Global issues in environmental engineering education

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ABSTRACT: Environmental engineering has been a topic of interest amongst engineering educators in recent decades due to the increasing number of global environmental problems, such as ozone depletion, rising global temperature, waste management, coupled with the increasing pressure on the engineering profession from the community to respond to these environmental challenges. With the expanding global population, there is a growing concern about the environment and the impact of technological development on it. This paper outlines the history and evolution of environmental engineering, what this evolving field entails, the relationship between environmental engineering and other professions concerned with similar issues and, thus, faced with same challenges. Finally, the role of women in, and their attraction to, environmental engineering, being of paramount importance to the harmonious development of this field, are presented and discussed in this paper.

INTRODUCTION

Evidence from statistics gathered from a global survey of 200 environmental experts' views on emerging issues concerning the state of our planet, which was conducted on in more than 50 countries, indicates that our planet is not in a healthy state and environmental issues continue to be of global concern [1].

Some of the emerging environmental issues highlighted from the survey were climate change (51%), freshwater scarcity (29%), deforestation/desertification (28%) and freshwater pollution (28%). This was followed by environmental problems stemming from poor governance (27%), loss of biodiversity (23%), and the two social issues of population growth and movements (22%), as well as changing social values (21%).

The survey indicated that the primary focus in Africa and West Asia was on land and water resources management, in Asia and the Pacific region it was on air pollution (mainly emissions of sulphur dioxide and nitrogen oxides), in Europe and Central Asia it was on energy-related issues (mainly due to transport and electricity use), in Latin America and the Caribbean it was on the use and conservation of forests and in North America the primary focus was on resource consumption and greenhouse gas emissions.

It appears that every region has its distinct problems to deal with and the adoption of strict policies is necessary in order to control the problems. However, introducing such strict policies might be only one way to control regional problems, but education is of primary importance, and it is the key to solving global problems and achieving a better future for generations to come.

It is imperative that educational institutions recognise the various regional problems and from this, they can provide more education on the specific environmental topics affecting the region. The problems may be local in scale, but they require a global solution, e.g. climate change. This is where a global curriculum on environmental engineering can be useful, as its flexibility allows institutions around the world to adopt and adjust the curriculum to suit local environmental needs. Engineers, particularly environmental engineers, are said to be the best profession to tackle the environmental problems. If they are equipped with the appropriate knowledge, skills and attitudes, they will be able to make a major contribution to finding solutions to eliminate environmental problems, such as the ones mentioned above.

EDUCATING ENGINEERS ABOUT THE ENVIRONMENT

There have been major discussions and debates in the past decades about engineers needing to be educated about, and for, the environment. This is an area that has been grossly neglected and overlooked in past education.

Engineers are not only expected to have some form of environmental education but also to take an active role in helping to solve environmental problems. This idea has come about because engineers are seen as the cause of problems but also as the solution to environmental problems. Travers gives a good example of how engineers can fall into both categories [2].

Travers states that many of the environmental problems of the present have been caused by technical developments for which the engineering profession has been at least in part responsible. On the other hand, many of the solutions to the same problems are also technical and, again, are the responsibility of the engineer. Although this may sound simple in theory, it is harder to achieve in practice [2].

Further, according to Travers, this is because environmental problems are complex and require the application of knowledge, expertise and experience from a wide range of disciplines. The current curricula are still very narrowly focused and little emphasis is placed on environmental aspects. Although most agree and accept that engineers need to be subjected to some form of environmental education, this requirement does not appear to be reflected strongly in early and existing curricula [2].

In the wake of the widespread emerging environmental problems and crises reported in the media, as well as increased demands from the public, a growing interest in the environment among engineering educators from around the world has been witnessed in the past decades.

It has become clear that engineering educators need to take a more proactive role in greening engineering curricula, and that changes to existing curricula are urgently needed to realise the environment as a part of the engineering curricula. With all the hype about the environment, and its relevance in engineering, this then leads to the introduction of environmental engineering.

THE INTRODUCTION OF ENVIRONMENTAL ENGINEERING

Environmental engineering has been an ongoing matter and topic of interest among engineering educators for quite some time now. This is mainly due to rising global environmental problems, such as those emerging issues and problems mentioned above.

Moreover, the increase in public awareness and pressure from the community at large has put demands on the engineering community to respond to these environmental challenges. The field of environmental engineering is, without a doubt, the most multidisciplinary of all the engineering fields and, perhaps, the most complex of them all.

WHAT IS ENVIRONMENTAL ENGINEERING?

There are many ways to define the exact meaning of environmental engineering. Below are some examples of common definitions used by various authors and professional engineering bodies to define environmental engineering.

A basic definition of environmental engineering was given by Safferman et al, as follows:

> *The application of engineering and scientific principles to protect human health and the ecosystem* [3].

Reible provides a broader definition:

> *Engineering involves the application of fundamental scientific principles to the development and implementation of technologies needed to satisfy human needs. For environmental engineering, the body of knowledge whose application defines the discipline is environmental science, the goal of the discipline is satisfying present, and future human needs through protection of the environment* [4]

The Institution of Engineers Australia (IEAust) provided a more comprehensive definition:

> *Environmental engineering is concerned with water and waste water treatment and environmental management (including application of re-use and recycling), waste management (including eco-efficiency and cleaner production concepts, and life cycle assessment), surface and ground water system environmental management (including water quality management), contaminated land assessment and remediation, natural resource management, environment protection, management and pollution control, environmental management system design (including environmental management planning and auditing), environmental impact assessment and environmental management planning, environmental information systems, natural system accounting (including economic evaluation), social impact analysis, community consultation and dispute resolution, sustainable energy planning and design, greenhouse gas mitigation and management, environmental risk assessment and management, and environmental policy formulation* [5].

THE RELATIONSHIP BETWEEN ENVIRONMENTAL ENGINEERS AND OTHER PROFESSIONS

It has been asserted that environmental engineers are a hybrid of an engineer and a scientist, thus making them the best profession to deal with environmental issues and problems. Indeed, this view is well illustrated by Reible, where he forms a relationship and the connection of environmental engineers with other professions working within the technical, societal and economic constraints [4].

Therefore, the work of an environmental engineer requires comprehensive knowledge and understanding from both engineering (e.g. chemical, civil, materials, mechanical) and science (e.g. biology, chemistry, environmental science). This just emphasises the broadness of this field. This multidisciplinary requirement may be viewed as a serious problem in the environmental engineering profession, as those engineers may be expected to acquire and display similar knowledge and experience as that of practising engineers from other fields namely, chemical, civil and mechanical engineering, as well as be knowledgeable about science [4].

THE EVOLUTION AND HISTORY OF ENVIRONMENTAL ENGINEERING

A series of environmental engineering education conferences was held at various universities between the 1960s and 1980s. The very first conference was held at Harvard University in the USA, to mark the importance of this new engineering discipline and to open up discussions concerning it. This *new* discipline was known at the time as *sanitary engineering* and, by 1973, this term was officially changed and renamed, *environmental engineering*.

The name and scope of environmental engineering has changed dramatically since its first inception. It has evolved over time from sanitary engineering, which deals mainly with the treatment of water and sewage. Sanitary and public health engineering initially was an area of practice for civil engineers. It was then changed to public health engineering and, as the problems grew wider, spreading to other parts of the environment. It was later changed to environmental engineering. The change of name was necessary to recognise the rapid evolution of undergraduate programmes in environmental engineering and also due to the broadening of the scope of the underlying field [6].

The adverse effects of environmental pollution on human health, when first identified were found to be linked to water-borne pollutants. Civil engineers during this period were the professionals responsible for building sewers and public waterworks to improve the sanitation and hygiene of those cities affected by the spread of these water pollutants. The practice of this area was then called sanitary engineering, and it is more commonly known today as water quality engineering [6]. Due to the early work performed by civil engineers in sanitation, the study area of sanitary engineering still remains a strong part of civil engineering education and programmes. The environmental engineering profession and discipline were basically non-existent in the past and, therefore, civil engineers assumed the role of environmental engineers.

In the early 20th Century, air pollution from combustion processes and the production of chemical smog became a major concern, which resulted in the increased involvement of other engineering professions, particularly chemical and mechanical, to tackle air quality problems. During this period, a few institutions began establishing and offering programmes in air pollution control in chemical engineering departments [6].

As concerns over air pollution, industrial wastes and solid waste grew, chemical engineers and mechanical engineers began to play a more important role in environmental engineering [7]. At the end of the 1980s, much of the education and employment in environmental engineering was expanded to incorporate soil and groundwater remediation, toxicology, risk assessment, atmospheric modelling and process design [7].

The scope of environmental engineering has since evolved and expanded to cover all facets of the environment, including air, soil, land, water and humans because of the increasing spread of environmental problems, public concern about the environment and environmental legislation.

The required areas of knowledge in environmental engineering have been subjected to periodic modification (mostly expansion) because of the increasing intensity and diversity of human activities. Civil and sanitary engineers were the pioneers of environmental engineering when environmental quality concerns were limited to safe water supplies, wastewater disposal and land drainage. Formal sanitary engineering curricula were introduced as postgraduate programmes to include public health engineering, water and wastewater treatment as the primary courses, which were recommended to be taken by all graduates [8].

Environmental engineering is said to be different from other classical branches of engineering because it is more broadly defined and multi-disciplinary in nature, as it touches on issues across other branches of study ranging from science, arts, mathematics and engineering. This broadness explains why there is such a wide variation between the programmes of study. To overcome this problem of the diverse nature of environmental engineering, it would be much simpler to harmonise environmental engineering education and develop a common curriculum in environmental engineering. Environmental engineering involves assessing, managing, preventing and controlling the impact of human activities on the environment. The environment is basically defined as our surroundings consisting of air, land, water,

humans, and all non-living and living things. Further, it entails the planning and designing of systems, equipment and technology for the management and protection of the environment. This requires that the environment be given top priority in any decision-making processes.

ENVIRONMENTAL ENGINEERING SPECIALTIES

It would be fair to say that the scope of environmental engineering education in the past was more narrowly defined and the curricula appeared to be more compact, whereas the scope of environmental engineering today is much more diverse and broad.

Some of the common environmental engineering specialties, as expressed by representatives from academia, the government and industry in a study conducted in the USA, include:

- Wastewater, storm water and water treatment;
- Solid waste management;
- Air pollution control;
- Hazardous waste remediation;
- Waste minimisation and pollution prevention;
- Risk assessment and safety engineering [3].

These specialties mentioned in the survey are commonly found in most environmental engineering programmes. However, since its inception, environmental engineering has expanded in scope, and it has become necessary to include issues such as sustainable development, recycling, cleaner production and Life Cycle Analysis (LCA) in the curricula.

SUSTAINABLE ENGINEERING

In addition to the exposure to some form of environmental education, engineers and, in particular environmental engineers of today, are pressured and encouraged to think and practise along this path of sustainable development, cleaner production, greener technology, ecological design, waste prevention and recycling, energy efficiency, resource conservation and environmental protection.

All of these are key topics in the future of engineering development and fall into this new study area of environmental engineering.

Environmental engineering, undoubtedly, is an important area, and will expand in the future as environmental problems worsen. If this is the likely scenario facing the planet, there will be a higher demand for more environmental specialists, namely, environmental engineers, to find solutions to environmental problems. Such achievements can come about only with proper education and training, and through a well-structured and designed curriculum for environmental engineering.

Specialists working in the field of environmental engineering can make a huge contribution to the overall engineering profession. Some of these benefits include:

- developing environmental technologies to solve environmental problems;
- improving the quality of life by conserving resources;
- improving efficiency for industry through recycling initiatives;
- raising the public image of engineers;
- contributing to global sustainability; and, finally,
- increasing the number of female engineers is also very important [9].

This, then, leads to the discussion of how environmental engineering could be the key to attracting more women to engineering courses.

WOMEN AND ENVIRONMENTAL ENGINEERING

As stated earlier, environmental engineering has evolved from sanitary engineering, which is a field predominantly found in civil engineering. Figure 1 shows the national enrolment of women in engineering courses in Australia (2001-2004). What is surprising about Figure 1 is that civil engineering programmes have not been particularly successful in attracting and retaining female students [10].

As highlighted in Figure 1, environmental engineering courses appear to be more successful in attracting female students as compared to the intake of female students for other classical engineering disciplines, such as mechanical and electrical engineering. Clearly, the fields of environmental engineering and chemical engineering are the preferred

choice among female students. As shown in Figure 1, approximately 40% of the enrolments in environmental and chemical engineering courses are women [10].

What is the reason behind this attraction? Perhaps environmental engineering is more appealing to women because it touches on the softer issues of engineering or *soft engineering* as opposed to *hard engineering*. As the statistics confirm, engineering is predominantly a male occupation. Hence, it is not surprising to find that about 80% of the students enrolled in engineering courses in Australia are men. Women, in the minority on these courses, will always have difficulties fitting into the male-dominated and oriented structure. Therefore, something should be done in order to remedy this situation.

There have been many discussions over the years among engineering educators, particularly female educators, on how to increase the proportion of women in engineering courses and make them more appealing to women. One option to consider is to integrate the environmental aspects into general engineering curricula. The challenge here, of course, is finding the availability of space in the already overcrowded engineering curricula.

Although the Australian national data have revealed that chemical engineering is a popular choice among females, the opposite finding, surprisingly, was reported in most countries of the European Union [11]. In Australia, of the five classical engineering fields, programmes in mechanical engineering appear to be the least appealing to female students, attracting less than 10% of the female population. On average, engineering course enrolments are about 20% female, which is a real reason for concern.

This reaffirms the statement made earlier in this paper about engineering being a male-oriented discipline. Similar findings also were reported in most countries of the EU. It was reported that females represent about 25% of the total number of enrolments in engineering courses [11]. This number is still very small in comparison with the number of women enrolling in science courses, especially in the humanities and the social sciences. It is clear that more work is needed to increase the participation of women in engineering.

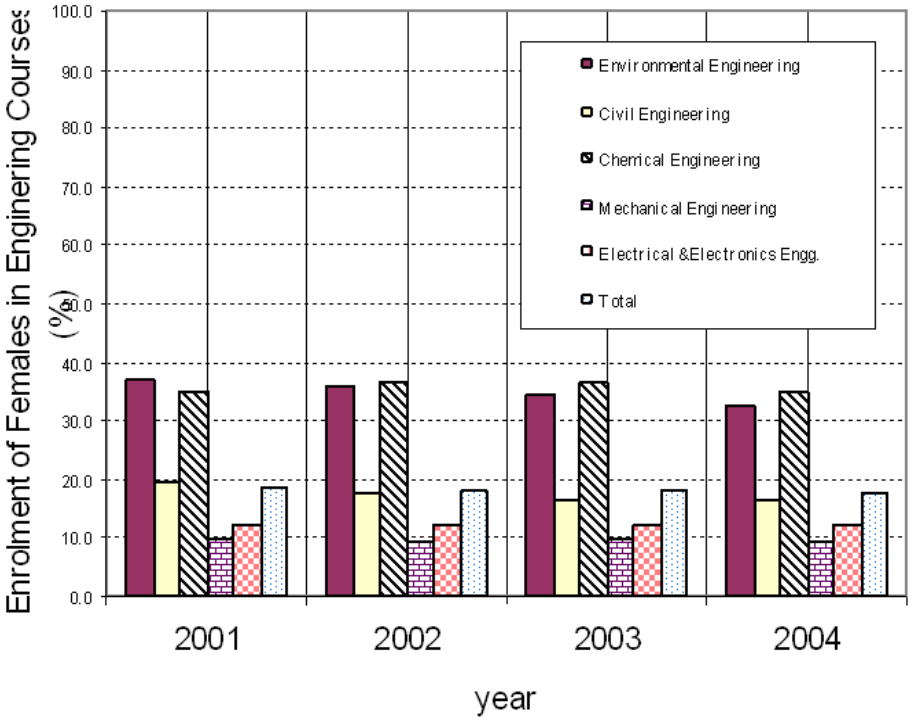

Figure 1: The national enrolment of women in engineering courses (2001-2004) [10].

CONCLUSIONS

The statistics gathered from a global survey of environmental experts illustrate just how fragile our planet is, and environmental issues continue to be a global concern.

Education is the key to solving global problems, contributing to global sustainability and achieving a better future for generation to come.

Engineers, particularly environmental engineers, are said to be the best profession to tackle the environmental problems, because they are seen as the cause of problems but also as the solution to environmental problems. There have been major debates about engineers needing to be educated about the environment, an area that has been overlooked in past engineering education. It has become clear that changes to existing curricula are urgently needed to include the

environment, its protection and sustainable development, as a part of the engineering curricula. It is of vital importance that the profession develops specialised programs in environmental engineering to create future environmental specialists; namely, environmental engineers, environmental scientists and environmental technologists equipped with necessary knowledge, skills and attitudes to solve environmental problems.

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