THE SOCIAL DIMENSION OF ENGINEERING EDUCATION IN THE GLOBALIZATION AGE

Abdel K. Mazher[1]

Abstract-*Technological advances have an enormous impact on our life. Engineering is no longer an isolated field of human activities. Its effect on social changes and human values is evident everywhere. Academic, industrial, and social institutions need to be restructured in order to meet today's competitive pressure and future challenges. Engineers have a special status in the globalization age and must be educated to face and solve new problems. The future role of engineering demands that social, ethical and cultural aspects be added to the technical dimension of engineering education. The next generation of engineers should have deeper concepts, wider views, more skills, and integrated tools to meet the challenges of the expanding spheres of knowledge and the challenges of globalization. Up till now the engineering education has focused on the technical dimension and neglected the social dimension. This paper suggests a reform of engineering curricula to integrate the social dimension into engineering education, utilizing engineering methods of research and training. A unifying approach, based on the system concepts is proposed to implement the suggested changes in engineering curricula. This approach combines the basic three tools of research into a dynamic whole tool that can be used by engineers to analyze the impact of globalization on social life.*

Index Terms- Globalization, Engineering Education, Curriculum reform, Social dimension.

1. INTRODUCTION

Advances in science, engineering and technology helped to solve many problems and at the same time created new problems for human beings. Engineers have developed high tech devices, equipment, and products that influence human life and behavior. Globalization, as a historical process of economic origin, nurtured by human innovation and technological progresses has profound implications on many levels. Globalization brought many issues and complicated human problems. Multinational and transnational corporations are integral components of globalization. The influences of these corporations on the word market produce a profound and abrupt shift in global economical, political and social systems. Many of these corporations employ engineers and uses high tech to influence the market.

Globalization intensified the problems that face the human life. These problems cover a wide spectrum of issues. Example of these issues are increasing the gap between north and the south; ecological, environmental and pollution problems; proliferation of weapons; exhausting the natural resources especially food, water and oil; global social injustice; human rights, democracy; and cultural diversity.

Problems of limited supply of food, water and energy create the issue of exhausting the natural resources. The implication may be in a form of wars to control water, oil, and food supplies with emphasis in producing more destructive weapons and pollution problems.

Engineers and scientists work to produce mass destructive weapons, which include nuclear, biological and chemical weapons. In addition to mass destructive weapons, advances in genetic engineering encourage the development of new weapons using discoveries in genetic engineering. This creates many ethical and social problems. Uncontrolled usage of cloning, genome research and application of RNA and DNA are other examples of health and ethical problems of engineering discoveries. Nuclear waste, radiation problem (from computer screen, mobile phones, and power lines, etc.) and the dangers of cancer are other examples of byproducts of advances in engineering and industries.

On the spiritual side the spreading of materialistic behavior is a dominating aspect of the human values. This is reflected in individualism. Many individuals focus on personal desires and materialistic consumption while neglecting social and family structure. Many individuals spend a large amount of time struggling and fighting for money to obtain the products of high tech. To enjoy the products of our high technical industries, many fellow humans focus on money and consumption. This has deep influence on the family structure. Drugs, violence, divorce are some problems. This will affect the social fabric and deepen our social problems. Social and ethical issues include

[1] *Aerospace Science Engineering Department, Tuskegee University, Tuskegee, AL 36088, (334) 727-8768, akmazher@tusk.edu*

the spread of poverty, violence, and inability of a large part of humans to benefit from the products of advanced engineering and technology. Human rights of equality and justice will not be fulfilled if the distribution of wealth, enjoying industrial products, and curing the related social diseases is not solved. In addition to that automation influences the job market and reduces the demand for more workers with the results of unemployment problems.

The advances of chemical industries have its side effects of chemical wastes and the spread of drugs between youth, which has destructive effects on the brain, the behavior and the economy of the country. Also, the engineering advances reached the movie industry that helped the spread of violence, individualism, egocentricity and increasing consumption of materialistic products. Advances in engineering and technology affect mass media too, which influences the opinions of people, their values, desires, motives and their role models. Mass media helps directing youth and children to focus on certain desires. Sellers of industrial and engineering products utilize mass media and the scientific discoveries in the psychology of the masses to convince masses to buy what they really do not need.

Engineering and technology must have a role to understand and solve the emerging problems and clarify the controversial issues. This can be achieved through engineering education. Integrating the social dimension in the curriculum is one step. The other step is to train engineers to understand and analyze the social problems and issues using engineering tools of research. This will help to have more deeper, wider and clearer picture of the social phenomena. In addition to that, enhancing the engineer ability in dealing with social issues will help to isolate the objective from the subjective and the relevant from the irrelevant.

2. GLOBALIZATION

Globalization is one of the most controversial issues of the present time. It is everywhere, in news media, in public speaking, on TV, on web-sites, in magazines, in specialized journals, in parliaments, and in corporate meeting halls. Extreme opponents charge it with impoverishing the world's poor, enriching the rich and devastating the environment, while fervent supporters see it as a high-speed elevator to universal peace and prosperity. What is Globalization? Amazingly, for so widely used a term, there does not appear to be any precise, widely agreed definition. Indeed the breadth of meanings attached to it seems to be increasing rather than narrowing over time, taking on cultural, political and other connotations in addition to the economic [1]. However, the most common or core sense is the economic globalization.

This aspect refers to the observation that in recent years a quickly rising share of economic activity in the world seems to be taking place between people who live in different countries, rather than in the same country. This growth in cross border economic activities takes various forms. People around the globe are more connected to each other than ever before. Information and money flow more quickly than ever. Goods and services produced in one part of the world are increasingly available in all parts of the world. International travel is more frequent. International communication is commonplace. This phenomenon has been titled "globalization." The age of Globalization is fast becoming the preferred term for describing the current times. Just as the Depression, the Cold War Era, and the Space Age are used to describe particular periods of history. Globalization describes the political, economic, and cultural atmosphere of today. While some people think of globalization as primarily a synonym for global business, it is much more than that. The same forces that allow businesses to operate as if national borders did not exist also allow social activists, labor organizers, journalists, academics, and many others to work on a global stage [2].

Americans tend to see globalization as somewhat more positive than negative and appear to be growing more familiar with the concept and more positive about it. A large majority favor moving with the process of globalization and only a small minority favors resisting it. Americans view globalization as a process of the world becoming increasingly interconnected. It is seen not only as an economic process, but also as one in which values are becoming more oriented to a global context and international institutions are playing a more central role [3].

There are many controversial issues associated with the globalization. Women rights, the dilemma of rich and poor or south and west, human rights, poor countries, third world vs. industrial worlds, environmental problems, natural resources, and culture diversities. These issues are the result of the complex interrelations between science, technology, engineering, and industry in one hand and the multinational/transnational corporations, economical and political systems of the world on the other hand.

This shows the strong links between globalization on one side and engineering and technology on the other side. Also, there are many emerging questions on the cultural and philosophical side of the globalization. Is corporate culture more powerful than national and international cultures? Is there a role of diversity in the globalization age? What are

the effects of modernization and post-modernization on different societies? What is the reality beyond the clash of civilization [4] and the end of the history [5]? Is there any role of engineering in this era?

3. RESTRUCTURING THE ENGINEERING EDUCATION

Engineering education, multinational/transnational corporations, economic and political systems are linked in the present day world. Engineering curriculum is related to the science policy of the countries. This in turn is influenced by the political and economical system of the countries. Engineers should be aware of this situation and should be prepared to understand the global picture of the influences of science and technology. To prepare engineers for the expanding market of globalization, reforming engineering education is suggested. This reform should propose a remedy for the deficiencies in the technical dimension of engineering curriculum and widen the understanding of engineers to assess the impact of technology on society. This requires a global approach to study social issues from the engineering perspective, and to suggest a unifying methodology to integrate the technical dimension and the social dimension into the engineering curriculum.

4. TECHNICAL DIMENSION OF ENGINEERING

Engineering mainly focuses on the analysis of processes and designing of systems, components, and devices that can be used to improve the working of existing processes or invent new artifacts [6] & [7]. Most engineering programs of education concentrate on creating engineers with narrow specialization without focusing on research training. The usual way of engineering education and research follows a segregation pattern, in which experiments, theoretical analysis and computational techniques are conducted as separate or segregated methods of research and education. In order to investigate and solve engineering problems researchers use these scientific tools separately. In this respect, engineers are trained to use only one of these methods in their engineering and science training. Engineering education for the next generation should direct students to master the basics of the scientific method in an integrated way. This requires proposing a unifying scheme to include the basics of measurements, visualization, computation, and theoretical analysis in the engineering courseware [8]. Also, the increasing interest in interdisciplinary programs should be crystallized in engineering curriculum.

5. SOCIAL DIMENSION OF ENGINEERING

The social dimension of engineering education should deal with the issues that relate engineering to human life, human health, social dysfunction, human rights, and cultural issues. Also, engineering education should prepare engineers to deal with the harmful byproducts of technology.

An engineering treatment of the social problems will reduce many of the controversial issues and isolate the roots of many issues. These roots can be explained using the scientific concepts of postulates, hypotheses and assumptions. Engineering studies of society is suggested through introducing a new field of social engineering.

Engineering methods can help to study the social phenomena in a systematic way and to investigate the impact of globalization on all aspects of human life. Training engineers to apply the scientific methods on social issues will help them to isolate the objective from subjective views. The total lab concept [8] was suggested as unifying scheme to restructure the technical dimension of engineering education. The same concept can be used as a unifying tool to integrate the social dimension and the technical dimension of engineering education.

6. SOCIAL ENGINEERING

Future engineering education must implement an element in engineering curriculum to discuss social issues from engineering perspectives and focus on the role of engineers in solving part of the harmful side effects of using engineering products. The total lab concept [8] can be extended to social studies. Sociological, economical and historical fields of humanities can utilize the basic formulation and concepts of the total lab concept to deal with and tackle problems in these subjects [9]. Social engineering is proposed as a new field of engineering, which utilizes the control theory methodology [10].

7. TOTAL LAB CONCEPT

The total lab concept relies on combining the three methods of scientific research to tackle problems efficiently. This concept uses 1) system approach for description, 2) modeling and control theory methodology for formulation, and 3) computer simulation for analysis, design and visualization. The total lab concept is of great importance in

training students to use theoretical, experimental and computational methods in an interactive and feedback fashion.

The system theory is a suitable tool in the process of curriculum restructure. Modeling and simulation is a suitable global methodology to investigate and solve problems. Systems approach and modeling methodology can be used to train students to work as team. A small group of engineers should have common background and each member should focus on one or two application areas. The total lab concept emphasizes the dynamic interaction of the three basic methods of scientific investigation to the problem formulation, analysis, and solution. It utilizes a general procedure for problem formulation using control theory methodology. It can be used to deal with different engineering phenomena, in many disciplines, as well as tackling problems of interdisciplinary nature. The social dimension can be implemented in engineering education by applying the total lab concept to analyze social phenomena.

8. TOWARD CURRICULUM REFORMATION

The engineering education is treated as a dynamic control process in which the basic elements of the curriculum are interacted in a feedback manner to achieve the planned outcome of the engineering education. Social dimension will be added in the form of social engineering to the engineering curriculum. Generally speaking a curriculum is a systematic plan to enhance leaning to achieve certain goals. Therefore, we will define curriculum, from systems viewpoint, as an interactive feedback dynamic process to enhance learning and to achieve specific goals. The main interacting elements of the curriculum are ***objectives***, ***content***, ***instruction techniques*** and ***evaluation methods.***

The ultimate goal is to produce an engineer that resembles an information processor with enhanced human natural intelligence in addition to artificial intelligence (AI). Information may come from engineering and social disciplines in form of reports, papers, books, information storage media, or from direct contact with the real world. An engineer should be able to use the fundamental tools of the scientific methods to process information and to reach results, and conclusions. Based on the above the following courses are suggested.

Laws of Nature and Nature of Laws

This course should cover the meaning, classification, usage and application of laws, hypotheses, postulates, rules and principles. The division of laws into fundamental and restricted laws is of crucial importance. The course should include the fundamental laws of engineering as well as social sciences. The course should give examples of roles of laws and rules in science, engineering and technology.

Data, Information and Knowledge

The goal of this course is to change students' skills from the skills related to information storage, to the skills related to information processing. Engineers should be able to differentiate between data, information and knowledge. Also, they should be able to know the differences between science, engineering and technology in their engineering disciplines. The course should enhance the students' skills to describe the nature and processes quantitatively and to train students to classify various engineering and social fields of study based on system approach. Information processing is the main focus of this course. Processing information include reduction, diffusion, induction, deduction, abstraction, theorizing, posing hypotheses and simplifying.

General Systems Theory

The goal of this course is to train students to formulate problems and describe phenomena using system concepts.

Modeling

The goal of this course is to train students to model different systems using fundamental concepts and methods of modeling. The course should train students to use laws to express the model in a mathematical form.

Computer Simulation

The goal of this course is to train students to simulate engineering and social phenomena using the available computer software. In addition to using canned computer software, students should be trained to write algorithms, computer codes and programs to model and simulate scientific and social problems.

Design of Experiments

This course should to train engineering students to design an experiment, to measure relevant quantities for modeling and to validate results of computer simulation. Student should be able to design an experiment to model components that are difficult to model mathematically and they should be able to validate the model theoretically, computationally and experimentally. Applied examples in this course should cover engineering and social dimensions.

Basics of Measurements

This course should train engineering students to use the basics of measurements in engineering and social fields.

Mathematics

This course emphasizes the use of mathematics in modeling social and engineering systems. In this regard, algebra, calculus, linear algebra and differential equations texts should be written and taught with engineering as well as social applications in mind. Mathematics should be the language used to express many engineering and social concepts and models.

9. EXPECTATIONS AND OBSTACLES

It is expected that applying the above ideas will produce engineers with capabilities, skills and tools that facilitate the tackling of different engineering problems. Systems approach and modeling methodology will enable engineers to formulate and solve problems of multidisciplinary nature. The flexibility of dealing with different problems is based on a deep understanding of the concept of laws, fundamental and restricted, and using these laws to transform problem into equations and statements. Computational methods, computer technology and visualization techniques will help engineers animate and visualize solutions for different situations and conditions using simulation technology. Experiment design skills will be of great importance in producing engineers, who will be able to measure, test and validate their findings. Despite that, there will be many obstacles facing implanting the total lab concept. The main one is the cost of this reformation. Many universities and colleges do not have the experimental facilities that can be used to teach most of the engineering courses that focus on combining theory, experiment and computer in a unifying approach. Another obstacle is the availability of instructors who are able to apply this concept in classrooms and labs. Other obstacles include writing courses, class materials and lab materials that apply the unified concept. In addition to that developing suitable methods to measure the performance of students' progress is a major issue. Writing of tests, exams and homework, which must be consistent with the concept, for evaluation procedures should be addressed.

10. CONCLUSIONS

This paper is the first phase of an ambitious project that intends to change the way of conducting teaching, research and research training, in engineering and social sciences. The ultimate goal of the paper is the curriculum development of engineering education to integrate the social dimension and to train students to use the basic tools of research as an integrated interactive tool to formulate, analyze and address solutions to social and engineering problems. Engineering education for the next generation should direct students to master the basics of the scientific method in an integrated way to deal with engineering as well as social phenomena. Hence, it is necessary in the 21st century to widen and deepen the role of engineers in our society. A consequence of that is the restructure of engineering curricula to reflect this view. This paper suggests that engineering curriculum reform will help to create engineers able to deal with the problems associated with globalization.

11. REFERENCES

[1] www.worldbank.org/globalization
[2] www.globalization.about.com
[3] www.americans-world.org/digest
[4] Samuel P. Huntington, The Clash of Civilization, and the remaking of World Order, Simon & Schuster, NY, 1996.
[5] Francis Fukuyama, The End of History and the Last Man, Free Press, NY, 1992.
[6] M. David Burghardt**,** *Introduction to the engineering profession***,** Harper Collins College Publishers, Second Edition, NY, 1995**.**
[7] Phillip C. Wankat and Frank S. Oreovicz, ***Teaching Engineering***, Mc-Graw Hill, Inc., NY, 1993.
[8] A. K. Mazher, ***The Total Lab Concept: An Integrated Approach to Unify the Technical Dimension of Engineering Education***, AIAA paper 2002-1053, 40th AIAA Aerospace Sciences Meeting & Exhibit , 14-17 Jan 2002, Reno, Nevada.
[9] A. K. Mazher, ***Toward A Unified Approach to Modeling and Computer Simulation of Social Systems***, Part I: Methodology of Model Construction, a ***refereed paper***, workshop on norms and institutions in multi-agent, Barcelona, Spain, June3-4, 2000. (**http://ccs.mit.edu/dell /aa2000/paper1.pdf)**
[10] A. K. Mazher, ***A Proposed Program of Social Engineering***, Part

I: Social Phenomena ***as Seen by an Aerospace Engineer***, paper submitted for publication.