The environment in engineering education

Edited by
David Brancher

Studies
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education

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Preface

The Environment in Engineering Education responds to the need – felt equally in the industrialized and developing world – for broadening and renewing the educational experiences offered to men and women preparing for the engineering professions. It deals with what is perhaps the major aspect of their responsibility to society. As the ninth in the series 'Studies in Engineering Education' it reinforces and exemplifies the approach made in the second, *Social Sciences and Humanities in Engineering Education.* It shows how the ability to meet the environmental challenge depends on a thorough grounding in relevant aspects of the socio-humanistic disciplines. And it emphasizes that these insights must be integrated with technique and the real world of engineering, as part of the educational process, if they are to be of professional value.

In the present volume four basic aspects are discussed by the authors: the engineering of the work environment; the choice and implementation of appropriate technology; the education of specialists in environmental engineering; the aims of academic organization and the strategies which can be employed by decision-takers in higher education. The problems approached by the authors have been identified as matters of high priority by the International Working Group on the Environmental Education of Engineers. The group, created to advise the Director-General of Unesco, held its first session in Paris in 1975, its second in Caracas, Venezuela, in 1977, and its third in Paris in 1979.

Unesco is indebted to Dr David Brancher, editor of this work and author of the sections on academic organization and appropriate technology, and to the other authors, Professor Gideon Gerhardsson, Dr Hassan El-Baroudi, Dr Dev R. Sachdev and Professor Adel Hamouda. It expresses its thanks also to George McRobie, who convened the meeting of advisers in appropriate technology, and to Professor Richard Booth and Dr Dennis Else, who contributed the material for the case-study on the work environment.

All authors have expressed facts and ideas independency of the Organization and their opinions are not necessarily those of Unesco.

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Introduction

David Brancher

Any discussion of the environmental education of engineers is likely to be disrupted by an awkward question: What does environment mean? If engineers are supposed to be taught about it, what they should do with it and what they should protect it from, then we need to know what it really is.

This is a fair question – and a revealing one. Trying to answer it reveals that things and processes which represent environment to one engineer are part of the job itself to another kind of engineer. For example, a chemical engineer discharging waste material into a river (with or without damage – it makes no difference) is having an effect on the environment. Environmental education for him or her means learning something about the ecology of rivers.

To the water-resources engineer dealing with the river, the same discharge involves the setting and enforcing of effluent standards, monitoring results, maintaining summer flows and so on. It is the very centre of the job. But take the same water engineer to the national park where the river begins and you may find that he or she also needs environmental education. The damming of rivers, the raising of lake levels, and the construction of roads and buildings can have a profound effect on the quality of the landscape and its recreational potential. This field of environmental education, in turn, we find to be the central responsibility of yet another kind of engineer – the landscape architect. The boundary between professional function and environment is clearly relative. Where it seems to lie depends on what kind of engineer you are.

We can find a similar relativity along the dimension of time. Twenty or thirty years ago, in most developed countries, 'the work environment' was a concept of limited meaning for most mechanical and production engineers. In so far as problems were recognized they were seen as belonging to specialists in industrial medicine and a few other subjects. Now it is generally understood that the industrial work environment, at least in many respects, is something to be engineered; to be studied, created or improved, and monitored, largely by engineers. The boundary

between the engineer's role and the setting of that role has shifted. It has moved under the pressures of public concern and a greater awareness within industry of what constitutes a well-engineered work process.

We can see, then, that the definition of environment and environmental education is hampered by relativity. Where the environment begins is relative to engineering specialization and is changing in time. Perhaps more precision might be gained by a consideration of pollution, for surely the control and elimination of pollution are primary aims of environmentalism.

Pollution can be objective, as in the case of toxic chemicals. It can also be subjective, as in the case of landscape degradation. And it can be both objective and subjective, as in the problem of noise. Pollution can have direct effects on human beings, as in the case of drinking-water supply. Its effects can be indirect, where it is affecting fish stocks. It can be more or less dependent of ecosystems and it can make itself felt through symbiotic or parasitic interactions which only an expert can comprehend.

Pollution can be totally unacceptable and call for elimination at all costs, or it can require economic judgement in which the costs of this or that level of treatment are balanced against the gains and losses which would result from using money (i.e. resources) in some other way. The idea of pollution as the presence of matter or energy where it is unwanted, at first glance so simple, turns out to be of little use in definition, in environmental education as in engineering itself.

Nor is the idea of resource depletion any more helpful. One reason is that resources exist only to the extent that they are recognized. A national park has been depleted if bad management has caused it to provide less of the wilderness experience for which it was originally designated. The centre of a historic town can lose its capacity to offer the architectural experience for which it might have been conserved. In both cases, and of course in a multitude of others, the losses are subjective but nevertheless real and important.

But even physical resources, unquestionably objective and tangible, depend on perception. Their depletion is real to the extent that we know we have uses for them. It is less real to the extent that we know that substitution or the elimination of need can be arranged at reasonable cost (and 'reasonable cost' is itself a matter of perception). Resources, then, may be tangible, intangible, aesthetic and 'economic', They appear and disappear in the light of what we know and what we care about. They are cultural constructs.

If we find such difficulty in defining environment, how can we handle environmental education? Chasing this elusive and amorphous spirit through the forest, we may perhaps wonder if the pursuit of definition is worth while. It certainly is not worth while in the sense that we will ever be able to say that environmental education is concerned with this

and not with that. An absolute definition will always escape us, and for a very important reason.

Engineering is about creating wealth – that is, physical, social, and mental well-being – in the real world. It takes things from this real world, the environment of engineering, and puts them back with added value. Without this addition of value, engineering has no meaning. Engineering for the sake of engineering is not engineering at all; it never was. In this sense all engineering is 'about the environment'.

A systems view

Has the word 'environment' any use for us at all, then, in this time of debate and criticism? It has, in only one respect, which we take from the field of systems theory. For engineering – whether we regard it as a group of people, as a cluster of institutions, or as a body of knowledge and skills' – is itself a system. And, like all systems it has an environment – other people and their values and goals; other institutions; other knowledge and activities. It tries to be open; to take information from the changing environment. It tries to redefine its environment by extending its field of information and control. And where it cannot maintain its existing goals engineering must adapt by finding new goals and by reorganizing its internal structure to match them.

All three of these characteristics can be observed in engineering. And it is only by taking a systems view that we can find a concept of environment and environmental education which holds its validity through time and across the many specialisms and responsibilities in the engineering profession. The paradox is that by defining the environmental education of engineers in this way we are ruling out the permanent definition of engineering itself.

The major implications are matters of vision. In the future, if engineers are to meet the environmental challenge, they will need to look: (a) outwards as well as inwards; (b) to future generations as well as this; (c) to less obvious effects as well as the obvious; (d) to intangibles as well as to tangibles; (e) to immeasurables as well as to measurables; and (f) to true wealth as well as to narrow commercial gain.

The logic of this Introduction, as so far developed, sets the slim volume of papers an impossible task. It is tempting, as always, to try to condense and summarize all that might be said; to reduce the field of knowledge (in so far as the authors may comprehend it) to a series of lists and prescriptions. This would be a mistake, carrying with it the certainty of trivialization. It seems better to be selective and to focus more narrowly, using two criteria which appear apropriate. First, it is important that the subjects should have contemporary international significance, having regard to the role of Unesco in bringing together the

developed and developing nations. Second, because many readers will be senior decision-takers in higher education, it seems appropriate that the papers emphasize the strategic matters which are important in developing environmental education and the schools which offer it.

Earlier, while attempting to resolve the conceptual problem, we noted some systems-characteristics which can be observed in the engineering profession, as it adapts to new circumstances. We can use these characteristics now in introducing the four papers.

Wider boundaries

Ten or fifteen years ago it would have been unthinkable to include the concept of the work environment in a collection of papers on the environmental education of engineers. More recently, however, a new awareness has shown itself in government, among industrialists and trade-union leaders, and in the general public. It shows itself in the recognition that the industrial work environment can have chemical and physical characteristics which are injurious to health in both the long and the short term.

At the same time, and under the influence of bodies such as the World Health Organization and the International Labour Organisation, the idea of health has itself taken on a wider meaning. This meaning, perhaps better expressed as 'wealth' in the original definition, expresses a concern for the well-being of the worker as a whole person. It sees the working individual as not only breathing and hearing and manipulating and moving, but also as someone looking for purpose in work, and the chance of self-fulfilment.

In some ways the industrial work environment has improved in the one and a half centuries since the earlier-developing nations began large-scale industrialization. Although much remains to be done, and new processes pose new risks, a proportion of industrial work is now cleaner, less toxic, quieter and safer. Where this improvement has occured, much of the credit belongs to engineers.

But comparisons must be made, not with historic situations, but with current expectations. The industrial worker of a century ago lived in a tight, self-contained, and inward-looking community of people who could imagine no other form of employment (unless it was the even harsher life of the agricultural worker of those times). His leisure hours were few, and he lacked the money to make full use of them anyway.

Today the picture is different. Even in the later-developing countries most industrial workers have radios and some have television. The young have opportunities to travel and the transistor has united them in an international youth-culture whose values the older generation is slow to comprehend. At all ages the industrial worker of today has expecta-

tions and aspirations which were limited to only a few, even ten or twenty years ago.

When these aspirations are not met; when management cannot see even that they exist; when work is felt to be cramping and monotonous; when the physical environment is unhealthy and potentially dangerous, we have the conditions in which workers can be alienated from their work, their employers, and even from each other. Of course, it is the task of managers and trade-union leaders to avoid the development of such a situation and to deal with it where it already exists. But the key role lies with the expert specialist – engineer, industrial physician, ergonomist and so on, in giving advice to both sides so that they can become one side. In his chapter, Gideon Gerhardsson reviews the expertise necessary in understanding and improving the work environment.

The role of the engineer in this important and critical activity varies from one industry to another and from one field of knowledge to another. In some situations the engineer needs to know, indeed should know, as much as anyone. In others the centre of expertise lies with another profession, but the engineer needs to appreciate the problem and what can be done about it. It is unrealistic to think that engineering students can and should be required to learn to an even depth throughout the field of the work environment. Not only would this be wasteful overall, it would inevitably mean superficial learning where high competence was required.

With this in mind, Professor Gehardsson uses two categories or levels in describing areas of knowledge: 'appreciation', where a broad understanding is sufficient; and 'working', where the engineer has the responsibility for effective action. More important still, the chapter recognizes that, because of the wide span covered by engineering, the definition of the two levels of expertise must vary from one branch of engineering to another.

As elsewhere in the environmental education of engineers, motivation can present a problem. It is not that engineering students are not capable of being interested in environmental matters. It is, rather, that their perception of engineering and the engineer's role tends to be limited to a narrow stereotype. The challenge to teachers is that this perception has to be extended so that students recognize the breadth of their future responsibilities. The paper suggests some ways in which the educational problem can be handled and emphasizes, in particular, the special contribution which can be made by case studies.

New goals

Earlier in this Introduction we underlined the difficulty in fixing the limits of environmental education, particularly where engineers are concerned. If indeed all engineering is 'about the environment' then it fol-