The Roles of Social Sciences in Engineering Education

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ABSTRACT

Engineering, particularly in India, is a very technical form of education, with very little emphasis on social science and liberal arts related subjects. It produces a large number of quality engineers from different institutions every year, who are highly capable of solving engineering problems in their chosen fields, but quite often find its difficult to effectively participate in the developmental activities in the country as they are unable to comprehend correctly the societal needs. The present society and the education system do not provide enough opportunities to explore nature and the society at large and thus quite often, the experts in various engineering fields become isolated and are unable to understand the real needs of the people. One option to bridge the gap is to introduce a few humanities, social sciences and ethics related courses in the engineering curricula. The paper discusses various possible methods to implement such a plan, evaluates them and concludes that at this point of time, the most appropriate solution would be to make these topics in-built into the engineering subjects. However, in order to implement this, the engineering professionals must get convinced about the need and the initiative should come from them.

Keywords: Education, Social Sciences, Humanities, Engineering

INTRODUCTION

Technical education is instrumental in making tremendous contributions to the economic and social growth of a country. It helps in producing quality engineers who can understand a problem, generate appropriate solution, implement the project and maintain and evaluate performance. This is more important in a developing country such as India, which faces gigantic problems and scarce financial resources. India has laid a great deal of emphasis on the development of appropriate quality of scientific and technical manpower to undertake the task of building the country, which is evident from the tremendous increase in the number of technical institutions in the recent times,

both at the government as well as private sector. However, with the opening up of the economy and the opportunities to compete globally, it has been understood that countries with higher and better levels of knowledge and skills will respond more effectively and promptly to the challenges and opportunities of globalization. Keeping in view the fact that there would be tremendous needs of qualified engineers during the fast developing stage of the country, efforts have been made not only to expand engineering education to create sufficient number of engineers but also to ensure that they are flexible, analytical, adaptable and multi-skilled through quality improvement programmes.

The technical education system in India can be broadly classified into three categories, namely, central funded, state government funded and self-financed institutions. It had been targeted that by the end of the eleventh plan, there would be 49 central universities, 15 Indian Institutes of Technologies (IITs), 30 National Institutes of Technologies (NITs), and 24 Indian Institutes of Information Technologies (IIITs). A large number of engineering institutions have come up in the private sector in the last two decades or so. The Government of India has also implemented Technical Quality Improvement Programme (TEQIP), with the assistance of the World Bank, to improve the quality of education and enhance the capabilities of the technical institutions. The reforms include faculty development, examination reforms, regular curriculum revision, with the focus on research and giving autonomy with accountability.

It is natural that questions be raised about the quality of education vis-à-vis the national needs and expectations in a fast-developing country like India. Not only is the actual learning and its relevance to the needs of the country important, but also equally important is the impacts that the engineering education has on the overall development of personality, thinking and sense of values in the graduates. Engineering students spend the most impressionable years of their lives in engineering institutions. Their perceptions of the national and societal developments and their roles in achieving them are initiated while they pursue their education. Quite often, the term development is misunderstood as economic development only and thus, the curricula are prepared mainly focusing on that aspect. However, after the initial phase of economic growth oriented development in India, the focus has now shifted towards *inclusive development* which includes *social development*, *development of the people* and *social mobilization.* It is therefore very important that the educational system meets this broader objective in today's world.

THE NEED OF SOCIAL SCIENCES IN ENGINEERING EDUCATION

Historically, the development of engineers with both a social vision and an instilled obligation to serve has not been a priority in engineering education. The technical focus attracted students who were serious and intelligent, but not necessarily interested

in human relations, social science, public affairs and cultural subjects. Engineering education meant providing students with analytical tools to understand problems and to create products and systems. The syllabi in the schools are usually quite heavy and the present system of school education does not provide enough opportunities to the students to explore science for the betterment of the society. The whole focus of the students is on doing well in the various nation-wide entrance examinations conducted for admitting students in professional programmes. Whatever spare time they get after attending school is usually spent on undergoing coaching for appearing for those entrance examinations. Such examinations test only the knowledge in the science subjects and English language and do not ask questions to test the level of awareness on human relations and the society at large. Thus, the students usually study these subjects just to score decent marks in the examination but do not feel the urge to go deeper to understand the concepts and their implications. The engineering discipline exploits fundamental sciences, namely, Physics, Chemistry and Mathematics to create practical applications for the society. Though the technical aspect of engineering has been covered reasonably well in Indian institutions, real education is much more than just technical knowledge. It should enable the professionals to have deeper understanding of their own roles and responsibilities towards the society and the environment. In many cases, the role of technical professionals remains peripheral in

formulation and implementation of policies for developmental activities as a vast majority of them have poor understanding of social, political and economic issues and thus are unable to relate themselves to the real needs of the society.

The question of how to educate engineers about the social implications and ethical issues of their work is a perplexing one. When the students are not challenged to think about the social, political and environmental influences and consequences of technology, implicit boundaries are generated within their minds that are not easily crossed in their professional practice. This may be attributed both to the syllabi and the quality of teaching at the school level. The teaching is aimed more on completing the syllabi and less on the learning of the students. The syllabi of the Science subjects cover a large number of topics and there is not enough time to learn on the relationships among the subjects and also the human side of sciences. If one goal of the profession is to serve society, then such boundaries can prove as significant obstacles. Thus, it is felt that a study of the social sciences can be of great help in providing engineers with a broader perspective and understanding of themselves and human behaviour. This knowledge can enable them to have a better appreciation of social processes and how they can contribute more effectively to the betterment of society. Essentially, the aim of engineering education is to inculcate in the students a vision that enables them to connect social and ethical responsibility so as to best serve the society. While the

aim of any education is ultimately to serve the society, it is particularly applicable for professional educations such as engineering and medicine as their services impact the society directly and almost instantly.

Even though the importance of social sciences in engineering education had been recognized in the developed countries long ago, in India, it has been understood quite late. There has been a realization to broaden the education of engineering and thus prepare them to serve the society with an awareness and sensitivity of the cultural, political, economic and social dimensions of their work. If engineering is to be practiced as a profession, and not just a social craft, engineering must learn to harmonize the natural sciences with human values and social organization (Wenk, 1996). In a sharp contrast to the attitudes and practices that prevailed earlier, engineers today are required to design sustainable systems, keeping in mind, the environmental impact of their manufacturing and use, their accessibility to people of diverse ethnicity and physical abilities, their safety and their recyclability. A number of instances from the recent past showcase how technical and socio-political issues are intertwined with each other. The question of reducing Delhi's environmental pollution was not just about replacing diesel with CNG but also the livelihood of the auto-rickshaw drivers and their capability to invest for incorporating the change. Similarly, the construction of a motor-vehicle plant had to be shifted from West Bengal to Gujarat was not due to some problems related to engineering, but the

social problem caused by the acquisition of land from the farmers. Both these cases underline the fact that if the planners and engineers would have considered the possible social impact of these projects, they could have incorporated appropriate measures during the planning stage itself. There are many such instances where social issues have overpowered the implementation of engineering projects taken up for the development of different regions. Thus, the solutions to many problems require not just a deep understanding of technology, but also the requirements of the society.

The society is increasingly getting into a technological world and the natural world almost does not exist particularly for those who live in urban areas. Even the rural society is getting more dependent on technology. Thus, very often human beings do not get the opportunity to adapt themselves to nature and to try to get adjusted to the technical world that surrounds them. Even the school education system in India does not provide any opportunity to the students to explore nature or the society at large. A logical consequence of such a situation is the isolation of the individuals and the creation of experts in narrow fields of specialization. However, there is no guarantee that the people who are experts will really make correct or optimal decisions which will be beneficial to the society. It would not be possible to take into consideration all the conflicting or otherwise aspects while making a decision.

Similarly, community participation has been recognized as very important

for the sustainability of any infrastructure or service. Thus, for taking a pragmatic view of a problem, engineers need to learn how to interact with the community and understand their needs and aspirations. However, the situation was quite different in the earlier days when the engineers were more attached to the society and understood the culture of the day. This may be observed by visiting historical places that in earlier days, human settlements, temples, forts, cemeteries were designed and constructed with defining elements of every civilization. The engineers and builders in those days were able to understand all the consequences of their projects. It came naturally to them as they were close to nature and the society. The present Indian society, particularly the urban population, is almost detached from the nature and the lifestyle makes it even more difficult to understand the society at large. Hence, the social responsibility does not come naturally in most cases. Even in schools and professional degree programmes, the students mainly get the opportunity to interact with a class of population and the academic loads, peer pressure and high expectations from the parents do not leave them with time to understand the society and the societal needs and responsibilities. This gives a strong justification for the introduction of a few courses related to social sciences and ethics in the professional degree programmes.

CONNECTING THE TECHNICAL TO THE SOCIAL NEEDS

While it has been widely accepted that there is a need to connect technical education to the social and ethical values, the difficulty, however, is in the implementation. It is necessary to change the culture so that engineering professionals understand the need and the importance of non-technical courses. In the actual curriculum planning, social sciences are considered relatively unimportant in the education of technical intelligentsia. One way to achieve the connections between the two is increasing liberal arts contents and spreading it out over the four years of the curriculum. Some of the universities in USA have engineering courses that provide students a theoretical framework and a historical perspective for ethical engineering practice, which is certainly crucial in developing engineers, who can ethically address broader considerations in practice. Keeping in view the importance of connection to engineering education, Wenk (1996) suggested that upper division technical courses be redirected toward problem orientations rather than discipline perspectives by taking a "top-down" or "case study" approach. Meanwhile, Bordogna *et al*. (1993) suggested that engineering problems should also emphasize on lateral thinking, experimental learning, integration-connecting the parts, correlating chaos, handling ambiguity, the design and manufacturing process, the formulation of problems, the implementation of ideas team work, social context, and above

all, recognition and incorporation of design as the final core of engineering. While integrating various aspects, the need of the people must be understood clearly and the concept of participatory planning must be taken into consideration, which is only possible if the engineers have the understanding of social issues. Unfortunately, an academic programme is still evaluated based on the courses taken by students, rather than assessing the outcomes of teaching in terms of technical knowledge and understanding societal needs and priorities. The institutes/ universities should try to show that students know the material they have studied rather than a list of courses and credit hours the students have taken. In particular, engineering programmes must demonstrate that besides the knowledge of core disciplines, their graduates have an understanding of professional and ethical responsibilities. The students should be able to understand the impacts of engineering solution in a global and societal context and must be able to take into account economic, environmental, sustainability, manufacturability, ethical, health, safety and other social and political considerations into their designs. Accordingly, engineering programmes need to be evaluated and efforts must be made to reorient them for meeting societal objectives.

In an average engineering college, the amount of time a student spends in learning applied sciences make it almost impossible for him/her to study the most fundamental ideas and the problems of humanities or social sciences. The present four-year engineering degree course teaches the student a great deal about technicalities of his/ her field, but very little about society. A study conducted in 2002 (Sarkar & Das, 2002) showed that the percentage of humanities and social sciences related subjects in premier engineering institutions such as Indian Institute of Technology varies between 6.74 and 10.06, which is low as compared to those of the universities in the USA where the percentage is about 20%. In order to mitigate this problem, a new approach was introduced in McMaster University in Canada by introducing a five-year engineering and society degree programmes which makes the bridge between technology and society both broader and longer (Hudspith, 2001). The main objectives of the programme are: (1) to enable students to better understand the relationship between technology and society; (2) to enable students to better understand how technology/ engineering might better serve humanity, (3) to broaden the education of the students through courses taken outside of the engineering curriculum, (4) to develop the art of inquiry into socio-technical problems, and (5) to provide an opportunity to be a part of a community that takes the social responsibility of engineering seriously. However, such a model may not be suitable for a developing country like India at this point of time as professional education is considered as a means to improve economic condition and thus both the students and the parents are likely to oppose a move to increase the time duration of undergraduate programme

from four to five years. Moreover, even if the duration is increased by the All India Council for Technical Education (AICTE) and the University Grants Commission (UGC), the engineering disciplines would try to introduce more subjects from their own areas as in each field the knowledge is growing rapidly. Another method would be to develop a curriculum that has a deeper and more analytic treatment of social science than what is at present. Instead of offering various courses, the different branches of humanities like sociology, political science and economics may shed their traditional isolation from one another and provide the students with an integrated vision and framework through which they can get a comprehensive view and understand the society better.

STATUS OF SOCIAL SCIENCE RELATED SUBJECTS IN ENGINEERING CURRICULUM IN INDIA

Many questions have been raised in the recent times regarding the quality of engineering education in India. However, the concern is not unique to this country only. Worldwide, there is deep introspection about what the future courses of engineering education should be. In less developed countries, it is even more relevant because of the special socio-economic problems and severe resource constraints. While there is no denying the fact that the technical content in the curriculum in most of the engineering institutions in India is of world standard, the question maybe asked if the system is producing engineers with concern for the

society and with ethical values. On a wider sociological level, it has also been claimed that the need to develop as a balanced individual and to understand the impact of technology upon daily life requires a broader understanding of the social context in which engineering operates (Florman, 1997; Jelen, 1997; Ruprecht, 1997).

There is also a view that the knowledge instantiated within the humanities is necessary to the civic and moral development of students (Johnston *et al.,* 1988). In many countries, accreditation bodies have formulated requirements that are relevant for preparing students for social responsibility, even though the term itself is not always mentioned. For example the Accreditation Board for Engineering and Technology (ABET), USA accreditation criteria requires that engineering programs must demonstrate that the students receive the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context and attain an understanding of professional and ethical responsibility *(*Zandvoort, 2008).

A study conducted by Webb (2008) showed that the average proportion of humanities credits for the US universities surveyed was 22.86%, with a standard deviation of 3.82 as compared to 19.49% and a standard deviation of 1.98 in the Gulf countries. It has been suggested by the All India Council of Technical Education (AICTE) and the University Grants Commission (UGC) that the share of Humanities and Social Sciences related subjects should be around 8-10% in the

engineering curriculum (Mathur, 1994). It is quite evident that the component is very low in the curriculum of engineering courses in most of the Institutions/Universities in India. A study of a few well-known engineering institutions in the country showed that the components of Humanities and Social Science related subjects in the curriculum of Civil Engineering is quite low as shown in Table 1 (Sarkar & Dash, 2002). The situation is not different in other branches of engineering.

New developments are taking place at a fast rate in every discipline in engineering. There is already a perception among the academicians of different streams that more discipline-related courses need to be introduced so as to keep the students up-to-date with the new developments in the respective disciplines. Even though they may appreciate the need of humanities, social sciences and ethics in engineering curriculum often they feel that the knowledge of the recent developments in a discipline is more important and useful for the students. Thus, it would be difficult to introduce such

courses until and unless the teachers in the engineering disciplines get convinced about their needs and utility. They may argue that it is enough to train engineers in science, mathematics, engineering theory and practice, whereas ethics, morality and societal needs would be picked up by the students at home and the surroundings. It might have been true earlier, but is not applicable any more as the society and social structures have changed tremendously over the years.

Another justification is often put forward that in any engineering curriculum; there are always a few slots as free electives and students may take humanities related courses if they wish to. It is forgotten that the purpose is not that the students take a few courses of their choice, but to ensure that the courses are identified and the syllabi are developed in such a way that they form a package and become part and parcel of the engineering curriculum. The identification of the courses must come from the engineering fraternity, who through their experiences, would be the right person to

TABLE 1
The percentage of Humanities related courses in the course curriculum of Civil Engineering Programmes at a few selected Indian institutions

Name of Institutions	Percentage of compulsory HSS subjects	Percentage of maximum possible HSS subjects
Indian Institute of Technology Chennai	6.74	6.74
Indian Institute of Technology Guwahati	6.68	8.36
Indian Institute of Technology Kanpur	8.50	8.50
Indian Institute of Technology Kharagpur	7.55	10.06
Indian Institute of Technology Mumbai	5.37	8.95
Birla Institute of Technology and Science, Pilani	2.14	23.57

(After Sarkar & Dash, 2002)

know the components of Humanities and Social Science related subjects needed in an engineering curriculum to make a complete all-rounded engineer. For example, it is widely accepted now that professional ethics should be taught to the engineering students and this realization is a moderately recent phenomenon. Over the years, it has been appreciated that each profession should have its own code of ethics that enable members to gain trust and faith in each other, without which, they cannot function and hence, the need of the course has been realized and implemented.

POSSIBLE MODELS FOR A BALANCED CURRICULUM IN INDIA

Keeping in view the present needs of the country, it would be beneficial if the All India Council for Technical Education (AICTE) and the University Grants Commission (UGC) revisit the prescribed percentage of Humanities and Social Science related subjects in the engineering curriculum. This is more relevant in the present time as the inclusive growth and sustainable development have been recognized as two key factors for the overall development of the country. There is also a scope to increase the knowledge and awareness of the students regarding their country, society and its needs within the existing curriculum by introducing the concept of social training during summer and other holidays in collaborations with Non-Government Organizations (NGO) and local government institutions. This will help future engineers

to gain first-hand information about the problems of the people, their needs and expectations. Guest faculty from such NGOs could also share their practical experience in dealing with issues at these institutions. Therefore, it is suggested that within the present curriculum, a few elective courses may be earmarked for humanities related subjects and the students are given the option to choose from a pool of subjects.

In line with the experiences of Canada, another option is to offer longer duration under-graduate programmes with sufficient number of courses in history of Science and Technology, Social Sciences and professional ethics. To make it attractive, the students may then be allowed to graduate in two disciplines: engineering and society. This option would be difficult to implement as there would be legitimate resistance from the students and the guardians if the duration of the programme is increased. However, the most effective way would be to educate the teachers in the engineering subjects about the need of Social Science, environment and ethics related topics in the curriculum and then ask them to redesign their courses to incorporate these topics as far as possible. For example, the knowledge of economics and finance is quite important for an engineer, but in many institutions in India, it is not included in the curricula as suitable slots are not available. Therefore, the relevant topics are sometimes included in the core engineering subjects so that the students get exposure on the subject. It must be appreciated, particularly by the faculty members of engineering disciplines, that

Humanities and Science are not rivals to technical subjects, but are complementary to each other. In particular, Humanities will help engineers to look at the same problem from different point of views and this will help in coming up with sustainable solutions for the benefits of the society at large.

Another option would be to develop flexible education and training system that will provide a foundation for learning at the secondary and tertiary education and there will be a scope to develop required competencies through a lifelong learning process. This implies that if an interest in social sciences is awakened at the basic education stage, it can be kept alive through lifelong learning.

CONCLUSION

India, being a rapidly developing country, is in need to produce a large number of engineers that are not only technically sound but also concerned about the needs of our society. An engineer in today's world should be extremely sound in his technical education as well as fully aware of how his skills would be of use to nation building, factoring in societal, economical and ethical needs. Unfortunately Indian engineering students study in an environment where social science and ethics related subjects are given low preference, as evident from the small number of subjects a student needs to complete to graduate. This has led to a divide between what is taught in the classroom and how the same cannot always be implemented in society. Education is not just learning formulas and laws from textbooks. It is also about learning how to utilize those skills in the real world. Crucial steps have to be taken to help bridge the gap between engineering and humanities. One way is to increase the number of Social Science and ethical courses in engineering curriculum by making policy decisions at the AICTE and UGC levels. Another is to increase the duration of the degree programme and also to introduce more subjects related to humanities and ethics. However, this option would be difficult to implement as there would be legitimate resistance from the students and the guardians. The best possible solution at this point of time is to make the topics of Social Sciences and ethics in-built into the engineering subjects. Finally, it is essential to remember that whatever skills and knowledge an engineer acquires is only of true value when it can be used for the betterment of mankind, of the society and of the nation.

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