Engineering Education to Consider Society in Systems Models

MARCEL JACQUES SIMONETTE[1]
LUCAS LAGO[2]
LUIS BARCO[1]
EDISON SPINA[1]
[1]Computer Engineer and Digital Systems Department
Engineering School - Universidade de São Paulo, São Paulo, Brazil.
[2]Software Solutions and Engineering Systems Section
Center for Information Technology, Automation and Mobility
Institute for Technological Research, São Paulo, Brazil.
marceljs@usp.br, llago@ipt.br, nuap@usp.br, spina@usp.br

***Abstract*:** Systems developed by engineers affect the society in several ways, and taking into consideration such effects in systems projects is a complex activity. In Brazil, engineering schools are not prepared to teach their students, neither to take this complexity into consideration nor to model the knowledge about the relationship between society and technology. We suggest the first steps to enable engineers to build system models that represent the necessary knowledge to deal with the effects of the systems created by engineering upon people and society in general.

Key-Words: systems engineering; system models; complexity; human factors; socio-technical systems.

1. Introduction

Systems developed by engineers are seen as triumphs of technique and technology, which bring to society products and processes never seen before. A large number of these systems have human and social interfaces that demand a series of conditions recognized by engineering, which has approaches and techniques to deal with human and social factors [1], [2], [3]. These approaches made and have been making successful projects. However, even considering the human factors, engineering tends to neglect the differences between human, social, and technical components. This is because of the reductionist features of the engineering processes and classical science, which eventually treat people and society as a constant in their models, or, in many cases, merely ignore the presence of human and social values within the treated problems. Jordan [4] argues that when a usability-based specification is being performed – a traditional approach of human factors – there is a tendency to consider the users as mere cognitive and ergonomic components of a system composed by user, product, and environment. This approach is a limited view of the people that interact with the systems, which dehumanizes this interaction.

We, human beings, have got personality, hope, fear, dreams, and aspirations, which affect the manner we interact with the systems. These human characteristics demand free actions, related to how we intend to use the systems, which not always correspond to the systems purpose [4], [5], [6].

Engineers are destined to create and maintain systems that affect society. However, their training in Brazilian universities and colleges brings up a serious consequence: people with interest in a system are considered as mere components of this system. This paper presents the first steps to a proposal for changing Brazilian engineering education; a way to prepare engineers to have a diversity of views about the same system, to build models that represent the necessary knowledge to deal with the relationship between society and technology within a humanistic dimension. It is a response to the complex activity of coping with the effects of the systems created by engineering upon people and society in general.

2. Problem Formulation – Complexity and orthodox science

The huge advancement of the classical way of facing obstacles have encountered and beaten an innumerous set of hard and intricate, however simple, problems. Simple problems do not mean easy problems. It just means that even the solution requires years of hard work, innumerous trials,

intuitive and tested models, reflections of trained minds, sophisticated experiments, and collaborations of several experienced and keen scientists, once that the path or even the input has been established, it is possible to foresee the output with reasonable hope. However, the challenges that our society is facing today are huge and diversified, and these challenges, such as the global warming, seem to confront the orthodox manners of science. The challenges of the 21st Century that our society is facing are complex, and deserve a new scientific look.

3. Problem Solution - Engineering Education

Engineering education is still subservient to the fragmented view of the orthodox scientific labor. This view prevents the complexity of considering the human beings that will interact with the systems from being rendered explicit into systems models.

To break the paradigm of the orthodox scientific labor, we believe in an evolution of manners of producing systems models that have humanistic dimensions, and we are working on Engineering Education to prepare the engineers to deal with the knowledge that is necessary to include humans and society in systems models.

3.1. Education

When someone talks about education, it is understood that there is a relationship between an individual, or a group of individuals, that bears knowledge versus those that, uninformed or/and non-competent, should get ready for hearing and learning. However, at the present time, people's natural reaction is much stronger and spontaneous in relation to cultural contents, which is full of signs, symbols, objects, and actions linked to human perceptual sensory world, and, mainly, everyday life, which involves states of being and doing for life and survival. Hence, the experience and increment of knowledge comes from the necessities of life and solutions of problems that are parts of the holistic condition of the human being. In contradiction, the universities have been prepared to be fragmentary. Hardly do universities have in their curricula the holistic and multidisciplinary knowledge, which characterizes the actions and forms of human expression.

To counterpoise the fragmentation of engineering education in Brazil, we defend the idea that not only the monologic discourse should be used in our universities, but that they also use the dialogic discourse, in order to foster the practices that allow the students to build the understanding of the issues through the interaction among themselves, and to find a better problem solution.

Our proposal considers that complexity performs a fundamental role in the construction of knowledge and meanings in a social way. It is a construction carried out through the interaction among people, which may lead to conflicts. However, this kind of education enables:

(i) to detect the conflicts, as we educate for the social, not only for the individual;

(ii) to solve the conflicts, as we educate under a holistic view, addressing beyond the reason, considering the subjectivity, the intuition, and the spirituality;

(iii) to prevent the emergency of the conflicts, as we educate with emotion, beyond reason.

3.2. Engineering

Engineering is the science and technique of civil constructions, fabrication of machines, and utilization of the nature resources for the benefit of man and his necessities. Kossiakoff and Sweet [7] state that engineering has concern towards efficiency. Hitchins [8] argues that classical engineering is linear and, in general, based on the Cartesian Reductionism. Engineering emphasizes functions, forms, structures, and architecture, aiming to achieve a whole equal to the sum of the parts.

During the 19th Century, engineering gained the structure of scientific discipline. That corresponds to a technological development in which the tools that had been used since the 13th Century were replaced step by step by machines, which during the 19th Century started to get linked to systems – electric systems, telegraph systems, railroad systems, and power transmission systems in factories. In its early days, engineering was understood as an application of the natural sciences knowledge; a view that keeps on mastering the theoretical reconstruction of technological sciences, at least until the end of World War II [9].

The postwar period, when the Systems Age starts [10], marks a new understanding of engineering. The systems start to demand that engineering should also have a human dimension. Auyang [11] argues that, when performing, the engineer needs to have knowledge about natural sciences, and understand both the human factors and the socio-economic factors to go beyond natural sciences in their mission of utility and services to society. Engineers

ISBN: 978-1-61804-266-8

cope with artifacts and people, making it possible to have harmony between nature and mankind.

Coping with conflicting situations, caused by the effects of the engineering-developed systems upon society is an engineer's constant task. As a path to deal with these conflicting situations, we turn back to the education of our engineers. We suggest changing the lens through which we see this education:

(i) replacing the opaque lens of knowledge acquisition by the translucent lens of understanding;

(ii) strongly decreasing the lighting upon "having", and insistently focusing upon "being";

(iii) not looking for the road to happiness, but finding the "be happy" as the true path.

4. Conclusion

Quite a few times, we have insisted that education can become the best of the solutions for the hardships of complexity upon the systems, and a tool to enable engineers to develop models that do not consider people and society as constants.

As engineering professors, our mission is to educate the engineers to minimize the harmful effects of the systems developed by them upon people and society in general. In this mission, we must transform the engineering schools in a place where we observe and talk about problems, and work to transform engineering into the source of creative solutions to disclose the necessity of considering the human and the social in systems models, as a way to deal with the relation between society and technology in a humanistic way.

Acknowledgement

This paper was supported in part by the Society and Technology Study Center (or, CEST – Centro de Estudos Sociedade e Tecnologia, in Portuguese) at Universidade de São Paulo.

References:

[1] Chapanis, A. *Human Factors in Systems Engineering* New York: John Wiley & Sons, 1996. 352p ISBN: 0471137820

[2] Nemeth, C.P. *Human Factors Methods for Design: Making Systems Human-centered*. Boca Raton: CRC Press. 2004. 392p. ISBN: 0415297982

[3] Sandom, C., *Human Factors for Engineers*. London: Institution of Electrical Engineers. 2004. 361p. ISBN: 0863413293

[4] Jordan, P., *Design Pleasure Products: An Introduction to the New Human Factors*, CRC, Boca Raton, 2002.

[5] Ackoff, R.; Emery, F., On Purposeful Systems: An Interdisciplinary Analysis of Individual and Social Behavior as a System of Purposeful Events. New Brunswick, NJ, *Aldine Transaction*, New Edition, 2005, ISBN: 978 0202307980

[6] Ottens, M.; Stubkjaer, E., A Socio-technical Analysis of the Cadastral System. In: Zevenbergen, J.; Frank, A.; Stubkjaer, E. *Real Property Transactions. Procedures, Transaction Costs and Models.* Amsterdam: IOP Press, 2008. ISBN 9781586035815

[7] Kossiakoff A.; Sweet W. N. *Systems Engineering Principles and Practice*. Hoboken: John Wiley & Sons Inc., 488p., 2003. ISBN 9780471234432

[8] Hitchins, D. K. *Systems Engineering: A 21st Century Systems Methodology*. Chichester: John Wiley & Sons, 2007. 528p. ISBN 9780470058565

[9] Poser, H., On Structural Differences between Science and Engineering. *Philosophy and Technology*, 1998, Vol. 4, Issue 2, pp. 81-93

[10] Ackoff, R., *Redesigning the Future: a Systems Approach to Societal Problems*. New York: John Wiley and Sons, 1974, ISBN: 978-0471002963

[11] Auyang, S.Y., *Engineering: An Endless Frontier*. Cambridge, Mass: Harvard University Press, 2006. ISBN: 9780674019782