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ECO-HUMANIST ORIENTATION OF ENGINEERING EDUCATION AND ENGINEERING ETHICS

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Abstract. *Keeping in mind the beliefs of our numerous contemporaries that we are living in a society of high technological, social and ecological risks, the authors point to both the positive and negative consequences of technical and technological development, and, in that context, the need for an eco-humanization of engineering education. The specific feature of the eco-humanist orientation lies exactly in its universality; it implies an attitude towards nature, man, work and, most of all, Life as a general value. Relating to this, an engineer's moral responsibility is coupled with such personal qualities as the ability of predicting more immediate and further consequences of one's activities, as well as the possession of such merits as prediction and risk prevention, self-control, a critical attitude towards one's own self, others, etc. Voluntary adherence to the moral requirements, related to an engineer's professional activities, assumes a developed belief in the need for such behavior, instead of the fear of possible punishment and condemnation by others. The building-up of engineering ethics and the moral responsibility as its backbone, assumes the need for a complex and holistic approach to the professional education of the engineers which is, in practice, contrary to traditional (pragmatic) education. Therefore, the authors of this paper think that it would not be pretentious to consider the reform of engineering education as the fundamental issue of the future, that is, as the most significant issue of the society's development without prejudice, political bias and outdated ways of thinking.*

Key Words: *Engineering, Eco-humanization of Education, Engineering Ethics, Sustainable Development*

INTRODUCTION

The late twentieth and early twenty-first centuries are marked by the development of science which is itself considered as the cause of the greatest quantitative and qualitative changes in history. To paraphrase F. Mayor, not at any moment has knowledge with its most rational forms in the shape of scientific findings stopped advancing and improving

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itself, and never has such an advancement been so rapid as in the twentieth century; neither was it so dizzy as in the last decades (F. Mayor, 1997:104). However, scientific findings have not always been in the service of progress. Consciously or unconsciously, some knowledge was used in a way that turned out to be destructive and it is still destroying man and his environment. Though risk is a lasting property of human existence, never in human history was it to such a threatening extent. That is why the contemporary epoch is marked as a "civilization of knowledge" as well as a "civilization of risk."

Accepting the thesis that contemporary civilization represents a civilization of knowledge and risk also means imposing the need to elaborate the ideas about some of the causes of risk generation, as well as the consideration of the issue of responsibility for its generation. In this context, it is necessary to point to the technical and technological development regarding preservation/jeopardy of life on Earth, and to the ethical codes of the professional groups very often accused of the generation of the "world society of risk," namely, engineers, as well as to the need to build their holistic, humanist and ecological view of the world.

ECOLOGICAL CRISIS, ENGINEERING AND ETHICS

The scientific studies of ecological issues have shown that industrial societies have based their development upon a powerful development of the production forces due to the development of science but, also, upon a wasteful attitude towards natural resources. It should be kept in mind that engineering has so far worked in the interest of human life, liberating it from a great deal of human labor while increasing the efficiency of all sorts of work efforts, and at the same time, improving the effectiveness with which communication needs are met. Yet, a rapid development of science has brought about an explosive development of engineering along with its dominant anthropocentric world view and an increasingly more profound disturbance of the ecological balance that is taking on planetary dimensions. Thus, scientific knowledge as well as the technological development based on it, have caused and are still causing the risks which are barely discernible yet cumulative, long lasting and with increasingly severe, and very often unpredictable, consequences; besides, they are also taking on a global character and a destructive potential from whose consequences even future generations will suffer (U. Bek, 2001:17-121). In fact, engineering and technology which are both the basis of the contemporary scientific-technological revolution, as well as the dominant world view that primarily stresses man as the master of nature and profit, can be regarded as the most important causes of the ecological crisis.

In numerous disputes about the role and importance of engineering and technology in contemporary civilization, two attitudes are dominant. *The first* one treats engineering as some alienating power that imposes itself, with respect to man, as a ruling force that enslaves him, turns him into a robot and deprives him of his sensibility, so that it is necessary to hinder its further growth (M. Weber, 1976). *The second attitude* claims that engineering is not a negative factor in itself and that it does not jeopardize the survival of man, that is, the "evil and danger that engineering really subjects man to are not comprised in the essence of this phenomenon as such (...); they rather spring from the nature of man where from they pass into his technical inventions so that, in their objectified form

and through their use, they reappear as a threat to humanity» (M. Pejčić, 1995:52).

We are witnessing the fact that contemporary engineering development has had great benefits for mankind. Mechanization, automation and computerization of the work process have lessened the danger of the violation of the human physical integrity, but despite it, man's psychic and moral integrity in his working environment has been increasingly disturbed. The application of chemicals in agricultural production has increased yield per acre; yet, the soil, the water systems, and the like have become, at the same time, polluted. Engineering really improves and enriches human life but it also endangers it. Man can produce, using the available engineering technologies, abundance for all human beings, but he can also destroy all life on the earth, including human. Regardless of the fact that science and engineering have, in their development so far, also exerted their negative influence, still, it does not mean that their future development should be hindered; on the contrary, their development should be encouraged for the sake of finding a solution for alleviating the present and avoiding all future risks. To renounce engineering means to return to ascetics, to an even greater hunger, poverty and desolation.

It is possible to avoid technological risks by creating a new, that is, an ecological world view. *The ecological worldview* is based upon perceiving inter-dependencies and inter-conditioning between nature and society as a subsystem of an otherwise unique system of "nature-society." Since it is necessary, for the survival of each system, to adjust the functioning among the elements in the subsystems as well as among the subsystems themselves, so is it indispensable, in this case, to bring into accord the development of mankind with the limits and possibilities of the biosphere, as well as to provide for the co-evolution of these two subsystems. The ecological view of the world determines man's attitude to nature as well as to other people, or in other words, in the most general terms, towards everything surrounding him. The major paradigm of this world view is the fact that people do not exist on the earth for their own sake. They are obliged, as the only conscious creatures, to perceive their place properly, as well as the role they play in the surrounding world, to respect all of the entities that exist independently of their will and fulfill a certain biosphere function. The existence of homeostasis in the "nature-society" system is possible only with the ethics whose basis is made up of a value system. The core of this system should be taken up by Life (not only of people but of all living beings), responsibility (before present and future generations) and prudence (in the sense of rational consumption of natural resources) (V. Miltojević, 2005:124-133). Ethics as a set of value judgments about what is good and bad, what is to be done or not and the like, aims at regulating human behavior, that is, human relationships (R. Lukić, 1982:103) while man is, as Sartre defines him, a completely free being made to face a highly ethic demand, namely, responsibility.

Keeping in mind the fact that man is a natural and social being, that his survival and life require two worlds, namely, the world of nature and the world he has himself created – the world of artifacts, ethics can at least be taken as tri-polar. In other words, it regulates the attitude of man to man, of man towards the world of artifacts and of man towards nature. As said before, the world of artifacts has been directed towards subduing the world of nature. At the time of that conquest, the demands faced by the engineers were related to the provision of a more comfortable and pleasant human life which, in its turn, demanded a greater expenditure of energy and raw materials. The need for energy was solved by the engineers first by the invention of the steam engine, followed by electricity and the inter-

nal combustion engine, as well as by the development of microelectronics and atomic energy. In their attempts to meet these demands, engineers have, in their own specific ways, contributed not only to the break of man's relation with nature but also to himself, which has, ultimately, caused numerous ecological problems. In the seventies of the last century, due to an increasingly more prominent manifestation of all the negative consequences of such actions, the need to conceive of a different place and role of man in the world surrounding him was pointed out; thus, the whole value system was re-questioned, including the ethics of the engineering profession, the prevailing model of social development and the overall education system.

However, engineering ethics is not only tri-polar. It is expressed through many relations, such as those towards objects and means of labor (engineering and technological procedures), members of their own profession, a work group which also includes members of other occupational groups, the organization of work in a company, business partners on the market (other companies and their representatives), society as a whole (namely, both towards its current economic and other problems and to the historical heritage and future expectations of its members), the natural environment and an attitude towards one's own self. Engineering ethics in the modern civilization assumes, on the one hand, a set of ethical principles an engineer is obliged to respect in his job (that is, what an engineer has to respect in view of the status and honor of his profession) and, on the other hand, the responsibility towards mankind especially under the conditions of the modern scientific-technical development. The acceptance of responsibility under the conditions of a disturbed ecological balance can be largely furthered by an ecological world view and its respective ecological ethics.

An engineer endowed with developed ecological ethics is obliged to avoid or to point, as a warning, to all bad effects that might be caused by some of the variants of the engineering task realization, or rather, he has to accept the idea that all that has been scientifically discovered is not at the same time socially acceptable for use. In this way, human engineering would oppose the realization of the "engineering systems which, by bringing profit, also bring about filth, that may also lead to the cruelest crimes performed in an especially organized way" (K. Stevanović Hedrih, 1995:99). Therefore, in the case of engineers, ethical responsibility appears in two phases, that is, in the phase of engineering creation and in the phase of engineering usage. Highly advanced ethical norms of this profession should protect both man's worlds (natural and artificial) as well as man himself without jeopardizing his mind and body.

An ecological world view and respective principles of ecological ethics are the prerequisite for the ecologization of technology, which means conducting production processes in tune with ecological environmental factors. The realization of these objectives (the creation of an ecological world view, the acceptance of ecological ethnic principles and the ecologization of technology), directly depend on the inclusion of the knowledge about ecological problems into the educational curricula and this with respect to the level and kind of education.

EDUCATION, ECO-HUMANIZATION AND ENGINEERING ETHICS

In the last decades of the twentieth century numerous theorists debated on the conception and program orientation of engineering education (P. Draker, J. Fourastie, Rihta, M. Pejčić and others), namely, they were debates initiated by rapid changes in the society, as well as the recognition of the enormous importance of engineering education and engineering staff in the future development of society. Regarding our research interest, we should, surely, mention the humanist critics who, in criticizing the concept of education that mostly characterized the industrial society ("education for work"), now stress the demand for the universal education of personality while, at the same time, they put a special emphasis on general education and humanist contents in the engineering education process.

Despite some criticism of this concept on the part of nihilists and other diverse groups of so-called "destructivists," it is beyond doubt that education plays an important role both in technical-technological and modern economic development, as well as in the wider social development. Hence, it does not come as a surprise that a major turn has taken place regarding the role and function of engineering education that is usually considered as related to the changes that took place under the general conditions of our society's development and, therefore, the changes in human living conditions. Thus, Fourastie stresses the need for "engineering polyvalence"; yet, he also believes that this in itself is not sufficient, that is, that education also assumes "general culture." Polyvalence and general culture, if "embodied in the values of the change" will, thanks to these values themselves, be "truly capable of sustaining modern mankind." Man has managed to step on the Moon but he has failed to avoid war, ecological catastrophes, and the like. Education, especially at the university level, should offer to the humanistic sciences, "those hopes of mankind," which in itself is best (J. Fourastie, 1973).

Formulated in a different way, yet similar in their essence, are the demands and messages sent by other theorists as well. The lack of humanist assumptions, morals and spiritual values turn science and technical knowledge into a "bottomless vessel." They are then not in the function of life, work, education and development. In fact, science and technology are then turned into life-denying forces annihilating the totality of human values. For an engineer's professional activities, the studies of occupational sciences are not enough. For the sake of the development of ethics, culture, an eco-humanist world view and life in general, it is necessary to have the contents of social, most of all, humanistic sciences. The humanist assumptions are man's inner nature. They are the basis of understanding "the fruits of justice and existence in freedom and in humanism, as the saving forces preventing the abuse of scientific and technical knowledge" (Ibid.). Without humanistic studies, there could be no qualitative changes of engineering education, without which engineers and other technical staff remain what they have been "made" by the traditional orientation in professional education.

In essence, the traditionalist (pragmatic) orientation in the engineers' professional education, has led and is still leading, contemporary civilization both to undreamt of heights, as well as to blind allies. The proof for this thesis is the growing crises and varieties of risks in society and nature. In view of the technical-technological risks for man, nature and the living environment in general, that is, the fateful nature of so many consequences of the risky undertakings and, on the other hand, a patronizing attitude of moral-

ity towards the needs of both individuals and society on the whole, today no one is still denying the responsibility and "jurisdiction" of ethics over the judgment of particular engineering actions, that is, their actions, decisions and plans in this sphere of human endeavor (M. Pejčić, 1998.). Therefore, the necessity of the ethical in technical activities springs from, most of all, the fact that it produces a set of existentially very "active" and "risky" outcomes in the working and living environment. Regarding the fact that engineering problems are almost always, at least partly, represented as moral ones as well, it has become clear that an engineer is obliged to add to his professional competence, which is otherwise needed for solving technical problems, what is regarded as *ethical preparation*, that is, an awareness of the existentially very important consequences of his work, as well as of his responsibility and the obligations resulting from it (Ibid.).

Consequently, it is necessary to change crucially cognitive orientations in current engineering education directed towards the creation of a new philosophy of nature, a new philosophy of man and human activities and a new philosophy of society. In the opinion of the paper's author, who is an expert in the field of upbringing and education, as well as problems of society and its development, what is at stake here does not refer to any Utopian projects, but to the real processes that represent a response to the demands and needs of the time in which we are living. At the same time, it is necessary to alter, only in principle, the very character, that is, the program orientation of the professional education of engineers. This does not only imply an introduction of special courses into the university engineering departments. Since these are complex problems which appear at the points of intersection of social, natural and technical knowledge, all courses should start from an analysis of ecological, ethical and other social problems of these spheres of activity, that is, from the consideration and implementation of new regulations, standards and requirements that lead to the harmonization and humanization of the relation between the developing society and the undergoing changes in the natural world.

Education must not be, first of all, regarded as or reduced only to specialist training, since today it is the very specialists whose work requires more than specialist knowledge (namely, wider, general-education, humanist knowledge). There is an objective need for the educational process not to produce only workers (engineers) but, at the same time, morally responsible participants in the professional world and social life in general. Surely, specialist knowledge in an engineers' professional education is indispensable, but modern standards (of safety, risk management, sustainable development) and international standards (ISO 9000, ISO 14000, OHSAS 18000 and the like) point to an increasingly more important need to integrate various aspects of a problem so that de-specialization can be freely said to have become a process of scientific development. Hence, in this direction and in that context, it is necessary to educate future engineers, especially when it comes to the formation of an ecological, humanist and morally responsible attitude towards nature, society and sustainable development of mankind in general.

In their academic education, students of technical departments should be provided with an opportunity to attend, over a short period of time, courses directed to the realization of the above described courses. Most surely, new knowledge, new ideas and concepts allied with the issues of technical-technological development and, thus, the issues of contemporary civilization, ask for a permanent improvement in teaching and maximal elasticity and flexibility instead of rigidity and stereotypes of the courses (V.Nikolić, 2004: 302-309).

In the international context, the general-education, social-humanist and especially ethical issues have been recently present at a great number of universities (such as Cornell University, the State University of Mississippi, Stanford University, Carnegie Mellon University, the Massachusetts Institute of Technology and others (W.T. Lynch, 1997/1998, p.28). In the USA, this program orientation is almost institutionalized in the Accreditation Board for Engineering and Technology (ABET) that determines the general engineering criteria (that is, the requirements of social-humanist and ethical character in addition to the narrow professional one); the same direction is taken by the National Science Foundation (NSF) and the National Endowment for the Humanities (NEH). The initial assumption is that an understanding of the ethical, social, economic and safety aspects of the engineering practice is essential for a successful engineering career. The 2000 Engineering Criteria also require that the engineering curricula should prove their students possess an understanding of their professional and ethical responsibility in the social and global context (Ibid.). What is implied in all the variants of these criteria is the fact that professional engineering education must comprise general-educational and ethical components that would comprise ecological, ethical, economic, health, safety, andragogic and other moments. Therefore, the emphasis is not only upon sociological and ethical but other humanistic disciplines. Fore example, at the Purdue University and the Massachusetts Institute of Technology, students may choose from the following academic subjects: history, ethics, engineering economic analysis and case studies, legal aspects of engineering practice, technology and values, engineering catastrophes, management, etc. (Ibid.).

Viewed in the national context, the courses with ethical contents as autonomous academic subjects are present in a small number of engineering faculties (the Technical Faculty "Mihajlo Pupin" in Zrenjanin, the University of Novi Sad); at the greatest number of university departments in Serbia and Montenegro, the subjects with sociological orientations are studied, while at the same time, there is a tendency to ecologize the university, namely, to introduce the disciplines referring to environmental protection and sustainable development and other diverse socio-humanistic sciences at a number of technical faculties, especially those of the University of Novi Sad (V. Nikolić, 2003).

The eco-humanization of engineering education, the realization of ethical codes and other criteria of the engineering profession, especially take on importance if consideration is taken of an increasing engagement of engineers in pedagogical-educational, teaching-scientific and information-instructive jobs and tasks regarding spreading and transmitting knowledge and experience (as well as moral-value attitudes, as V. N. adds) from different technical fields in school and outside-school forms of work with the young and adults. Especially evident is the problem referring to inadequate pedagogical-andragogic and psychological preparation for the realization of these forms of work. In undergraduate studies, no matter if the student has chosen some engineering curriculum as his basic academic or specialized professional studies, the curricula and syllabus should also include those academic courses that treat pedagogical-andragogic and methodical contents necessary for the organization, realization and evaluation of teaching-educational work.[1] In that

[1] Inadequate pedagogical-andragogical and didactic-methodical preparation of teachers (with an engineering profile) who teach professional disciplines in professional schools and are part of professional and academic studies, has a series of shortcomings and disadvantages both in teaching and outside-teaching work. This problem should be solved in a systematic way, primarily, by setting up the requirements for this kind of

sense, in our region, an especially developed teaching-educational practice is organized at the Technical Faculty "Mihajlo Pupin" in Zrenjanin of the University in Novi Sad and the Technical Faculty in Čačak of the University of Kragujevac. It is upon the pedagogical-andragogic and didactic preparation of these students and the narrow professionalism that the ultimate outcome of the educational process depends, including the realization of all the humanistic assumptions, requirements and criteria of the engineering profession that we have mentioned.

An engineer's professional activity is immediately related to the fate of nature, the living environment, man and contemporary civilization in general. The better the complex (professional and social-humanistic) quality and the more successful the teaching-scientific process of education and the more advanced the experts, the smaller the number of incorrigible losses, professional errors and risks in the working environment. Accordingly, in addition to the needed coordination, interdepartmental and interuniversity professional and scientific cooperation, the university must organize special conferences, congresses, meetings, seminars, etc. with a pre-determined agenda in order to stimulate the necessary contacts and, consequently, create the conditions for a permanent eco-humanization of engineering education within the global framework.

CONCLUSION

There is no doubt that the contemporary living and working conditions dictated by scientific-technological development impose the need for changes in the engineering education system, with the aim of enabling the young and adults to face creatively and in a morally responsible way the society of rapid changes, new discoveries, advantages and risks of technical-technological development. Regarding the fact that engineering problems, always emerge as moral ones as well, it becomes clear that it is necessary to add eco-humanistic subjects to the traditional (pragmatic) professional education of engineers and other technical staff and to develop an awareness about the existentially important consequences of their work, as well as responsibilities and obligations springing from it. Regarding the fact that general-educational, social-humanistic and especially ethical subjects are present at a great number of technical universities in the world, the results of this theoretical research point to the need for undertaking new research tasks of an empirical nature in order to study, in a systematic and in-depth way, the present state of the teaching-educational practice in our country, as well as to find ways and possibilities of implementing the contemporary demands, standards and criteria in our technical departments. Likewise, it is necessary to adjust them to the intentions and recommendations of the European Union in this field. In that sense, this paper should be understood as an in-

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teachers' education. Referring to the national system, the proposed University Education Act, founded upon the principles of the Bologna Declaration, brings about, in that sense, a set of new solutions in comparison with the present Act. The innovations lie in the fact that university education is realized through academic and professional studies, thus overcoming the division between high schools and faculties, in addition to connecting fundamental theoretical and professional education. Students are allowed to choose, in addition to the core group of narrow-professional courses, subjects from other disciplines (among others, those that enable them to do highly qualitative teaching-educational work). The flexibility of the curricula of the basic academic and professional studies opens up a set of possibilities for professional orientation, and thus qualitatively mobilizes the teaching staff.

vitation to a collective consideration and undertaking of new research tasks that have, as their main objective, comprehensive eco-humanization of engineering education as the basic prerequisite for a different attitude to the professional role, activity and responsibility of engineers in the creation and realization of the concept of sustainable development.

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EKOHUMANISTIČKA ORIJENTACIJA TEHNIČKOG OBRAZOVANJA I ETIKA INŽENJERA

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Imajući u vidu stavove brojnih savremenika da živimo u društvu tehnološkog, socijalnog i ekološkog rizika, autori ukazuju na pozitivne i negativne posledice tehničko-tehnološkog razvoja i u tom kontekstu na potrebu ekohumanizacije tehničkog obrazovanja. Specifičnost ekohumanističke orijentacije, upravo, je u njenoj univerzalnosti; podrazumeva odnos prema prirodi, čoveku, radu, a pre svega Životu kao opštoj vrednosti. S tim u vezi moralna odgovornost inženjera je povezana sa takvim ličnim kvalitetima, kao što su sposobnost predviđanja bližih i daljih posledica svojih aktivnosti, prognoze i predupređivanja rizika, samokontrole, kritički odnos prema sebi, drugima itd. Dobrovoljno pridržavanje moralnih zahteva, vezanih za profesionalno delovanje inženjera, pretpostavlja razvijeno ubeđenje u neophodnost takvog postupanja, a ne zbog straha od moguće kazne i osude drugih. Izgrađivanje etike inženjera i moralne odgovornosti kao njenog stožera predodređuje potrebu kompleksnog, holističkog pristupa profesionalnom obrazovanju ovih kadrova, suprotstavljenom u praksi tradicionalnom (pragmatičnom) pristupu. Stoga, autori ovog rada, smatraju da ne bi bilo pretenciozno da se reforma tehničkog obrazovanja razmotri kao temeljno pitanje budućnosti, odnosno kao najznačajnije pitanje razvoja društva, bez predrasuda, političke pristrasnosti i zastarelih načina mišljenja.

Ključne reči: *tehnika, ekohumanizacija obrazovanja, inženjerska etika, održivi razvoj*