given the students nearly half of the semester to complete what I thought was a rather short and straightforward assignment, I was stunned by the quality of their papers. Their writing was unfocused and riddled with grammatical, syntactical, and logical errors. The weakest papers were nearly unreadable and the strongest were rigid and formulaic. I know now that the former could have been improved dramatically had the students been asked to redraft their work at least once, and the latter had I held a short in-class discussion on style and tone. All of the students would have benefited from a clearer prompt that asked them to write for a particular audience.

I know now that my earliest attempt at incorporating writing could serve well as a list of writing-in-the-discipline “don’ts”:

- Don’t assume students will understand, or even recognize, the audience for whom they are to write.
- Don’t assume that students understand how to write in a particular genre without some explanation, however brief, of the conventions of that genre.
- Don’t assume that students will produce finely crafted papers in response to a poorly or vaguely worded prompt.
- Don’t assume that students will produce finely crafted papers without a properly staged assignment that includes multiple drafts and opportunities for feedback.
- Don’t respond slavishly to students’ grammatical and syntactical mistakes.

Clearly I had a lot to learn about teaching writing.

As awkward as my first attempts at including writing were, I persisted, and over the next few years my efforts at weaving writing into my courses improved significantly. I kept that same assignment for a while, tweaking it, elaborating on the prompt, and providing more direction. At some point I added the requirement that students submit a rough draft. The students' writing, on average, got better, and this encouraged me to include simpler, smaller writing assignments in my classes, including some I now recognize as what the literature calls *writing-to-learn* activities. (I describe that term more fully later in this book.)

My students' writing continued to improve, and I started to notice other benefits. The writing seemed to help the students become more engaged, and it helped them gain a better conceptual understanding of the computations they were performing. Writing helped them go from knowing *how* to apply a particular formula to knowing *why* they were applying it. These benefits convinced me that even though writing took a little bit of time away from traditional treatment of the course's content, the time students spent on writing was time well spent indeed.

This benefit was even evident in the feedback I got from my students on the writing I asked them to do. Judging from the comments I was getting on mid-term evaluations, it was clear I was doing something right:

- "That exercise really helped me understand what was going on with derivatives."
- "The writing was a nice break from all the formulas we were studying for the past three weeks."
- "It really helped me when we wrote about the work we did in class the past few days."
- "Writing the proofs made sense, but they made even more sense when I had to write about the writing I was doing."

Comments like these encouraged me to continue using writing in my courses and to learn about new ways to use it.

The Next Steps

During the summer after my first year at the University of North Carolina Asheville, I took part in two faculty development activities that had a profound effect on my teaching of writing.

The first of these activities was a two-day workshop organized by the university's Writing Intensive Committee and centered on Katherine K. Gottschalk

and Keith Hjortshøj's slender but substantial book, *The Elements of Teaching Writing: A Resource for Instructors in All Disciplines* (2004). One of the goals of the workshop was to convince faculty who were on the fence that writing has a valuable role in every course, in every discipline. Another goal was to provide faculty who were interested in designing a writing-intensive course with the basic skills they would need to put such a course together. The workshop's leaders, faculty from our institution, taught participating faculty how writing could be used to accomplish course goals and about the ways writing could be incorporated meaningfully into just about any classroom. I finished this workshop feeling energized, with several fresh ideas for using writing in my own courses, some of which I describe in Chapters Four and Five.

The second activity was a faculty learning circle sponsored by the university's Center for Teaching and Learning and based on L. Dee Fink's text *Creating Significant Learning Experiences: An Integrated Approach to Designing College Courses* (2003). This book is replete with inventive strategies for engaging students and empowering them to take control of their own learning. Writing figures prominently in many of those strategies. Reading Fink's text and discussing it with my colleagues in the learning circle helped me to see that writing isn't just a superficial supplement to any given course. Rather, I began to see how writing can help students engage course content on a deeper level, even in courses far removed from traditionally writing-intensive areas. I began to see how writing could be integrated with other learning activities. The learning circle motivated me to apply for writing-intensive status for the linear algebra course I would be teaching in fall 2006.

In order to meet to my school's expectations for writing-intensive courses, I made sure to include a number of writing activities that would challenge my students both to write authentically in their discipline and to write reflectively about the experiences they had as they worked to master the content in the course. Students would spend the semester working on successively more robust drafts of a traditional research paper. They would also respond to a wide variety of "low-stakes" writing assignments, including three-minute microthemes, learning logs, and collaborative conceptual quizzes.

The first time through, I still made some mistakes. I know now that with a bit more preparation I could have saved myself a great deal of effort. For instance, had I put in place some system of peer review, I could have avoided offering feedback on every one of the several drafts of the students' research papers. Had I known it was pedagogically permissible to do so, I could have responded only

occasionally to each student's learning log entries, saving myself an hour or two of reading and responding every week. Most important, had I thought the matter through I would have realized that any one of the several new activities I had introduced would have been beneficial, and that I need not have added them all at once. I know now that, like any curricular changes, changes in the role of writing in a given course are best made incrementally, a little bit at a time. After all, it is better to make a few thoughtful adjustments carefully than to implement sweeping changes haphazardly.

My steps were shaky ones, but I made fewer missteps than I had in the past, and the quality of the writing my students crafted was uniformly high. Moreover, I sensed that students had gained greater understanding of the concepts of the course due to my request that they write reflectively about them. Even though teaching the class left me exhausted, helping my students learn to write in their discipline was one of the most rewarding teaching experiences I have yet had. Moreover, I had discovered an unexpected benefit of incorporating writing in my classes: the writing assignments I had introduced were as new to me as they were to my students, and they offered me a way to reinvigorate my teaching. By giving me fresh ways of approaching the material I'd taught several times before, writing helped me to get over my boredom of discussing determinants *yet again*. Writing forced me to reinvent the way I'd been teaching for the past several years, and this reinvention was challenging, intriguing, and fun.

In the following semesters I began creating more writing assignments for students in all of my courses. I write about all of these activities, and many others designed by instructors in a broad variety of quantitative disciplines in later chapters, but I offer some brief highlights here:

- Students in my Calculus I courses produce a variety of documents pertaining to the mock trial between Isaac Newton and Gottfried Leibniz that they stage in class.
- Students in my precalculus courses write poems with some sort of mathematical structure, content, or theme. They have a chance to share these with one another in a reading near the semester's end.
- Students in all of my upper-level courses serve on "homework committees" tasked with performing peer reviews of drafts of homework solutions. They write reports summarizing their reviews in which they highlight frequent mistakes and uncommon insights.

- Students in all of my courses craft dialogues in which they explain advanced mathematical concepts to a fictional peer who struggles valiantly, but seemingly endlessly, with each course's content.
- Students in my course on mathematical proofs write frequently about writing as they analyze the subtle meaning of various mathematical terms and phrases.
- Students in this same course spend the semester collaborating on a “textbook” for the course. The students in one semester's class wrote a seventy-page booklet and spoke about their experience in writing it at a regional mathematics conference.

A few of these activities I invented myself, and many others I adapted from assignments I had read about or heard about from colleagues in other disciplines. Indeed, as I grew more serious about incorporating writing in my courses, I began a thorough search for more and better ways to do this.

Reading Up

The ideas I found came from many places, not just my own discipline. I took a position on my university's Writing Intensive Committee, which gave me the opportunity to borrow ideas my colleagues in other departments had dreamed up. I also read widely on teaching writing, uncovering in my search everything from general texts on writing instruction to sourcebooks containing sample prompts and writing assignment outlines. I attended sessions on writing at mathematics conferences, and I attended sessions for faculty in math and sciences at conferences for scholars of writing and composition.

Although I have learned a great deal from this research, I have also come to realize that there are holes in the existing literature on writing in quantitative disciplines. There are useful relevant sources, but most of them focus on one or another aspect of writing in quantitative fields to the neglect of other aspects. None of them provides a comprehensive background in both the theory and practice of writing in quantitative areas. This background would benefit instructors in these areas who are interested in incorporating more writing in their courses.

Many sources, generally written by instructors in quantitative disciplines, offer concrete and practical support to the aspiring teacher of writing in the form of writing activities, assignments, and exercises. In pedagogical periodicals, and indeed in some books, I have discovered many examples of writing assignments that can be used in quantitative courses, but they are offered without the information instructors need to use them successfully. (See, for instance, Crannell, LaRose,