Preparing Engineers to Be Ethically Responsible

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Before the Challenger accident in January of 1986, I used to have to do a lot of stage setting to dramatize the moral situation of practicing engineers. Engineers, like most technical professionals who work in corporations, were virtually invisible until the Challenger disaster. Of course, I include chemists and physicists among these technical professionals.

Many of us had a sense that the products of the work of these professionals impinge upon just about every aspect of our lives. But most of us who are not engineers, physicists, or chemists did not have a picture of how they go about their work. Even well educated people puzzle the difference between the work of a chemist and that of a chemical engineer.

After the Challenger disaster, many of us avidly followed TV, radio, and newspaper accounts of the decision-making that led up to the ill-fated launch. Again, when the Presidential Commission conducted its investigation, activities of engineers and managers inside Morton Thiokol, NASA, and other organizations were brought out into the daylight.

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What did we learn about the moral situation and responsibilities of engineers? The events of one critical scene are familiar to many. The night before the launch, engineers at Morton Thiokol, the company that produced the solid rocket booster, had to make a recommendation whether or not to launch. Their approval was required. The engineers agreed in recommending that the launch should be postponed once again. They judged that the temperatures would be too low for the critical, now notorious, O-rings to function properly.

Officials at NASA did not react favorably to that verdict. They pressed managers at Morton Thiokol for the release to launch. The managers and engineers caucused and could not reach an agreement on a recommendation to launch. In the end, a Vice President of Morton Thiokol gave in to the pressure from NASA. He told the chief of engineering to take off his engineering hat, put on his management hat, and make a management decision. An engineer who was present later described this scene. He said that it held the kind of tension you experience when you are about to be fired. The chief of the engineers put on his management hat and made the recommendation to launch. The engineers at Morton Thiokol fell into line and did not oppose the decision, once it had been made. An engineer from Morton Thiokol who was at the launch site voiced his opposition even after the recommendation to launch had been received —but to no avail.

So we learn that the engineers played a role in decision making in a complex scene that included their managers and officials at NASA. They had technically-based reasons for resisting the decision to launch in the abnormally frigid temperatures. However, they could not make their case powerfully enough to persuade their managers to hold out. We now know some of the details of their failure. In the end they were overruled. The outcome was a disaster.

The pressures in this particular scene were extraordinary. And we may suppose that the breakdown of the effort to caucus and reach agreement was also extraordinary. Perhaps it was a situation to which we can correctly apply that over-used term "worst case scenario." But it opens a window to workplace scenes in which engineers and managers try to reach a decision that will have an impact for better or worse on others who are not present. And such scenes are not presented in the customary education or training of engineers, chemists, or physicists, unless they happen to get co-op jobs.

For those of us who teach engineering ethics or technology and society courses, the scene showed a familiar pattern. For teaching purposes, we have compiled cases of actual episodes. This scene at

THE ETHICS AWARD INAUGURAL SYMPOSIUM—SESSION II

Last month we published the papers delivered in Session I of the Ethics Award Inaugural Symposium, held on May 31 during the 1991 Annual Meeting in Baltimore. While Session I presented personal viewpoints of professionals with experience in a variety of areas, including industrial and government research, consulting, and teaching, the speakers in Session II provided insight into the viewpoints of professionals as a group and of agencies responsible for defining, and in some cases monitoring, ethical behavior in all aspects of professional activity. The problems of management in professional ethics are common to many fields of science and engineering. Regulations established by government and other agencies to meet these problems will affect chemists whether or not the regulations were promulgated in response to any misbehavior of chemists. It is important for the chemical profession to be aware of the attitudes and principles shaping ethical guidelines affecting chemists as well as the current regulatory mechanisms that enforce ethical codes.

The presentations of the speakers in Session II appear in this issue as follows:

"Preparing Engineers to Be Ethically Responsible"—Dr. Vivian Weil, National Science Foundation and Illinois Institute of Technology

"Fostering Responsible Research Practices"—Rosemary Chalk, National Academy of Science—Ms. Chalk was unable to provide a paper for publication because the study on which she reported informally has not yet been completed.

"Psychological Research on Ethical Dilemmas and Decision Making"—Dr. Elizabeth Baldwin, American Psychological Association

"Ethics in R&D in Industry"—John W. Collette, Director, Administrative and Scientific Affairs, Central Research and Development, Du Pont Experimental Station

Morton Thiokol reminded us of other cases. For example, it brought to mind the engineer back in the 70's at Convair, which had the contract for the fuselage of the McDonnell Douglas DC-10. This engineer recognized the seriousness of the problem with the latching of the cargo door. He was overruled in his attempts to have it dealt with properly. Again, the scene was a complicated one—one company under contract to another, and a government regulatory agency, the FAA, without the independence or resources to function as intended to protect the public. Or we might recall the Ford Pinto engineers. They proposed several feasible, inexpensive options to remedy the defect in the Pinto. Managers and engineers were fully aware of the car's vulnerability to fiery explosions in rear-end collisions even at 20 miles per hour. Yet none of the engineers' recommendations to remedy the defect was accepted.

Recalling these and other scenes in which the recommendations of technical professionals were overruled or ignored, some colleagues and I decided to try to go through the window opened by the Challenger investigation to learn more. We wanted to understand better how decision making in technological organizations proceeds. We wanted especially to know how engineers and other technical professionals do and should contribute to making decisions which affect others for better or worse. We were eager to discover how engineers and managers communicate with each other, what makes communication go well and what makes it break down, as in the ill-fated Challenger caucus. One thing was crystal clear—engineers need to be prepared to be ethically responsible. The scenes we had learned about suggested that life in corporations was too complicated for technical professionals to manage as decent, responsible people without good preparation.

We pursued our investigation with resources provided by a grant from the Hitachi Foundation to the Center for the Study of Ethics in the Professions at Illinois Institute of Technology, the Center which I direct. The research group was made up of myself, another philosopher specializing in applied ethics, the director of an ethics center in Chicago supported by member companies, a member of IIT's Business School faculty, a faculty member from Northwestern University's Kellogg School of Business, the CEO of a middle-size company that makes gaskets for motor vehicles, and a manager/engineer at Motorola to whom hundreds of engineers report.

We found very little in print that was useful. The single best item in the literature was an article written for the Cal Tech Alumni Magazine by Richard Feynman, the Nobel-laureate physicist who participated in the Presidential Investigation. He wrote about how he went and talked to engineers and managers working on the various systems for the Challenger. He described the clues he found that indicated whether the engineers and managers were on the same wavelength in decision making.

His account gave us the idea of interviewing engineers and managers. We worked out two sets of questions, one for engineers and one for managers, with assistance from a specialist in this type of research. Then we pretested the questions. We hoped to find out what makes for effective communication and what factors lead to constriction or breakdown.

We interviewed in ten companies at eleven sites, companies ranging from a small entrepreneurial business to several large international Fortune 500 companies. Our study included a chemical plant. Every company we approached gave us access, and in each we found a strong interest in the problem we sought to investigate. Sixty interviews were conducted, with about an equal number of engineers and managers. Only two of the managers were not originally trained as engineers, and it was only with great difficulty that we found those two.

I will describe our chief findings and explain what they tell us about how engineers and other technical professionals should be prepared to be ethically responsible. Our most startling finding is that it is an important part of the engineer's role to be an advocate. Engineers have to learn how to make technically-based judgments and advocate them. In some respects, these are ethical judgments. At least ethical considerations are usually at the heart of these judgments and bear on them.

If engineers are to function as advocates, they must develop the full range of skills of an advocate, skills we tend to associate with lawyers. This is the function expected of them in companies and other organizations. Engineers must be able to defend their judgments in face-to-face discussion and in writing; they must know when to press and whom to press. They must learn how to mobilize support for their positions and to negotiate. In our study, managers reported that engineers need to ask questions about everything going on around them. They have to understand the scene they are in so they can be good advocates. For engineers, "negotiation" has perhaps different connotations than for lawyers. They are not combatants but participants in a cooperative enterprise. Their communications should appeal to reason and to the common ground they share in wanting to make good decisions. To summarize, our research indicates that engineers have to take responsibility for activities that are not in their job description. One company had as a slogan, "The engineer is responsible for everything."

When the engineer discovers a problem affecting safety, the task may be to see that senior people are alerted, that the information reaches them. There is not necessarily a conflict between engineers and senior officials. They share a desire to make good decisions with respect to safety. The engineer needs to realize that to get the attention of very senior people, it may be more advantageous for a department to sign a report than for an individual engineer to do it alone.

When we asked engineers and managers what they did when they disagreed, we heard again and again that they keep discussing the matter until they reach agreement. If they are stymied, they will agree to call in someone else or several others who know something about the matter. They will enlarge the discussion. This sounds like obvious common sense, not a specific ethical mechanism—but often the obvious needs to be pointed out. The guiding insight is that behaving responsibly depends on making connections with people—on opposing compartmentalization.

These findings suggest specific things for prospective engineers to look for at the point when they are being hired. Is there a company telephone book so that it is easy to get access to people within the company? The lack of a company director may flag an environment where the kind of communication I have described is discouraged. Geographical separation may be another such flag. It is not easy for design and manufacturing people to iron out problems if they are in separate buildings. We interviewed at a company where the geographical separation necessitated a system of bicycles.

These findings have implications for the education of technical professionals. Our Hitachi project is oriented toward training inside companies as well as toward the school training of engineers. I can summarize the aim of company training quickly. The idea is for managers to train engineers to be advocates. At this point, we are in the process of working out a training program that can be pretested in companies. We are looking for companies in which to do the pretesting. We hope they will include some of the companies in which we interviewed, but we would like to find others.

The aim in engineering education is to break the mold in current education that assigns students problems detached from a context in the real world. The homework problems, for example, need to be opened up so that students see what they mean in the real world. Very slight changes in problems will do the job. For example, one instructor reported changing problems in studying fluids. The problems involved chemicals going through tubes, devices for speeding the flow, and the like. In the problems, enormous quantities of fluids were flowing, to be dumped eventually. The change the instructor quietly made was

continued on page 20