A Multidisciplinary Course on Technological Catastrophes

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This paper describes a multidisciplinary course entitled "Technological Catastrophes" that is offered as a General Education elective in Science, Technology and Society (STS) at North Carolina State University. All students entering the university since Fall 1994, including engineering students, are required to take at least one STS course [1]. The purpose of the STS requirement is threefold: 1) develop an understanding of the influence of science and technology on civilization; 2) develop the ability to respond critically to technological issues in civic affairs; and 3) contribute to an understanding of the interactions among science, technology and human values.

Course Background

The course was originally developed at Lafayette College as a required senior colloquium for liberal arts majors, including students enrolled in the Bachelor of Arts in Engineering Program, by an interdisciplinary team of engineers and chemists with advice from colleagues in economics, sociology and religion. Senior colloquia were designed as multidisciplinary capstone experiences with substantive focus on human values.

In developing the course it was immediately recognized that technological catastrophes lend themselves to multidisciplinary analysis. A familiarity with the technology itself is essential to an understanding of why such accidents occur and what their effects are. Likewise, the behavior of complex organizations is a relevant topic. The economics of risk and risk management also play an important role. Finally, social and behavioral aspects of how risks are perceived have a great bearing on the success or failure of risk assessment and risk communication.

At the heart of this inquiry is a critical examination of risk and methods of risk assessment, topics which involve fundamental value judgments. The impacts of technological catastrophes also have values dimensions, as, for example, where third-world exploitation is an issue, and where the impacts are international, cross-cultural, or intergenerational in scope. The social and ethical responsibilities of individuals and of corporations are also brought to light by technological catastrophes.

Course Description

The course is designed to approach the topic of technological catastrophes through integration of perspectives drawn from engineering, the natural and social sciences, and the humanities. The required readings are written by engineers, scientists, sociologists, psychologists, journalists, political scientists, and management analysts. Lectures and discussions focus on the human, organizational and technical factors underlying the causes and impacts of technological catastrophes, with significant emphasis on interdisciplinary approaches to risk assessment and risk management. Two models of risk perception are explored, the quantitative approach employed by most engineers and other technical experts ("technical rationality") and the "social or "cultural rationality" approach favored by many social and behavioral scientists. In addition, the implications of the different risk models for designing efforts at risk communication between experts and non-experts are evaluated.

The course seeks to develop an understanding of the underlying causes and impacts of technological catastrophes through synthesis of four major case studies: the Bhopal chemical leak, the space shuttle Challenger explosion, the Chernobyl nuclear accident, and the Exxon Valdez oil spill. Throughout the course, students are challenged to evaluate the nature of "catastrophe" in terms of human safety (as in the case of Bhopal and Chernobyl), environmental impact (Chernobyl and Exxon Valdez), and the role of advanced technology in society (all of the cases, but especially Challenger). Consideration is also given to options for living with complex technological systems (or modifying or abandoning them in some instances), and the relative merits of preventive versus response strategies in dealing with technological catastrophes.

Pedagogical Methods

The course makes extensive use of cooperative learning techniques, including student group projects on past and potential catastrophes, and other innovative pedagogical methods, such as use of the World Wide Web and video documentaries.

In-class exercises include risk assessments, judging probabilities and discussion of the causes and impacts of the case studies from the perspectives of the analytical models introduced in the course. Group projects consist of research and presentation during an entire seventy five minute class period of a case study of a past or potential technological catastrophe that was not included elsewhere in the course. The presentations, which are required to actively involve the rest of the class, often include simulations, talk show formats, and mock hearings. Recent topics have included Airline Safety, Dam Failures, Computer Network Crashes, Breach of Biological Containment, and High-Speed Police Pursuits.

World Wide Web links utilized include primary source archives from the Three Mile Island, Chernobyl, Apollo 13, Challenger, and Exxon Valdez cases, and other resources such as the discussion of the Challenger case maintained at the World Wide Web Ethics Center for Engineering and Science located at the Massachusetts Institute of Technology. Documentary videos, obtained from PBS and various broadcast and cable channels, include footage of the disasters and/or their aftermaths for all of the major case studies considered in the course as well as such cases as a ship explosion that leveled downtown Texas City, Texas, Three Mile Island, Apollo 13, and a gas leak which occurred at a Union Carbide plant in Institute, West Virginia. Students are also required to screen the feature film, *Apollo 13*.

Students are evaluated on the basis of preparation, class attendance and participation in class discussions; two writing assignments; the group project (which also incorporates peer evaluations by group members and the classroom audience); and a take-home final examination.

Student response to the course has been very positive, with course evaluations generally well above the departmental average.

Relevance to Contemporary Issues

A course on technological catastrophes is relevant to both the general educational needs of students, and the specific needs of science and engineering majors and students interested in STS. All students will evaluate risks in their daily lives as well as their inputs into the processes of democratically controlling technology (e.g. through voting or purchasing products). Most science and engineering graduates will implicitly, if not explicitly, deal with risk assessment during the course of their careers. In the context of STS education, few topics are more germane to the relationship of contemporary technology and human values than the issues of risk assessment and equitable risk management.

The course addresses all three goals for the STS component of the General Education Requirement at NC State. The course helps students develop an understanding of the influence of science and technology on civilization by considering how complex technologies are developed and operated, and how dependent individuals and communities have become on their safe and efficient operation. The course assists students in developing the ability to respond critically to technological issues in civic affairs by exposing them to four detailed case studies of complex technologies, their potential catastrophic impacts, and the controversies surrounding their continued development. The course contributes to an understanding of the interactions among science, technology and human values by continually raising questions concerning the acceptability of risk, the appropriateness of technical versus cultural perceptions of risk, equity issues in the distribution of risk, and the ethical responsibilities of individuals, corporations, and governments concerning the safe operation of complex technological systems. In addition, the course qualifies as an elective in the five-course minor program in Science, Technology and Society.

While enrollment in “Technological Catastrophes” is not limited to engineering students, engineers have comprised forty to fifty percent of the course enrollments. Interaction with students from other academic and social backgrounds, especially those with non-technical majors, enhances the experience of the engineering students by giving them exposure to the views on risk and catastrophe held by others. Indeed, STS courses such as this are an appropriate and very effective vehicle for exposing engineering and other students to contemporary issues and the importance of engineering solutions in a global societal context.

Reference

[1] J. R. Herkert, “STS for Engineers: Integrating Engineering, Humanities and Social Sciences.” Session 3561 of these proceedings (1997).

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