THE IMPORTANCE OF ENVIRONMENTAL PROTECTION AND PROFESSIONAL ETHICS TO ENGINEERING AND TECHNOLOGY DEPARTMENTS IN HIGHER EDUCATION

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Abstract — *As nations spend billions of dollars cleaning up environmental mistakes from decades of abuse, the question arises of what role institutions of higher education may play in preparing future professionals to prevent environmental destruction. Primary and secondary educators in the United States have, over the past decade, incorporated programs into their curricula designed to develop student sensitivity to the environment. Institutions of higher education, however, may lag behind. We believe that assessing the current practices of higher education in teaching environmental protection and professional ethics could provide critical information for improving educational practices. To obtain this critical information, we developed a pilot survey to explore the extent to which courses in environmental protection and professional ethics are taught within higher education. The survey was sent to 2000 educators representing undergraduate and graduate programs in engineering, science, and technology. The survey results suggest that professional ethics courses may be widely taught, but environmental protection courses are not.*

Index Terms — *environment, ethics, pollution.*

INTRODUCTION

Human survival depends on a number of natural resources. Water is certainly one such resource; air is another; and energy sources such as fossil fuels are a third. Reviewing the presence and effects of pollutants in each of these natural resources is a helpful way to begin a discussion of the role of higher education in preparing future professionals to prevent environmental destruction.

Water. Water is a resource with unique properties, essential to all life. It is a basic factor in the growth of natural communities and human civilizations. The safety of a drinking water supply is influenced by impurities that fall into three classes: organic chemicals, inorganic chemicals, and microorganisms. Discharge of wastewater represents a growing threat to water supplies by adding all three of these impurities to water resources. Wastewater from cities, industries, mining operations, farms, and rural homes contains organic, inorganic, and microorganism impurities that can and do contaminate drinking water supplies. If organic pollutants present in wastewater are not removed, they can rob water of the dissolved oxygen normally present. Also, organic chemicals such as pesticides may directly poison aquatic organisms, including those connected to human food supplies. Inorganic chemicals in wastewater such as certain phosphorus and nitrogen compounds can cause excessive overgrowth of algae. Microorganisms in discharged wastewater are a major cause of disease [1]. For many years industrial and municipal wastes have been buried in landfills, in abandoned wells and mines, or discharged directly into rivers and other bodies of water. Only recently have we come to better understand how these practices can pollute groundwater which was once thought to be the safest source for drinking water.

Air. Air is as essential as water; however, numerous pollutants taint the air we breathe. Misuse of fossil fuels has polluted the air so severely that in some regions it is a significant cause of death [1]. Solid particles such as lead, asbestos, and soot are dispersed in the air. Liquid droplets of hydrocarbons and sulfuric acid float in the atmosphere. Gases such as carbon monoxide, nitrogen oxides, and sulfur dioxide are mixed in the atmosphere that surrounds us. These pollutants may impair breathing and exacerbate heart and lung diseases. The landscape is also influenced because forests and other vegetation are sensitive to air pollutants. Construction materials such as mortar and metal are corroded by some of these pollutants. Smog and acid rain are a few other examples of the effects of air pollution.

Energy Sources. Energy sources are essential and commonly used in three ways. First, the energy released by mining and burning fossil fuel may be used directly as heat. Second, the heat energy might be converted into work, using refined oil to run machinery and power automobiles. Third, the heat energy from either fossil fuel or nuclear sources may be converted to electricity. All of these uses of energy discharge pollution in forms that can range from waste heat, to many of the air pollutants mentioned above, to radioactive materials.

The last few decades have seen a strong movement begin to clean the environment from these pollutants released by new technologies and lack of concern for their effects. This lack of concern may be due to the dearth of understanding by engineers of the effects of these technologies on the environment, and also to a preference

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for economic factors over ethical factors. Nonetheless, cleanup costs may be shown to be many times greater than the cost of educating engineers to protect the environment and to build in them strong ethical behavior to protect natural resources.

EXAMPLES OF CLEANUP COSTS

Cleaning up pollution is expensive. The average cost to clean a contaminated groundwater site under the U.S. Superfund cleanup program, for example, is $25 million [2]. Cleaning up some polluted sites is even more expensive than this average. For example, cleaning up lead-contaminated soil and groundwater from an eastern U.S. site where automobile batteries were discarded will cost an estimated $40 million [3]. And the cleanup cost of toxic metal and acid releases from California's Iron Mountain Mine is estimated to approach $1 billion [4]. Thousands of such polluted sites can be found worldwide, and estimating the cost to clean up all of these sites is likely to yield a staggering number. In the U.S. alone, estimates place the total cost of cleaning up all the private and public polluted sites as high as $500 billion to $1 trillion [5].

In addition to paying for cleanup, the high cost of pollution is often incurred in terms of human health. Some human costs are local. For example, in the Great Lakes region of the U.S. and Canada, children born to women who have high levels of PCBs (polychlorinated biphenyls) from widespread improper disposal suffer retarded growth and score significantly lower on certain memory tests [6]. Other human costs are global. In 2002, the World Health Organization listed unsafe water as one of the top ten health risks worldwide [1]. Widely-read publications indicate that an estimated 1 billion people worldwide drink contaminated water [7]. Also worldwide, urban air pollution killed an estimated 800,000 people in 2002. Lead pollution killed an estimated 234,000 people [1].

These few examples illustrate the high cost of pollution, both in terms of the money required for cleanup and in terms of the impact on human health. The cost of pollution is many times greater than the cost of educating engineers to protect the environment and its natural resources.

A CHALLENGE FOR ENGINEERING AND TECHNOLOGY EDUCATORS

Most engineering and technology educators would agree that environmental protection is a matter of primary importance to humans and to the future of humanity. Some of us also feel a sense of frustration, of "where can I begin?", "how can I help?" or "what are my roles and responsibilities?" Some of us fear that we do not know enough or that we are just "amateurs," unlikely to have any significant impact whatever we do. Others ignore the issue hoping that it will go away. These thoughts were the driving force behind our desire to survey educational institutions regarding their courses in environmental protection and professional ethics.

PILOT SURVEY OF EDUCATIONAL INSTITUTIONS

A four-question pilot survey was designed to explore the extent to which environmental protection and professional ethics are taught in undergraduate and graduate institutions in engineering, science, and technology. The survey was sent by e-mail to over 2000 educators around the world. The four survey questions are listed below as the captions to Figures 1-4.

Sixty educators responded to the survey. Almost all of the respondents taught in engineering and technology programs. Most of the respondents (42) were in the United States. Other respondents were in Latin America (8), Asia (5), the Middle East (4), and Europe (1). Survey results were tabulated by location and by discipline. Two locations were considered, the U.S. and other countries as a whole. Other countries were considered as a whole because of the small number of non-U.S. respondents. Three groups of engineering and technology programs were considered: those in the civil, mechanical, and electrical/computer disciplines.

RESULTS

The first survey question asked respondents if their institution has a department in the field of environmental or green engineering. As illustrated in Figure 1, 64% of all respondents indicated that their institutions have no such departments. When responses from the U.S. were collected and compared to responses from other countries as a whole, the results for the two groups were almost identical. In the U.S., 64% indicated no environmental or green engineering department. In other countries as a whole, 65% indicated no such department.

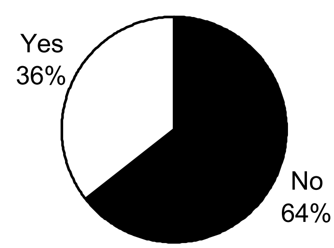

FIGURE 1
DOES YOUR INSTITUTION HAVE AN ENVIRONMENTAL OR GREEN ENGINEERING DEPARTMENT?

The second survey question asked respondents about required courses in their department on environmental protection. As illustrated in Figure 2, 69% of all respondents indicated that they have no required courses in environmental protection. When divided into responses from the U.S. and responses from other countries as a whole, the results were 70% no required courses for the U.S. and 66% no required courses for other countries. Among disciplines, respondents from civil engineering departments were most likely to indicate one or more required courses. In these civil engineering departments, only 34% of respondents indicated no required courses, in contrast to the 69% rate for all respondents shown in Figure 2. Electrical/computer engineering departments were most likely to indicate no required courses. In these departments, 92% of respondents indicated that they had no required courses in environmental protection.

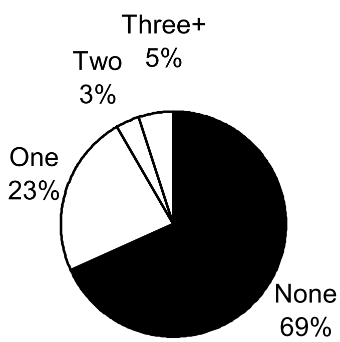

FIGURE 2
IN YOUR DEPARTMENT, HOW MANY REQUIRED COURSES ON ENVIRONMENT PROTECTION DO YOU HAVE?

The third survey question asked respondents about optional or elective courses in their department on environmental protection. As illustrated in Figure 3, about half of all respondents—52%—indicated that they offer no optional or elective courses in environmental protection. Results from the U.S. suggest that other countries as a whole may be more likely than the U.S. to offer optional and elective environmental protection courses. In the U.S. 55% indicated no optional or elective courses; in other countries as a whole only 44% indicated no optional or elective courses. Among disciplines, the results were similar to those above for required courses, with respondents from civil engineering departments being least likely to indicate that they had no optional or elective courses. Respondents from electrical/computer engineering were most likely to indicate that they had no optional or elective courses.

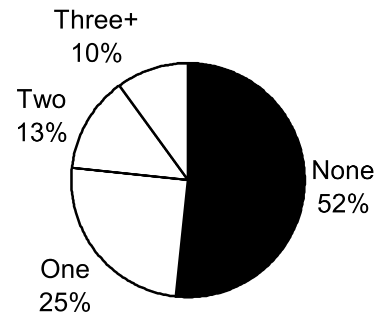

FIGURE 3
IN YOUR DEPARTMENT, HOW MANY OPTIONAL OR ELECTIVE COURSES ON ENVIRONMENT PROTECTION DO YOU OFFER?

The fourth and final survey question asked respondents about courses offered in ethics and professional responsibilities. As illustrated in Figure 4, 24% of all respondents indicated that their department or college offers no such courses. Results by location suggest that other countries as a whole are more likely than the U.S. to offer no ethics and professional responsibility courses. In other countries as a whole 44% of respondents indicated offering no such courses. In the U.S. only 15% of respondents indicated offering no such courses. Among disciplines, civil engineering respondents were most likely to offer no such courses (56% indicated none.) Mechanical engineering respondents were least likely to offer no such courses (30% indicated none.)

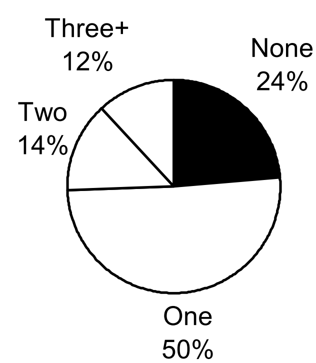

FIGURE 4
IN YOUR DEPARTMENT OR ELSEWHERE IN YOUR COLLEGE, HOW MANY COURSES IN ETHICS AND PROFESSIONAL RESPONSIBILITIES DO YOU OFFER?

Conclusion

The results of the pilot survey help reveal the extent to which environmental protection and professional ethics are taught in undergraduate and graduate programs in engineering and technology. The survey results suggest that professional ethics are widely taught in these programs. Adding percentages in Figure 4 shows that a total of 76% of the respondents indicate offering one or more courses in ethics and professional responsibilities. In contrast, except for civil engineering, most engineering and technology programs appear to pay little attention to environmental protection courses. Adding percentages in Figures 2 and 3 shows that a total of only 31% of respondents indicate courses in environmental protection that are required; only 48% indicate courses that are optional or elective.

The low response rate to the pilot survey (60 respondents out of 2000 contacted) is consistent with the conclusion that most programs pay little attention to environmental protection courses. Also, educators in programs with interest in environmental protection may be more likely to respond to a survey on that topic. As a result, the survey results may even overestimate the true extent of environmental protection coursework in engineering and technology disciplines.

Why so little interest in environmental protection courses? One possible explanation lies with the industries that we serve. Because educators adapt curricula to meet industry needs, industry is a major driving force in the curriculum. Industry may simply not be interested in students who have completed courses in environmental protection. We propose that educators could improve the engineering and technology disciplines, however, by being proactive. The huge costs of pollution and its cleanup are borne by all of us, either directly through our health or through the cleanup costs to industry and taxpayers. By improving education for our students about the consequences of pollution, we can lead change in industry and reduce the costs of pollution and its cleanup.

To build on this pilot study, we plan to survey educators further to increase the number of respondents. Our goal is to create a more complete picture of the state of environmental protection education in engineering and technology departments.

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