ENGINEERING EDUCATIONAL OBJECTIVES FOR SOCIAL DEVELOPMENT

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There is increasing evidence that, through technological innovation and application, engineers have been social revolutionaries with considerably more impact than self-professed revolutionaries (Kranzenburg 1969). Technology is part of the delicate fabric of human activity. The reinforcement of this fabric is a social goal deserving the highest professional commitment.

The ferment in the current social environment can hardly be avoided by engineers in either their personal or professional lives. Members of the profession cannot stand aside from the events of the day. They must respond positively to the challenge.

This paper provides a framework for defining educational objectives and experiences which will assist young men and women in meeting professional challenges and in the fulfillment of their aspirations.

Is engineering education relevant? There are ‘econs’ who contend that the world has already paid too high a price for the fruits of technology and lay much of the blame for this at the feet of the engineering profession. Their cure would be to halt nearly all of those human activities that modify the physical environment. This would clearly reduce the burden of educating engineers. Certainly, this is an extreme view held by a small minority of the environmentally concerned. However, as with all extreme views, there is some measure of truth in their contention. Indeed, the engineering profession has been quick to respond to the question of environmental issues and has publicly demonstrated a moderate level of social consciousness. There is, however, still a lingering doubt as to whether educators have done all they might in this sphere.

There have been many changes in engineering curricula, much restructuring, greater student choice in electives, increased requirements for courses in the humanities and social sciences. Have these changes in themselves done much to alter the way in which student engineers view themselves and the world around them? Are their values and intellectual skills those most needed to influence change positively? But most importantly do they contribute to the development of critical standards of their thought and action?

OBJECTIVES OF ENGINEERING EDUCATION

Christopherson (1967) in his book The Engineer and the University, arguing on behalf of professional education in the universities stated that “a subject to be worthy of study in a university must say something about nature, about man, about society, or about the means whereby societies are organized and maintained.” This is a fitting complement to the definition of engineering given by Lapp (1970): “a profession, responsible and accountable for man’s physical environment, its management and control.”

Is it possible then to be more specific about the objectives of an engineering education? Here one could argue from several different viewpoints: from the perspective of the university lecturer, the entity called the profession, the prospective employer, the student, the parents of students and society in general. It will be most instructive to focus on the viewpoint of the intended primary beneficiary, that is, the student. For most students the objective is preparation for a vocation. Indeed, this objective is common to nearly all university students and, when they speak of relevance, this is what they have in mind.

Unfortunately, the perception of the nature of the practice of engineering is likely to be poorly defined in the case of the freshman engineer. Furthermore, faculty members are often ill prepared to subsequently clarify the vocational role of the engineer. Perhaps this is just as well, since the one immutable characteristic of a technological society is change. However, worthy the matching of graduate capabilities with only the employers’ immediate manpower needs may be in the eyes of student and employer, it is a path leading only to premature professional obsolescence. Therefore, the challenge is to provide the opportunity for students to discover that it is a mastery of those fields of knowledge and of those intellectual skills which are of enduring value that is of highest priority. This is a difficult task and one to which we shall subsequently turn our attention.

What then are the fields of knowledge and intellectual skills which are of enduring value in professional and personal life? It is well to ponder Hutchins’s (1968) rule: “the benefits of education are indirect. The mind is not a receptacle; information is not education. Education is what
remains after the information has been forgotten. Ideas, methods and habits of mind are the radioactive deposit of education.”

Although Hutchins (1968) has, in another context, expressed disparaging thoughts about engineers and engineering, his penetrating insight into the world of the twenty-first century commands respect. One must agree that precious little information is retained from week to week, let alone one, two and five years after graduation. On the other hand, our ideas, methods and habits of mind are shaped from a lifetime of experience, of which attendance at university is but one.

The question then is; what ideas, what methods and what habits of mind are worthy of nurturing in university and how is it to be accomplished?

As a tentative proposition, the ideas should concern man, materials and energy. The order is not accidental. Engineering activity of whatever sort starts from a human need, however primitive or selfish this need may be. Engineering is for people, and it seems that the professional of the twenty-first century will have to have a much clearer notion of man-environment dynamics in the broadest sense. There is nothing new in the centrality of ideas on energy and materials to the education of the engineer. It is to the structuring of these ideas, so that students may discriminate between which ideas are important from those which are trivial, that more attention should be directed.

The methods and habits of mind which characterize the educated professional are systematic enquiry, critical analysis and rational decision making. The emphasis attached to design in current engineering curricula is welcome. There is a risk that such courses may come too late in the student’s program or that the student might conclude that such modes of enquiry are not relevant to a mastery of fluid mechanics or network analysis.

THE STUDENT AND THE VALUE SYSTEM

Perhaps it is naïve to hope that university education might do something to shape the character of the value system of its students. Indeed, many would argue that this is not the business of the university. Yet there are values of the university community, which, by osmosis, are passed on to students. Professors tend to overestimate the impact of formal educational experiences. Students generally contend that peer group associations are much more significant.

Value criteria tend to beplutonious — respect for truth, honesty, tolerance, faith, integrity, lack specificity and in many ways are akin to the kinds of characteristics adopted in science and engineering. But the more fact that there are no absolutes in these value criteria is important for professors and students to keep in mind. To recognize the diversity of value preferences by individuals and the propensity for their change with time and circumstances is a useful educational experience. That important decisions are sometimes made, even by engineers, on the basis of impulsive or expedient value criteria should be recognized.

Value indoctrination is clearly an unacceptable practice and antithetical to the idea of a university. What is required though is a learning environment which causes the student to think consciously of the nature of values and value models, first by thinking critically of the behavior of others in a historical or literary setting, or even in the current scene. Over time, the judicious introduction of curricular and extra-curricular situations involving decisions based upon several criteria will result in the laying of a tentative foundation for a personal value model. While the influence of faculty through example may be minimal, a sympathetic response to students caught in a value judgement dilemma is important. A dogmatic or authoritarian response, however tempting, should be suppressed in favor of a patient dialogue aimed at enabling the student to formulate his value criteria.

The point is that ideas, methods and habits of mind are not ends to be sought independently in separate parts of the curriculum. Rather, they should form a multidimensional matrix within the entire curriculum.

ACHIEVING THE OBJECTIVES

The conceptual framework has been outlined in very general terms. What are the means for achieving these goals? What activities, modes of learning, expression and thought deserve attention? The stress on student-centered learning leads to an acknowledgement at the outset that diversity of student cultural attitudes and intellectual aptitudes is a plus rather than a minus. This leads to the suggestion that a further shift from the passive to the active mode on the part of students is due. This implies acceptance of a diversity of methods for expressing activity. To be more explicit one might re-examine the purpose of lectures in student learning. Do they provide professor satisfaction with resultant student numbness? What are the alternatives? Self-paced instruction, programmed learning, tutorials, recitations, computer-assisted instruction, experimental and design laboratories, and independent study are educational technologies, each involving a larger share of student activity than the lecture. None is a panacea. Diversity of modes, however, is likely to lead to higher levels of learner satisfaction.

Curriculum structure is a particularly vexing matter. Structure implies some rigidity and if overdone can lead to undue conformity among graduates. Yet there is a certain structure to the main ideas, methods and habits of mind associated with engineering. The structure should be made more explicit through continuous feedback to relate current study to earlier learning activities. This is admittedly an extremely difficult task. However, the task would be made easier if the prescribed core courses were limited to about 60% of the total curriculum. The balance might then be divided equally between (i) electives from prescribed discipline fields and (ii) electives freely chosen from the university offerings.

The structure of the essential ideas, methods and habits of mind then could be made explicit within the 60% core. The design of the balance of the curriculum accordingly should become a student responsibility, based upon student-defined needs and objectives. An impractical proposition, academic colleagues are sure to chorus, but consider the potential advantages for students. Furthermore, it could have a salutary effect upon the quality of university teaching if the actual
The learning performance of students was compared with their objectives.

**LIBERALIZING THE CURRICULUM**

Consider the question of disciplinary balance in the curriculum. Much of the non-science or non-engineering component of current curricula is included as a gesture towards liberalization of learning. Yet it is not what the student studies that gives him a liberal education, but how he studies it, and the way it is taught. Engineering courses can be liberalizing, provided as Hutchins (1968) states, "bondage of any kind is excluded except bondage to the truth."

The disciplinary balance in the curriculum can reflect institutional commitment to liberalization. The Canadian Accreditation Board (CAB 1981) of the Canadian Council of Professional Engineers has developed, over a number of years, a set of criteria which are designed to be flexible enough to permit the expression of an institution's individual qualities and ideals. The criteria (Fig. 1) provide for a minimum of 2 years (in a 4-year degree program) of engineering sciences and design and synthesis. Of these 2 years, no less than 0.5 year should be in engineering science, and no less than 0.5 year should be design and synthesis. The criteria provide further for 0.5 year each in mathematical foundations, basic sciences, and in the combined areas of humanities, social science and administrative studies. Beyond the above minima there is a further 0.5 year in which to expand the foundations and provide for special courses, in the various branches of engineering.

The component of the curriculum devoted to the humanities and social sciences has been a vexing matter for engineering faculty in Canada as elsewhere. There is much to be said for ensuring that opportunities are available for students, and for encouraging them to seriously study some aspect of the humanities or social sciences. Students then can begin to formulate a better model of their own values and that of their profession against a broader frame of reference. The Canadian Accreditation Board recommends that such courses "deal with the central issues, methodologies and thought processes of the humanities and social sciences at a level which challenges the student" (CAB 1981).

The thrust of the CAB (1981) guideline is that students must be aware of the role of the professional engineer in society and the contribution engineering work makes.

**INTERPRETATION OF CAB CRITERIA**

**INTERPRETATION DES NORMES D’ACCREDITATION DU BCA**

![Diagram of CAB Criteria](image)

*Figure 1.* Canadian Accreditation Board Criteria (1981)
to the economic, social and cultural aspirations of society. CAB (1981) states that:

The foundations must be laid for an understanding of:
(a) the nature of the human and natural environment and the impact of technology on it;
(b) the functions and roles of individuals, organizations, business and governments in shaping our society and its values;
(c) the ethical and legal responsibilities, guidelines and constraints within which the profession functions.

Whether the young student will select those courses which address the topics at a level to challenge him is a question. This part of an engineer's education should be structured to ensure both depth and breadth, limited as time may be in a typical engineering curriculum.

The informal experience of university life provides untold benefits for many students. Here again, diversity of opportunity is important. Student government is important, but not all students can participate. Sport, the student engineering society, residence life, and creative arts are among other important extra-curricular activities, which release the mind at periodic intervals from the objective of acquiring a degree. Body, spirit and mind are liberated at least temporarily from the bondage of seeking a qualification for a lifetime of work.

CONCLUSIONS

What then is the model? The curriculum must be devised and learning objectives stated which develop the intellectual abilities and skills of comprehension, application, analysis, synthesis and evaluation. While the area of study must continue to center on man, materials and energy, students should embrace those ideas, methods and habits of mind which will carry them throughout their professional career.

It is not sufficient to state that there will be a course in thermodynamics, in fluid mechanics, or in sociology. One must consider whether each course is structured and learning activities designed so as to achieve the educational objectives.

The ability of graduate engineers to play their role in reinforcing the fabric of human activity through a sensitivity to the humanistic and social dimensions of their environment should be ensured.

Finally, the achievement of the objectives will require a strong commitment on the part of students and faculty alike. This may not be easy, particularly in times when universities may be called upon to meet perceived short-term needs as defined in the political arena. Engineering educators have the opportunity and indeed a responsibility to take a leadership role in ensuring that universities remain a place for free expression, experimentation and innovation in professional education.

REFERENCES