

# **Social sciences and humanities in engineering education**

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# Social sciences and humanities in engineering education

**Case studies and papers from the International Seminar  
on the Role of Social Sciences and Humanities  
in Engineering Education (Bucharest, September 1972)**

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# Preface

*Social Sciences and Humanities in Engineering Education* deals with an obviously interdisciplinary and complex problem which is of widespread interest and indeed urgency in the Member States of Unesco.

The publication presents case studies and selected papers from the International Seminar on the Role of Social Sciences and Humanities in Engineering Education, convened by Unesco in Bucharest, Romania, from 5 to 8 September 1972, in pursuance of resolutions 3.22 and 2.23 approved by the General Conference at its sixteenth session. This seminar made special reference to a previous Unesco publication, *The Teaching of Social Sciences in Higher Technical Education—An International Survey*, published in French in 1967 and in English in 1968. That survey was carried out during 1964–66, thus the present volume may be regarded as a development of the survey, reflecting eight years' evolution of engineering education.

Engineering educators—both those concerned with the 'technical' and the 'liberal' stems of engineering education—members of higher-education faculties and officials responsible at the national level, as well as members of the education committees of professional engineering organizations, will find in these pages informative case histories which are drawn from a variety of countries and reflect different points of view. Unesco believes that the material presented will help to inspire research and further international co-operation in this field. Such research and co-operation are considered essential for the adequate planning and modernization of the content of engineering education in response to the changing needs of society.

After the background paper prepared by the Unesco Secretariat, three case studies are presented which were prepared as keynote papers by Getulio Kiyotomo Hanashiro, Professor of Sociology at the Latin American Faculty of Social Sciences (FLACSO), Santiago de Chile, Republic of Chile; Professor Roman Moldovan, member of the Academy of Social and Political Sciences of the Socialist Republic of Romania; and Professor Henry Knepler, chairman of the Humanities Department of the Illinois Institute of Technology, Chicago, United States of America.

Unesco wishes to express its gratitude to the authors of the case studies, who also participated in the Bucharest seminar, and especially to Professor Knepler who selected the papers for inclusion in this publication at the close of the seminar, in consultation with the Secretariat, and kindly co-operated with the Secretariat in the editorial preparation of the texts. The authors of the case studies have expressed facts and ideas in complete independence of the Organization, and their opinions are not necessarily those of Unesco.







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# Introduction

Henry Knepler

In 1967–68 Unesco published an international survey called *The Teaching of the Social Sciences in Higher Technical Education*. The present volume complements that study. It focuses on fewer countries and is intended to show the development and use of the social sciences as well as the humanities in engineering education by means of a few, selected cases rather than in the form of surveys. But while this study complements the earlier work, it also carries it forward considerably. Much has happened with respect to education and to technology in the nearly ten years that separate the beginning of the research for the previous volume from the publication of the present one. Higher education has gone through profound changes in these years, and technology has been affected by pervasive changes in the social and cultural climate in many parts of the world. The group of educators whom Unesco invited to Bucharest in September 1972, to discuss the role of the humanities and social sciences in engineering education, clearly felt both the urgency and importance of the subject—more, I am sure, than they would have ten years earlier.

This introduction has two purposes: it will attempt, first, to point to some of the key elements in the three papers which formed the basis of the Unesco seminar, as well as the short additional paper by Professor Minoru Tanaka, the only participant of the 1972 meeting who had been a member of the previous survey. Second, the seminar itself will be described and its discussions briefly summarized. Its results, as embodied in its recommendations, will be set against the background of some recent developments which throw some light on the future of the humanistic and social education of engineers.

One preliminary point may be worth making. A difficulty of international symposia often is simply the definition of terms to be used or rather, their lack of definition or definitiveness. What is classed, for example, as social science in one place may be seen as something entirely different in another. The meaning of humanistic and social science subjects, the fields or areas of study they encompass, or the academic disciplines they represent will, I hope, become clear in each case. As for engineering, I have tried, somewhat arbitrarily, to adjust the terminology. In descending order, there are: (a) licensed engineers (*ingénieurs diplômés*) referred to simply as 'engineers'; (b) engineering technologists (*ingénieurs technologues*), in Chile called *ingenieros de ejecución*, an intermediate rank not found, for example, in Japan; (c) technicians or technologists (*techniciens*) who, in some countries, are also trained in institutions of higher learning.



The three main papers represent, fortuitously and advantageously, three main components of our world today. In reading them one is aware, as so often, of the inadequacy of social, cultural and economic labels, but for better or worse, it is well to keep in mind that each of them represents a major division : the developing countries of the Third World, the socialist countries and the capitalist countries.

The profound changes which the Republic of Chile is undergoing are inevitably reflected in its educational system. The eight universities of Chile, seven of which are involved in engineering education, vary greatly from each other. They are autonomous institutions, whether private or governed by the State, and their programmes are the result of a historical development going back, in at least one case, to the middle of the eighteenth century. Yet—and that, too, is significant—six of the eight date from the twentieth century, with three of them founded since the Second World War.

Professor Hanashiro's paper is a clear, detailed survey of the development and present state of the programme in the humanities and social sciences in the engineering education of each of these universities. To summarize them is, perhaps, less useful than to seek out the general patterns that exist and the reasons that led to their development. Professor Hanashiro refers to student unrest, particularly at the country's main university, the University of Chile, in 1966. The reforms which resulted, at least in part, from such pressures led, above all, to more flexible curricula. Students were able, more so than before, to fashion course programmes according to their wishes. The number of compulsory subjects was reduced, several options were opened up in some cases, and some free choices allowed.

As far as the humanities and social sciences were concerned, the result was a considerable and rapid diversification. The amount of time allotted to these fields does not seem to have changed appreciably—it ranges from 4 to 12 per cent of total time, depending on the institution and the field of specialization in engineering—but the subjects taught, and the manner of teaching them, has undergone sometimes profound reform. A number of social science disciplines are very recent additions to the curriculum, taking their places by the side of—and at times replacing, in part—the traditional subjects, of which economics remains the most thoroughly entrenched and most widely taught.

Three of the universities—the University of Chile and the two technological universities—have departments of social science especially devoted to the teaching of engineering students. At the other universities the social science programmes are designed to educate specialists in their respective fields. Those departments and institutes are then expected to render services to other professional schools within the university or to admit students from them to their courses. Professor Hanashiro points out that, in practice, that does not work too well.

At the University of Chile, engineering is part of the Faculty of Physical Sciences and Mathematics, two of whose thirteen departments are the Centre for Humanistic Studies and the Department of Industry. The centre, which predates the student unrest of 1966, offers two obligatory courses, one in philosophy and the other in the social sciences, and optional ones in a



wider range of academic fields. The Department of Industry gives engineering degrees and combines the function of a department of industrial engineering with that of teaching some social science, mostly economics but also, since 1971, sociology.

The Technological University Federico Santa María established a Department of Human and Social Sciences in 1970, which does not give degrees but is designed to give courses for engineering departments in economics, administration (management) and psychology. It offers a large selection, heavily concentrated in economic and administrative subjects, but also including the teaching of some foreign languages.

The Technical University of the State (Universidad Técnica del Estado), finally, contains two social science departments, one for industrial engineers in the School of Civil Engineering, and the other for engineering technologists. Both are recent foundations: they were established in 1969. Both offer a number of courses, some of them compulsory. The first named department offers seminars limited to a maximum of twenty students, in contrast to frequent large lecture courses elsewhere. These are given at several levels and are greatly conditioned by the interests manifested by the students. The department serving the engineering technologists offers a more limited number of subjects, also in obligatory courses, not, however, as seminars but in classes with an average enrolment of sixty-five students.

What is being taught, and what happened to various plans and projects, as described by Professor Hanashiro, reflects certain realities. One such reality is that the social sciences, except for economics, are recent arrivals on the scene of engineering education and have to compete not only for space in the curriculum but also for recognition as expressed in the appointment of full-time professors, well-developed programmes and so on. Second, in a country undergoing social change, such as Chile, the social sciences can become an ideological and intellectual battleground. Engineers and engineering students are by and large less concerned with social change, especially rapid change, than students in some other fields. Professor Hanashiro notes that the social sciences were introduced and diversified at the urging of students, in many instances. At the same time he notes that, in some cases, engineering students seem to study them merely because they are obliged to. Part of this discrepancy is due to differences in students: the ones who urge the development of new programmes are not necessarily the ones who later take the courses. But that discrepancy is less significant, perhaps, than what is taught. Here I come to what is clearly Hanashiro's most emphatic observation, one to which I shall recur in the discussion of the Bucharest seminar itself: the social sciences and humanities need to concern themselves with those aspects of the education of the engineer, the Chilean engineer in this case, that relate his training, his future career and his interests most clearly to the major, current concerns of his society. Hanashiro characterizes those, in the case of Chile, as the problems of underdevelopment and of technological dependency. The main difficulty he finds with regard to this need is that, 'because of the conditions created by the present national circumstances, there is a tendency to approach the social science programme with a rather "committed" attitude, closely related to political positions'. In other words,



ideology and doctrine may determine choices of what is to be taught, and how, and may therefore cause partisan reaction as much as learning. Hanashiro cites the example of the University of Concepción where an extensive and elaborate social science programme, designed on ideological grounds, failed within a year owing to dissension and opposition. Its unified 'course for social consciousness' was intended to develop 'critical and unified learning, based on scientific experience which questions and overcomes wrong and deformed interpretations of reality'.

To sum up, Professor Hanashiro finds 'of the universities included in this report, less than half have satisfactory programmes' in the social sciences and humanities for their engineering students. He finds entrenched traditional organization which is hard to overcome. Yet he also finds extensive, recent development which indicates a major potential contribution of the humanities and social sciences to the education of engineers in Chile.

The Romanian contribution to the seminar consists of two papers, one by Professor Roman Moldovan, who served as chairman of the seminar, and the other by two of his colleagues. As in the case of Chile, we are involved here with a limited number of engineering schools; in contrast to Chile, they differ relatively little from each other, as central planning plays a greater role in their development. The papers are therefore able to give very detailed and lucid accounts of individual courses and course programmes which I shall not repeat except in briefest form. Like Chile, Romania recognizes three levels of engineering careers, distinguished not only by the length of their training but also by the amount of study required in the social sciences and humanities. The highest level of engineer has a larger requirement than the intermediate, not only in absolute but in percentage terms. Professor Moldovan, by counting 'applied' subjects, finds that 29 to 37 per cent of the engineering student's time is devoted to these non-technical subjects. His colleagues, using a more limited system of classification, arrive at 10.7 to 12.7 per cent. (This compares with a variation of 4 to 12 per cent in Chile, and a rough average of 17 or 18 per cent in the United States.)

The courses are in three categories: obligatory, optional and elective. There is no fixed, total programme, but requirements vary somewhat according to the different specializations. Three courses are uniformly obligatory: philosophy, political economy, and scientific socialism (political science). These are taken in the earlier years. In the later years follows work in other areas of the social sciences, in the organization and planning of industrial enterprises, and choices in industrial psychology, industrial sociology and methodology of science.

The methods by which these materials are taught are under constant review, as are the materials themselves, and there are processes, as described by Professor Moldovan, designed to keep the faculty up to date in a rapidly changing world, and to help them to hold the attention of their students. Lectures, seminars, debates and discussions, research projects, practical exercises, visual aids are all used when they promise to be effective. Professor Moldovan stresses the constant participation by industry in the teaching process, the ongoing exchange between industry and classroom, visits to plants and co-operative farms, etc.



The emphasis placed on the social role of the engineer pervades both Romanian presentations. The whole educational process of the social sciences as taught to engineers is designed to develop the theme of social roles : close links are made, not only between technological and economic problems, but other social problems as well. We find, for example, a Marxist-Leninist analysis of the economic relations of the capitalist countries, as well as a course in socialist economics which is not merely theory but is applied to the Romanian situation. The course in Marxist philosophy (dialectical materialism) introduces issues related to contemporary science and takes into consideration the social concerns of youth. There are also courses in determinism, epistemology, theory of knowledge and cybernetics. There are lectures and discussions which stress the social implications of scientific development, and the relations of science and ideology. In sum, philosophy is extensively taught. The distinction between the humanities and social sciences, carefully made in other cultures, is not a consideration in the Romanian programme. 'We are', the authors say, 'particularly concerned with the forming of a moral attitude in accord with the requirements of our society.'

The central instrument is the course in scientific socialism, a lecture and discussion course in the implications of scientific-technological change in capitalist society and its confrontation of citizen and system. The Third World is extensively discussed in the course 'to show the inevitable march of humanity towards progress and national liberation'. Another topic is the possible convergence of social systems caused by technology.

Professor Moldovan in his conclusion makes two points also made by others of entirely different social outlook : the social and humanistic education of the engineer needs to take his career and future role into account. General education which precedes his engineering training, even in the best *lycée* or the like, is therefore not enough. And, to be effective, this professional social and humanistic education needs to be given throughout the student's academic career, not just in its early stages.

The brief report on Japan by Professor Tanaka is interesting because his participation in the previous survey permits him a particular insight. His report, a summary rather than a detailed discussion, indicates that major changes are under way also in Japan. The report *Fundamental Concepts for the Reform of Higher Education*, issued by the Central Educational Council in 1963, envisages the creation of new engineering programmes to be concerned with the fields of public service and industrial management ; it foresees the necessity of devising programmes in engineering which combine the humanities, the social and natural sciences as joint bases for the technological education to be given. In 1970 the University Chartering Standards were amended, providing for a reduction in the amount of general education, but also a loosening of all required content which, in Professor Tanaka's opinion, provides new opportunities for programmes that intensify the association of the humanities and social sciences with the natural sciences and technology.

The Tokyo Institute of Technology offers what may be the most systematic advanced work in the humanities and social sciences for engineering students in Japan. In addition to general education in the first years of the programme,



it provides the opportunity for 'concurrent studies', advanced work with the possibility of some specialized research. This, incidentally, reflects the situation in Chile, where the most thorough work in the social sciences for engineers is also carried out, not at a general but a technological university, and of the United States, where institutes of technology were the first to diversify and extend the areas of non-technical subjects. At present, too, the Tokyo Institute of Technology seems to be the leader in the attempt to integrate the humanities and social sciences with the professional education of engineers: it is in the process of developing a department of social engineering.

The paper on the United States is hard to summarize because it is itself a summary. More than 200 universities, colleges and institutes offer educational programmes in engineering. The programmes and the institutions are not subject to any central control or direction: there is no national ministry of education, no national plan or recognition of schools and programmes. The wide range of possibilities for study—and for change—available in the United States therefore precludes the kind of generally applicable analysis that we have in the case of Romania or the detailed description we have in the case of Chile. Two brief case histories are included in the report, those of the Illinois and Massachusetts institutes of technology. They are given to exemplify the general development, and more particularly the changes that have begun to take place, and to show the extent of humanistic and social science education available to engineering students.

For historical reasons, all programmes leading to the first university degree (Bachelor of Arts or Bachelor of Science) in the United States have long contained a component called 'general education' which, in the case of engineering, has traditionally been devoted to humanistic and social science subjects. The struggle to obtain a share of the curriculum, to establish departments, employ professors, and develop programmes was therefore finished long ago. The report tries to recount, above all, what has happened in the last ten years to change the picture, and how these changes are beginning to manifest themselves.

The essential point of the United States development in the 1960s and early 1970s is the transformation of the basic concept of general education itself, and its replacement, in part, by the idea that the humanities and social sciences have basic functions in the professional, not merely the general, civic or cultural education of engineers. Various research projects and conferences by nationally constituted committees in those years concluded that the humanities and social sciences needed to be integrated into engineering education, not serve alongside it. The engineer of today and of the future has such a pervasive influence on the well-being of man, indeed on his survival and the survival of the earth as a viable place to live, that cultural and social factors need to form the bases of his professional judgement along with the traditional bases in the physical sciences and mathematics. The major research projects and conferences described in the United States report, it should be noted, combined engineers with humanists and social scientists. The results, far from showing antagonism between the two groups, produced a large consensus that engineering education needed basic reforms in its



humanistic and social components. The question was, of course, what subjects, what areas of study would be useful, and how they were to be taught. The major part of the report is devoted to brief descriptions of representative experiments in new courses and other educational programmes designed to achieve solutions to these questions, in particular the question of how these areas of study can genuinely be integrated into the bases of engineering education.

The seminar was held from 5 to 8 September 1972 at the impressive new Polytechnic Institute in Bucharest. To this observer, one of its important effects, one that is often not considered, was that the discussions did not, at any time, divide the participants along lines that some might expect to find: anyone listening to the discussions would have had considerable difficulty to determine who, among the participants, was an engineer and who a social scientist or humanist. In that respect the seminar bore out completely the experience of such projects in the United States as the Olmsted or Punderson reports, described later. The engineers, social scientists, or university administrators present differed on some issues, but not along professional lines.

Of course it can be said that participation in the seminar of itself meant that the participants were predisposed to accept the principle of a role for the social sciences and humanities in engineering education. While they would differ on the content of that role, the participants from socialist countries, like the Soviet Union and Romania, and from the United States and Japan, for example, agreed on the basic fact that these subjects were essential to engineering education.

Participants from Western European countries, on the other hand, reported that dominant opinion in the engineering profession, and in engineering education, was not yet generally convinced of that view, and continued, at least in many instances, to see the role of the engineer in purely technological-economic terms. It was in fact a Western European (not an engineer) who wished to modify a recommendation that humanistic and social subjects be in some manner made obligatory in engineering education.

If there was little debate as to the need for the humanities and social sciences, there was more discussion as to their purposes. Here a contrast should be noted, best represented by views expressed on behalf of Chile and the United States. It is the contrast between the technologically developed and the developing (or underdeveloped) societies. Professor Hanashiro repeatedly expressed the view that underdevelopment and technological dependency were the main problems to which engineering education needed to address itself. Social scientists should see their main purpose in assisting engineers to become conscious of and to cope with these twin issues. Opinion in the United States, on the other hand, is beginning to see certain dangers in the untrammelled development of technology. Here the social sciences are seen as a means to help to channel, to control technology, by making future engineers conscious of the vast social forces which technology puts at their command. Not only this seminar but other international forums show that some participants from Third World countries perceive attention to



ecological dangers on the part of developed societies as attempts to impede their own development.

Apart from that issue, which the seminar was of course not designed to resolve, the participants concerned themselves with ways to make students understand the magnitude and importance of the problems that the humanities and social sciences set before them. Here the seminar recognized a basic problem : engineers, by their choice of careers, indicate an inclination towards building something, towards the material and the specific. They have, as one large-scale study of engineering students put it a few years ago, 'a low tolerance of ambiguity'. Yet the issues with which the humanities and social sciences confront them are by their very nature ambiguous and open-ended. They complicate, even impede, specific solutions. The question of how to approach that basic dilemma, of how to reconcile the specifics of technology with human and social values, occupied much of the seminar's time. Two areas were discussed in particular : the training of teachers in the humanities and social sciences for engineering schools ; and the specific orientation of courses and other educational programmes.

As for the training of teachers, the experience of the Soviet Union, reinforced by some plans in Chile, is relevant. There suitable and interested graduates in engineering are given post-graduate work in the humanities or social sciences. Once that process is complete, it is hoped that as educators these graduates will be able to make their subjects explicit and relevant to engineering students. They should, in other words, be able to talk the same language. But not only that : the various social scientists trained in this way should of course also be able to select from within their fields those subjects and ideas that may be of particular importance to engineers.

As for the educational programmes themselves, the participants of the seminar expressed considerable interest in the various experiments that organized some of the educational experiences along project lines. It was felt that the usual system of courses organized according to fields of study is unlikely to be superseded totally. But some participants saw promise in new principles of organization which base themselves on setting up engineering problems for students to solve. These problems are not thought of as simply embodying small, specific issues and answers as in equations or laboratory experiments. On the contrary, they should be extensive and designed to lead the student to the utilization and application of several fields of knowledge. To solve them, the student should find it necessary to search for knowledge in a variety of fields and to experiment with a variety of approaches to solutions. He may work in teams with fellow students, some of whom may come from other fields of study than his own.

This basic problems approach parallels the real tasks of engineers more closely than subject-oriented courses, and is also likely to assist them in their professional work in another way : as the complexity of technology increases, engineers are more and more expected to co-operate with other experts with different backgrounds and training. They increasingly need an understanding of the *modus operandi* of other fields, in order to be able to work fruitfully themselves. In this regard Recommendation 9 is particularly relevant, which envisages 'the assignment of social scientists and humanistic scholars to