Coordinating Collaboration:
Reading and discussion courses as a response to the problem of specialization in engineering curricula

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When reflecting on the reading list for our small discussion group, I came up with two overriding themes that I'd like to state here as problems for the engineering profession. First, our readings taught me quite convincingly that engineering is, well, hard. Now, this came as no surprise to those of us who have taken quite a number of engineering classes, and it is certainly no revelation for people who are interested in the problems of engineering education. However, as I will explain in a moment, these readings taught me about the demanding nature of engineering in a way that my coursework, especially the first two years of the curriculum, could not. The second problem, really a corollary more than a distinct issue, is that engineering requires the ability, and even a certain eagerness, to cooperate with, collaborate with, and—above all—to understand people who work in related fields. Increasingly, I've realized that these "related fields" extend well beyond the scope of engineering and the physical sciences and include everything from economics and psychology to literature and philosophy; in fact, the demands of the extremely challenging and important modern problems we are equipping today's engineers to grapple with make it difficult, in my view, to identify work that does not fall under the purview of "related fields." The economic, psychological, ethical, and rhetorical problems facing the experts in my major—nuclear engineering—spring to mind as a significant example.

Perhaps not surprisingly, since I am being trained in a field whose methodology rarely wavers from the classic "problem-solution" form, I spent my time in our reading group and a lot of time since thinking about some of the solutions the authors we read may—directly and indirectly—have been offering. I'd like to share some of those thoughts with you today. As I go, I will try to make the case for why this course is important, and I will end with a discussion of how all this relates to our theme of sustaining—and indeed, retaining—the engineering students of today.

As I said, the first problem our authors illustrate is just how difficult engineering is. The most prominent example was undoubtedly the Manhattan Project; indeed, Richard Rhodes (1986) makes a convincing and comprehensive case for the project's status as "the greatest achievement of organized science in history" in his tome *The Making of the Atomic Bomb*. However, other examples abound, with perhaps the most interesting surfacing in Douglas Adams's humorous but acutely insightful essays from *The Salmon of Doubt*. For instance, in the essay "What Have We Got to Lose?" Adams (2002) begins with the statement, "Some of the most revolutionary new ideas come from spotting something old to leave out rather than thinking of something new to put in." Though his examples are simple at first, including the Sony Walkman and a "well-made dry martini," few people familiar with the history of engineering will, I think, doubt his point that sometimes this "subtractive" design methodology demands the sharpest thinking. Through studying some real engineering projects and real scientific challenges—rather than grinding through difficult but conceptually isolated problem sets—our group started to get a clear message. Make no doubt about it, our authors told us again and again, work in the sciences and engineering is hard and getting harder.

And why is this the case? Well, progress, of course, plays a key role; as scientists and engineers learn more, each successive generation has a larger body of knowledge—theories and theorems, laws and techniques, data tables and standards—to be familiar with. With this growth in knowledge has come increased specialization, and necessarily so. Our readings, from Henri Poincare to Henry Petroski and Richard Feynman to Richard Dawkins, document this march of knowledge. Many of us lament the pedagogical consequences of this change; Samuel Florman (1996) has, in his words, "written many impassioned pages" preaching the need for more liberally educated engineers. Indeed, ABET's new standards seem to be, in part, a response to this often-articulated ideal and will hopefully pave the way for increased flexibility in engineering curricula.

However, by itself, this curricular change doesn't really address the root problem. We would do well here, I think, to apply a lesson from historian and philosopher of science Thomas Kuhn (1996), who really captures the tension I'm trying to get at. He writes, "Although it has become customary, and is surely proper, to deplore the widening gulf that separates the professional scientist from his colleagues in other fields, *too little attention is paid to the essential relationship between that gulf and the mechanisms intrinsic to scientific advance*." Part of the point here is that for scientists and engineers to continue their work, we *need* specialists; indeed, if we were ever to attempt to have a course like our reading and discussion group made mandatory, the fact that it would likely displace an oh-so-sacred "advanced technical elective" would kill it dead in its tracks. One word, "specialization," is all the ammunition opponents have needed in the war on courses like ours.

But this needn't be the case. The readings our group has done and the experiences we have had suggest a better solution—one in which "specialization" is also *our* rallying cry. The idea of specialization really links the two problems I've mentioned. The increases in knowledge gained from specialization is a big part of why engineering has "gotten harder," because there is simply more knowledge for students to learn. This is the perspective on specialization that puts a strain on curricula and deafens many ears to the messages in Florman's "impassioned pages." But recall our corollary problem; the increased need for interdisciplinary understanding and cooperation. As technical experts become more and more narrowly focused, they become increasingly reliant on experts in closely—and not-so-closely—related fields. Increased specialization requires increased interdisciplinary cooperation. *This* perspective on specialization is what demonstrates the need for courses like ours; in our zeal to design curricula that train engineers to be increasingly specialized, we have neglected, it seems to me, to equip them to deal with the negative consequences of their narrow focus.

I talked at the beginning of this paper about offering a solution to these problems—or rather, this problem; for—like the particle and wave aspects of light with which some of the physicists we read about grappled—these problems are two sides of the same coin. I have hinted that I believe courses like ours could be a part of that solution, but it remains for me to explain how this is the case and why our readings in the history of science and technology support this claim. Let me now try to do that.

One of the requirements of our course was to write weekly responses to our readings and post them on an online discussion forum. I wrote in one of my entries about how physicists Niels Bohr and Albert Einstein and engineer Leslie Groves—the general in charge of the Manhattan Project—were effective because they were "scientific coordinators." That is, their success came not so much from making breakthroughs in their roles as specialists, but by bringing together ideas from seemingly disparate disciplines and making sense of them. Incidentally, this is the same role Crick and Watson played in the discovery of the structure of DNA and the de facto invention of the discipline of molecular biology; Watson's *The Double Helix* should have been on our reading list.

Anyway, in the case of Bohr and Einstein, being scientific coordinators required a good deal of specialized knowledge in the disciplinary areas they tried to unite. This was not the case, however, for Groves, who was a civil engineer and knew relatively little about the most challenging scientific aspects of the Manhattan Project. What he did know was which role each type of specialist had to play—that is, the disciplinary knowledge they possessed *and* the ways in which they would need to work with complementary experts in other fields.

Encouraging collaboration in this way is no small task; after all, specialists in different disciplines inhabit different worlds, at least according to Thomas Kuhn. Kuhn (1996) believed that the epistemology of each discipline creates a matrix that defines not just a particular discipline, but the worldview of its disciples. This is obviously true across the broadly defined disciplines—physicists, mathematicians, and engineers, for instance, have vastly different ways of looking at the world and going about their work, as a number of surprisingly sophisticated jokes attest. Yet subtle but no less debilitating methodological differences can exist within the same building, department, or research group as well, and there just aren't enough General Groves's to go around.

This, I believe, is where courses like ours come in. A reading and discussion group like this one is ideally suited to getting students thinking about the problem of interdisciplinary collaboration in an increasingly specialized scientific landscape. First off, since it was open to all majors, students brought their own disciplinary understandings to the table, and we sometimes learned about other disciplines by describing to each other various problems and projects we have worked on—I wish the humanities student who was enrolled in our course hadn't had scheduling problems; her perspectives would no doubt have been valuable as well. Second, by reading about major projects in science and engineering from a variety of genres—history and philosophy as well as popular and technical science and engineering writing—you get many perspectives on the projects and can come to understand how no scientist or engineer is an island. This provides a much more realistic picture of the collaborative ways engineering happens. For instance, before reading Rhodes' *Atomic Bomb* book, I had totally overlooked the contributions of pretty much everyone but the physicists. And yet Oppenheimer, Teller, Fermi, Szilard and company would never have gotten Fat Man to work without the explosives knowledge that Manhattan Project chemical engineers provided. Nor would they have been able to test their early theories were it not for some dedicated radiochemists who separated the first isotopes. The list, of course, goes on and on, but I probably never would have considered it without reading and discussing Rhodes' book. Though I didn't realize it at the time, this course was familiarizing me with the disciplinary matrices of dozens of specialties, within the sciences and beyond, thus equipping me to understand and work with these specialists in the future. The truth is, *all* engineers will have to work in interdisciplinary teams. This course provides the valuable service of getting students to think about how that is accomplished.

So what does this have to do with "sustaining engineers?" Well, preparing them to be more effective in their future collaborations will surely help sustain them when the going gets tough. But more relevant to me is a point which first acknowledges that fundamental to sustaining engineers is retaining them in the first place. A friend of mine once mentioned that her zoology professor is the world's foremost expert on fly wing growth. We certainly have analogously specific experts in engineering, and some students are happy to look forward to similar roles. I am not one of them. Neither, it seems, are a number of my colleagues in UW-Madison's writing fellows program, a group of interdisciplinary writing tutors from dozens of majors. I have half a dozen writing fellow friends who began their careers at Madison in engineering. Why did they leave? Not because they couldn't hack it, but because they refused to submit themselves to a curriculum with 15 credits of liberal studies electives. Their interests were broader than that. These are students we need in engineering, students who realize that there are lots of exciting opportunities for, to use a GE recruiter's terms, "breadth people" as well as "depth people." This course can show students that an expert on fly wing growth or F-16 wing design can collaborate on fascinating projects with dozens of other experts. Such an experience might have helped my friends see the forest through the trees. As a student who until very recently was planning his post-graduation escape from engineering, I can tell you it worked for me.

References

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