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VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ

FACULTY OF ELECTRICAL ENGINEERING AND COMMUNICATION
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A KOMUNIKAČNÍCH TECHNOLOGIÍ

DEPARTMENT OF FOREIGN LANGUAGES
ÚSTAV JAZYKŮ

THE ENGINEER OF THE 21ST CENTURY
INŽENÝR DVACÁTÉHO PRVNÍHO STOLETÍ

BACHELOR'S THESIS
BAKALÁŘSKÁ PRÁCE

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VEDOUCÍ PRÁCE

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Bakalářská práce

bakalářský studijní obor **Angličtina v elektrotechnice a informatice**

Ústav jazyků

Studentka: Anastasia Boyarchikova ***ID:*** 168342

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NÁZEV TÉMATU:

Inženýr dvacátého prvního století

POKYNY PRO VYPRACOVÁNÍ:

Identifikovat role, možnosti, požadované dovednosti a výzvy, kterým čelí profese inženýra dvacátého prvního století. Doplnit vlastní komentář založený na nově nabytých znalostech získaných při studiu doporučené literatury.

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ABSTRACT

The bachelor thesis is focused on the identification of the roles of an engineer of the 21st century. It addresses possibilities and required skills needed for engineering activities and describes numbers of global challenges that should be resolved by the engineers in the new century. These are problems of the different areas of science and technology, including social and ethical aspects of these problems. The work defines the main functions of engineers' activities which influence their job duties; it emphasizes engineers' social responsibility and necessity to observe rules of professional engineering ethics; it stresses special importance of being competent in professional communication in foreign language environment. A decisive factor for responding to the whole complex of engineering problems of the 21st century is the existence of modern engineering education in society. The concept of engineering discourse community, both from the point of view of applied linguistics and social sciences, finishes the work.

KEYWORDS

Engineer, the 21st century, engineering profession, global challenges, engineering activity, ethics, discourse community

ABSTRAKT

Tato bakalářská práce je zaměřena na identifikaci role inženýra ve 21. století. Zabývá se možnostmi a požadovanými dovednostmi potřebnými pro inženýrskou činnost a popisuje řadu globálních výzev, kterým čelí inženýři nového století. Jsou to problémy v různých oblastech vědy a techniky, které rovněž zahrnují sociální a etické aspekty. Práce definuje hlavní funkce inženýrských činností, které určují zaměření inženýrských profesí; zdůrazňuje nutnost dodržování pravidel profesionální etiky stejně jako schopnost dorozumět se s ostatními členy mezinárodního inženýrského společenství. Zásadním faktorem pro schopnost reagovat na problémy dvacátého prvního století je existence moderního inženýrského vzdělávání ve společnosti. Tematika inženýrské diskurzní komunity, a to jak z hlediska lingvistického, tak z hlediska sociálního, uzavírá tuto práci.

KLÍČOVÁ SLOVA

Inženýr, 21. století, inženýrské povolání, globální problémy, inženýrská činnost, etika, diskurzní komunita

PROHLÁŠENÍ

Prohlašuji, že svou bakalářskou práci na téma The engineer of the 21st century jsem vypracovala samostatně pod vedením vedoucího práce a s použitím odborné literatury a dalších informačních zdrojů, které jsou všechny citovány v práci a uvedeny v seznamu literatury na konci práce.

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1. Introduction

We are people who live in the 21st century, the century in which humankind and technology go hand in hand. The decisive influence of the development of technology on our age is generally known. In the past century, technology evolved quite slowly, and each innovation had a great impact on reality. Nowadays, new technologies do not produce a furore. Each year there are more and more new inventions which will undoubtedly affect our lives. For this reason, changing modern world needs global knowledge within technical, social, political, economic and ethical issues leading to an improvement in quality of our life. All these issues are included in a discipline of engineering which is inextricably linked with the concept of the engineering profession.

The main aims of this thesis are to identify the roles, possibilities and required skills for the engineer of the 21st century. There are a lot of branches of technical activities which include a number of specialized fields and disciplines focused on the practical application and the use of scientific, economic, social and practical knowledge to the treatment of natural resources for the benefit of a man. From this, the next purpose of my thesis follows – challenges faced by the engineering profession today. The engineer of the 21st century must have special moral qualities and deep knowledge in different areas of science and technology. Thus, the modern engineer is a "well-coordinated system" that works for the benefit of humankind.

This bachelor thesis will focus on five specific aspects that will demonstrate possible predictions of future image of the engineer of a new millennium. The main part begins in Chapter two which deals with the determination of the word "*engineer*" and his/her brief duties. The third chapter is about the world's major problems that have an engineering dimension. The following chapter focuses on official duties and professional engineering ethics in accordance with a branch in which the engineer works. The fifth chapter describes the causes of the crisis that exists in the engineering education. The sixth and last chapter discusses the concept of an engineering discourse community which is closely connected with English for Specific or Specialized Purposes, a variety of language, the main aim of which is providing an adequate and effective communication within a definite group of people. This communication process within the group is called by engineering discourse community. It has certain qualities that have to be respected by its members.

2. What is engineering and what does it include?

In order to determine who an engineer of the 21st century is, it is important to understand what engineering is and what this term includes. "Engineering" originates from two Latin words: "*ingenium"* which means "cleverness" and "*ingeniare"* which means "to contrive, devise". Engineering is the process which is intended to create, build, design and improve all spheres of human activities. Engineer is a humanitarian profession. On the one hand, it is a person who creates a project of future technical systems or processes and their operation, maintenance, elimination and modernization for future customers. The customer is used in the text as the entity initiating the launch of the engineering activity to achieve any goal. The customer can be an organization, an individual, society etc. In these activities, the engineer seeks to achieve benefits for the customer, using his/her knowledge, skills and understanding to accomplish this goal.

On the other hand, some people believe that the engineer makes most of his/her decisions standing at the drawing board. But this is not true. The engineer spends most of his/her time by studying literature and requirements, by exchanging views and selecting employees. Therefore, the ability to maintain good relationships with people and cooperate with them successfully plays an important role in the work of engineers. Identifying and evaluating new technical problems are an important part of the engineering work. The engineer has to determine how people will use newly developed tools. He/she is also obliged to anticipate the effect caused by the appearance of new commercial products, for example, a mechanical toothbrush. Thus, the activity of the engineer depends to a large extent on the needs of society, recognizing the usefulness of his/her inventions, and how these inventions help people. There is an opinion that the engineer spends most of his time doing work which a technician or a mechanic is responsible for. By no means! Engineers often have to think abstractly, to ponder the facts, calculate and compare and rarely have to deal with specific instruments. Furthermore, the layout of the device developed by engineers is mainly used by technicians, so in such a case, the engineer is not always able to "work with his hands". Thus, the engineer does not have to deal with technical systems (devices and technological processes), but with their descriptions. He/she changes these descriptions from obscure customer's requirements into clear and unambiguous discriptions, for example, constructed drawings. In addition, he/she uses tried and tested procedures in engineering activities in accordance with the regulations. This understanding has been developing since the 20th century.

2.1 What should an engineer of the 21st century be like?

But time is changing, together with the society changing over time, too. Challenges we will face tomorrow, will be significantly different from those we face today. That is why we need the "new version" of an engineer, the engineer-fighter with unlimited force to solve the acute vital engineering problems who is also competitive in conditions of market economy. The most important requirements for "new version" can be summarized as follows:

The engineer of the 21st century should know everything, i.e. he needs to be able to find information quickly and he needs to know in which way to use this information. In the age of High technology, Google is often used enabling the users to get a huge flow of information after a couple of a second. And as search engines become more sophisticated, the probability that the information is relevant is increasing. However, the transformative effect of being able to access information instantaneously cannot be overemphasized. According to many people, we "know more than we know" because in addition to knowledge we possess we also know where to find information about specific things. Most of us know how to fix our computers, not by knowing so ourselves, but by knowing whom to ask. The introduction of the internet expanded this network of contacts to literally every piece of information that is out there. However, as Apelian states *"... while finding information is already trivial, the communalization of knowledge will make it essential for the professional engineer to be able to judge the quality of the information that he or she has. Thus, teaching to how to deal with an abundance of information and how to judge the relevance and the quality of the information at hand will be the educational challenge"* [1].

He/she can do anything. In other words, the engineer should be able to evaluate goals that need to be achieved, tools which helped to get these goals and to use tools proficiently. His/her strong analytic skills are very important in these activities, i.e. the ability to think, to reason, to analyze the situation. In principle, it is the ability to spread out the situation on the components and take a look at them from a different perspective.

He/she can work with anybody anywhere. The dynamic nature of life and professional activity requires communication skills. Engineers have to deal with a large volume of business information that must be correctly understood, which is difficult if communicative competence is not developed. The engineer realizes his/her communication skills in public speaking, in negotiations, discussions in production meetings, in conflict resolutions. The possession of norms of speech contributes to the regulation of human relations, it helps promotion on the career ladder. A man spends a significant part of his life at work surrounded by people linked together by common problems and interests. Therefore, rules of business etiquette play an important role in everyday life. It is recommended to regulate the relationships between people

involved in the same activities. Office etiquette is based on respect, tact, kindness, attention and sensitivity to an employee. The dynamic nature of life requires further engineer communication skills: the ability to integrate quickly into the labour collective, willingness to adapt to new working conditions and the regulation of relationships between people in the process of joint activities. The engineer must be able to work in a team, to be aimed at the overall production results, to participate in making rational decisions, to understand and accept the views of his/her partners, to consider constructive criticism, to present his/her development publicly.

3. The world's major problems that have an engineering dimension.

At the turn of the century and the new coming millennium, humankind all over the world eagerly listens to the voice of scientists, to their forecasts, aspirations and expectations with hope and anxiety. What will be in the 21st century? What can be done for the improvement of the lives of people on the planet? Ordinary people of the Earth, the state and political figures, scientists and thinkers, believers and atheists – they all critically rethink the path traversed by mankind over the period of the millennium and the 20th century.

The last century has significantly improved the lives of people on the planet. Space exploration, successes of biomedicine, the development of aviation and biotechnology, creating powerful nuclear, thermal and hydroelectric power plants, microelectronics, new transportation systems and new materials, information technology and automation, fast cars and highways, television and the Internet, large-scale computerization and other achievements of scientific and technical progress change and, in some cases, facilitate and improve our everyday lives. We have changed our philosophy, and even our world. But, unfortunately, achievements of technological revolution placed before the international community too many new problems. Often what has been conceived and created for the benefit of a man, turns into its opposite. It may sound a little bit frightfully, but this "back side" of the medal represents global problems of our humankind.

Global problems are problems related to the vital interests of the whole of mankind, of all people, nations, continents and all social forces and classes around the whole world. And it is a real problem that acquires a worldwide character. In other words, there are unsolved problems which pose a threat to the future of humanity and must be addressed to ensure the further progress of societies. The combined efforts of the whole human race is the only way how to solve and save the planet Earth on the basis of mutual collaboration and intensive investments not only in material but also in physical, moral, and mental fields.

Global problems are the result of a long historical development of an antagonistic society (a society in which personal or selfish goals are realized with damage to social or altruistic aims) in which the insufficiently rational and efficient use of natural resources, science and technology is carried out by states. The world's major problems are a natural consequence, the result of all the contemporary global situations on the planet at the end of the 20^{th} century.

If we look objectively at the situation which is taking place in the world, the current state of the world can be described as follows: poverty of the majority of population, half-starved existence of a large number of people living on the planet, an acute lack of health care and mass

premature mortality (especially among children), relatively low physical, social and intellectual culture of the majority of people. All these factors have extremely negative consequences for the economy, culture, environment, social psychology of people.

At the last forum "NAE GRAND CHALLENGES FOR ENGINEERING: IMPERATIVES, PROSPECTS, AND PRIORITIES", which is organized annually by National Academy of Engineering [2], questions connected with inspirations for new younger engineers and grand challenges that we are faced with at present were discussed.

Dr. Robert H. Socolow, a professor of Mechanical and Aerospace Engineering from Princeton University, highlighted four major categories of Grand challenges existing in the international arena [3]. According to his opinion, the first and the most influential category is sustaining the whole natural environment. This issue includes relationship between a human and nature: sustainable development of civilization, associated with the increase in population and the increase in its needs for sources of energy, food, fresh water and quality of life, should be at a certain level. And this is difficult to disagree. Scientists from all over the world in one voice declare that the process of emission of various harmful gases and dust in the atmosphere is growing as well as deforestation of forests. According to scientists, the process of appearance of the ozone hole over Antarctica becomes a common phenomenon because of gas emission. The main trouble is not the existence of the hole over Antarctica but the fact that the thin ozone layer protecting life on Earth against the deadly ultraviolet radiation has become thinner on the whole surface of Earth. Precipitation of dust on the ice of the Arctic and Antarctica may lead to partial melting, and as a later consequence will change the reflective ability of Earth. The possible development of such processes is still too inconsistent. Some scientists argue that it can cause a cold snap and even glaciers. Others confirm that the accumulated carbon dioxide in the atmosphere (the atmosphere such as glass), through which the solar radiation is passing, does not transmit infrared radiation back into the space: it creates a greenhouse effect. A huge amount of substances generated as a byproduct of industrial activity enters the hydrosphere - the oceans, seas, rivers, lakes and groundwater. According to current data, the volume of all the water available on the planet is 1.4-1.6 billion of cubic kilometers. About 94% of it is concentrated in the oceans; another part is in glaciers, soil and the atmosphere. Fresh water, which is so necessary for man, is only 2% of the entire volume of the hydrosphere and is distributed on the planet very unevenly, which causes the lack of this water in some regions of the world.

The second category mentioned on the forum by professor Socolow was Personal and Community health. At the present time, highly topical issues include sustaining life and safety,

protection from natural disasters and everyday stress. In the near future, the world population will reach 8 billion, and at the same time, almost one third of this population is doomed to starvation, living in conditions that are not adequate to our civilized ideas. Advances in biotechnology and medicine, made possible by what is called "ENGINEERING", pose before mankind the new issue of biological safety, and ethical and legal issues. On the one hand, the successes and achievements of science and technology caused that diseases like the plague, cholera, smallpox, etc. have been eradicated from the large parts of the world. On the other hand, there are still some problems which have not been solved yet, e.g. finding an effective treatment of diseases of our century: AIDS, cancer and attacks of the century - drug and alcohol abuse. Human health is threatened by the diseases. For this purpose, we need research and development in the field of biomedical engineering, which would allow creating a "personalized medicine" that implements the individual approaches to the patient in matters of diagnosis, selection of medicaments, determining treatments using computerized catalogs.

"*We have a record of being dangerous to each other*" - Dr. Robert H. Socolow notes in his report on the forum [4]. And this is the third category of challenges: Vulnerability and Security. Human vulnerability is associated with both natural factors (earthquakes, floods, hurricanes, tsunamis), and possible man-made disasters, as well as a manifestation of terrorism. There is an urgent need for the development of new technologies predicting natural disasters, detecting rapidly countermeasures to thwart enemy actions, organizing rescue of people.

Human progress is directly related to the scientific and technological revolution, with a qualitative leap in the productive forces of humanity, but also a qualitative leap in the means of destruction in the military. For the first time in history, man is endowed with a real opportunity to destroy all living on earth. In the world there are enough weapons of mass destruction to destroy all life on the planet repeatedly. The experts of The United Nations (UN) calculate that 100 small nuclear bombs (energy from 5 to 50 kilotons) would lead to the destruction of all life on the large area of the planet.

"*Why both we support environment, personal health and safety? The 4th category is an answer- Joy a living*"- professor Socolow continued in his report [5]. Electronics deliver music to us which is of marvel's fatality. Air travels allow us to access to the completely new variety of human culture and natural settings. Curiosity about knowing or learning something is enabled by providing incredible access to information. Engineering in many forms enables amazing discoveries about universe and life, which we share. Satisfaction of human life is the supreme

goal of people on earth. It is important to use all the technical and technological capabilities in order to make human life comfortable, interesting and enjoyable.

The main idea of this forum may be defined in the following words. At present time, there are issues that require to be given attention by the scientific sectors of society. What should the engineer of the 21st century be like? How to build a system of higher technical education in the near future? What should the overriding priorities in scientific research be? What is the role of the engineer in a society?

On the one hand, there are proposals for developing technical sciences, for a new and more responsible role of the engineer in the community; on the other hand, there is the call for more humane interpersonal skills, for ensuring natural and technogenic safety, for respect towards nature, the call for spirituality and the harmony and peace in society.

However, everything that has been mentioned above represents general classification of Challenges of the 21st century.

3.1 14 Grand Challenges for Engineering in the 21st century

As previously mentioned, the *US National Academy of Engineering* organized a special commission of experts who identified 14 Grand Challenges for Engineering in the 21st century [6]. These are the problems of the different areas of science and technology; however, they are extremely important for the development of humanity as a whole.

1. Advances in personalized learning
2. Making solar energy economical
3. Enhancing virtual reality
4. Reverse-engineer the brain (how to create thinking machines — computers capable of emulating human intelligence)
5. Higher participation of the engineers in medical science.
6. Advances in health informatics
7. Restoring and improving urban infrastructure
8. Secure cyberspace
9. Providing access to clean water
10. Providing energy from fusion
11. Preventing nuclear terror

12. Managing the nitrogen cycle
13. Developing carbon sequestration methods
14. Engineer as a tool for scientific discovery

One of the priority tasks of the experts is called the mastery of fusion technology [7]. The relevance is determined by the fact that the energy issue is highly acute. Wars are made on energy sources, there are conflicts between states. Hydrocarbon reserves are not infinite. Reserves of raw uranium for the needs of nuclear power are limited, too. New developments are continuing in the using of alternative, including renewable energy sources (solar, geothermal, wind power, and others.). However, these developments lack the perspective of fusion energy. Scientists have learned how to run the reaction in the hydrogen bomb, but still cannot control the process of the reaction in order to use fusion energy safely for industrial purposes.

Fossil fuels cannot remain the dominant sources of energy forever. It is solar power which offers an attractive alternative and a long-term, sustainable energy source. Its availability far exceeds any conceivable future energy demands. It is environmentally clean, and its energy is transmitted from the sun to the Earth free of charge. But exploiting the sun's power is not without challenges. The overcoming of the barriers to widespread solar power generation will require engineering innovations in several arenas — for capturing the sun's energy, converting it to useful forms, and storing it for use when the sun itself is obscured.

The improvement of urban infrastructure has been called by experts as the priority task among the problems of the 21st century. By the end of the 20^{th} and beginning of the 21^{st} century, it became obvious that the world's largest cities were choking on the flow of people, vehicles and goods. Therefore, this problem requires an immediate solution. It is necessary to create a life-support system of cities which includes access to clean, safe water, sewage collection and disposal systems, electricity, pipeline transport to make the lives of people in cities more comfortable in the environmental, economic and social terms.

Another no less important problem is the use of new information technologies in the medical field. Most diseases occur in the early stages imperceptible to a human eye. When they are identified, their treatment becomes either impossible or the disease has already had time to cause irreparable harm to human health. Early and accurate diagnosis of the disease is the key to successful treatment. To implement more in-depth introduction of information technology in health care is a grand challenge for scientists and engineers. Is it important to develop new medicaments and treatments, including the use of nanotechnology.

To develop virtual reality is another technological challenge. According to the scientists, with the help of such technology, it will be possible to solve some problems in the field of education and training of some person's skills that can be used in the treatment of psychological disorders, when restoring memory, etc.

The reduction or elimination of the release of carbon dioxide into the atmosphere is another world's major problem related to engineering, technology and science. The concentration of carbon dioxide in the air is increasing and transport emissions of this gas are very high. Therefore, it becomes difficult for people to breathe and there are more frequent cases of respiratory diseases like asthma or lung cancer. Furthermore, it is also necessary to reduce emissions of nitrogen compounds in the atmosphere. Under their action, the ozone layer of the earth is destroyed, and the sun's ultraviolet radiation, meeting no resistance in the atmosphere reaches the ground, causing a "greenhouse effect".

In the mid-1980s of the 20 century, there were no mobile phones. People received information mainly from books until a worldwide network of the Internet has been created. Neither has the computer entered into our daily lives. At present, so many things are available for people: a satellite TV and radio, hybrid cars, using different energy sources. The genetic compositions of many organisms were deciphered, the analyses of the human DNA are widely used in practice, experiments on animal cloning are conducted. Laser technology is used in medicine as well as CD and DVD systems. An extremely powerful telescope has allowed to examine distant galaxies, the study of the Large Hadron Collider has brought us closer to unraveling the origin of our galaxy. Over the past quarter of the century, human society has changed significantly and its life has become more comfortable thanks to the work of engineers. However, there are still plenty of problems facing humankind and requiring the engineering solutions. In my opinion, on the basis of the above mentioned, engineers of new millennium have to work with a lot of responsibility and dedication to give an adequate response to different challenges of the 21st century.

4. Engineering profession

Engineer is a specialist with higher technical education, the creator of the information about the architecture of the material, about the means for achieving a goal or method of manufacture of the product/products, and is responsible for directing and controlling the manufacture of the product.

Engineering profession is considered to be highly responsible and necessary. An engineer is an indispensable employee of any industrial enterprise. There are several specializations within which the given occupation can exist: for example, the engineer estimator, civil engineer, design engineer, welding engineer, environmental engineer, chemical engineer, an electrical engineer and others.

4.1 Job duties

The main functions of an engineer may be clearly defined and assigned to specific professions.

1. The function of a technical analysis and forecasting. Its implementation is connected with the explanation of the technical contradictions and production needs. It identifies trends and prospects of technical development, the rate of technology policy and, accordingly, outlined the basic parameters of an engineering problem. In short, it is formulated in the answer to the question of what should the production of tomorrow be. An engineering "bison", i.e. managers and leading specialists of research and design institutes, bureaus and laboratories, represents people who perform this function.

2. The research function of engineering is to find a concept of a technical device or process. Research engineer is obliged to find a way to "enter" a task intended to be developed within the law of natural and technical sciences, i.e. to determine the direction that will lead to the goal.

3. The design function complements and develops the research function and sometimes merges with it. Its main reason is that the bare bones of the concept of the device, mechanism overgrown by muscles of technical means, the technical idea are getting a desired form. The engineer-constructor takes into account the general principle of operation of the device as the basis - the result of the efforts of researchers - and "translates" it into the language of drawings, creating firstly a technical and later a working draft, a new combination which has a new functional properties and is qualitatively different from all others created from technical elements.

4. The function of the design is the sister of the two previous functions. The specificity of its content is, firstly, that the design-engineer constructs not a separate device or appliance but the entire technical system, using machines and mechanisms created by constructors as a "detail"; secondly, during the drafting it is often necessary to consider not only a technical, but also social, ergonomic and other process parameters, i.e. to go beyond the purely engineering problems. The work of the designer completes the period of engineering pre-production; technical idea acquires its final shape in the form of detailed design drawings.

5. The technological function is associated with the implementation of the second part of an engineering problem: how to make something that is invented? The engineer must combine technical processes with labour; he/she has to make it so that the interaction of people and equipment, time and materials costs were minimal, and the technical system worked efficiently. The success or failure of technology is determined by the value of all engineering work spent on the establishment of a technical object and a perfect shape before its production.

6. The function of regulating production. The designer, constructor and engineer define with common efforts how and what to do. At the same time there is the simplest and the most difficult thing - to do it. This is the task of the worker: to direct his/her efforts, to organize his/her work with labour and to subjugate other joint activities of workers in order to solve a specific technical problem - it is a matter of a production engineer, the Supervisor.

7. The function of maintenance and repair of equipment. Here, the name speaks for itself. In many cases, a super modern technique requires maintenance engineering training of its employees. Debugging and maintenance of vehicles, machines, production lines, control of the regime of their work rest on shoulders of service engineers. They are increasingly needed for remote operations as well.

8. The function of the system design is relatively new to the engineering; however, it is more important than many other functions. Its meaning is to give the entire cycle of engineering operations a uniform orientation, complex character. There is a new profession of engineer-system technology, designed to provide expert evaluation of the process of creating complex technical and especially the "man-machine" systems that require their constant diagnostic analysis aimed at uncovering and backup bottlenecks, developing solutions to address identified deficiencies. Experts-Universalists have to help the leader to reach agreement on the entire program of work consisting of various projects.

4.2 Ethics

Engineering activities (professional, knowledge-based, socially responsible as well as human-dimension design and operation of technical devices) play an increasingly important role in human society. Modern engineering professionalism does not only involve the development of scientific bases of design technology, the awareness of the goals and objectives, the meanings of engineering in general, its place in the culture of the 21st century. Engineering is also considered to be very important to the understanding of its social responsibility, to the natural and social transformation of the human space, to the needs for transformative efforts commensurate with controlling human capabilities. .

In order to understand what *Engineering ethics* is, it is necessary to explain the meaning of the word *ethics*. The field of ethics is the synonym for culture whose main aim is to regulate the relationship and responsibilities between people in the society. To put it in another way, people are given moral precepts and generally accepted standards of right behavior by ethics. It provides answers to questions: How to live? What to seek in life? To what extent should our actions be guided by our theories in ethics?

As a discipline of the moral, ethics has undergone a long way of development. Every thinker was trying to expand its scope and consider morality through the prism of his experience. For instance, German philosopher Immanuel Kant put emphasis on the concepts of duty, obligation and responsibility [8]. The more the secrets of nature were discovered by people, the higher the responsibility of possession of these secrets was. However, concurrently, it should be noted that under certain conditions there are the interactions between technologies, techniques, and people in which it is not possible to determine the level of responsibility in terms of superiority of technique over the humankind. For example, who is responsible for global warming, melting of polar ice caps, raising the level of water in oceans as a consequence of floods? The right answer is humanity as a whole. Every person on the Earth is responsible for it.

Professional engineering ethics is an integrated system of certain norms, principles, precepts, prohibitions and rules of scientific work, communication and behavior of engineers. Moreover, ethics is determined by the specification of a branch in which the engineer works. Among the rules of professional engineering ethics the following ones may be found:

- to implement engineer’s work conscientiously;

- to create wealth for the benefit of the people, not causing dangerous harm for environment and human health (special concern should be given to military equipment and weapons of mass destruction);
- to take responsibility for results of activity;
- to be in compliance with certain formal relations with engineers involved in the creating of a project. Effectiveness of the future project depends on social climate.

The search for new solutions is progressing better and faster with the help of discussions and brainstorming in an engineering community. The list of the above rules represents fixed legal documents relating to security issues, intellectual property and copyright. Certain rules of professional activity of engineers are assigned to the administrative institutions and regulate the activities of an organization (enterprise, company, institution, etc.). Unfortunately, there is no holistic system of rules and principles of engineering ethics. In addition, this approach does not distinguish between the moral, legal and administrative frameworks governing the activities of engineering that are incorrect.

According to the *National Society of Professional Engineers US* [9], there are three main groups of moral norms, principles and rules governing the professional activities of an engineer, three kinds of relationships:

- Engineer and the subject of his work and activities (engineering, technology and organization of production). The key attribute of these relations is humanism which should regulate activities of engineer during the development, design, construction and operation of the equipment and technology, organization of production from the standpoint of the personal, technological and environmental safety.
- Engineer and colleagues. The observance of the norms, principles and rules of the engineering culture of communication is the main objective in this case. Here, we cannot forget about the existence of creative freedom, pluralism, criticism and struggle of opinions, dialogue and mutual understanding between people showing interpersonal skills, tact, correctness in dispute.
- Engineer and society. The main requirement is a social and moral responsibility of the engineer for the results of his/her work and its consequences.

The fundamental, system-engineering ethics principle should be the principle of humanism, which is specific in its specific. The engineer must consider the man as a supreme value, he has strongly contribute to the humanization of engineering, technology and production.

All things considered, the professional activities of the engineer require a set of the following qualities: service to scientific and technical progress, devotion to engineering, high level of professionalism, expertise, innovation, hard work, honesty, integrity, discipline, high demands on himself/herself and self-criticism, i.e. nothing human should be alien to the engineer. As a consequence, it is important not to forget about the professional and personal honor and dignity, taking care of the engineering profession prestige and good citizenship. In this way, social competence of an individual engineer, assuming responsibility to the society for the consequences of his/her decisions at all levels of engineering - from the design to practical implementation - is today's essential structural feature of the professional culture of engineers.

4.3 English language

Engineers, as the representatives of one of the largest and most socially significant groups, who determine the future progress of humanity, are now actively involved in the integration processes in the field of science and technology; for this reason, they have to be able to take part in international programs and projects. This factor involves the acquisition of professional contacts and the presence of professional foreign language communicative competence. The formation and development of this future engineers' competence is highly important, which is confirmed by numerous reviews of employers who prefer to hire those applicants who speak foreign languages.

Knowledge of English language is a mandatory requirement of a career in modern society. Employers believe that English is recognized as the global language of science, education and business (today's scientific *lingua franca*). Nowadays, it is expected that a graduate of a technical university is a specialist not only in knowledge necessary for the implementation of engineering activities (design, production, operation of production facilities), but also a specialist who is capable of professional and intercultural communication in foreign language environment.

Let us consider the example that illustrates the using of the English language ubiquitously. Let the example be the Russian engineer who works with the Russian company. He is faced with the need to examine in depth the new imported equipment. Today, none of the innovative projects in the field of telecommunications or in industrial construction is complete without the using of uninterruptible power supplies. The engineer does not only have to choose the best generator for the project but he also has to explore where to buy the Wilson generator with all necessary certificates and licenses. All this information leads to the following question: How can a modern engineer choose the brand and its parameters for the particular device without making a mistake? The answer is: to examine the technical documentation carefully. But what if it has not been translated into the Russian language yet? The solution is simple: just read it in English language. Thus the fact that the modern engineer is required to read and speak in English language is being illustrated. Wherever the engineers operate - in the field of television or energy or construction of transport or in any other branches of engineering - he/she has to understand fully the appropriate terminology and special technical abbreviations. The engineer will not be able to become highly-qualified without this knowledge and skills of reading technical drawings and formulas in English language.

It is evident from what has been mentioned above that the engineers have to acquire not only General English, but also English for Specific or Specialized Purposes (ESP). Such a language is designed to meet specific needs of users, it reflects activities of the disciplines or professions, it serves as well as the way in which users communicate in order to reach an agreement upon certain goals. In the engineering profession, using a specific language, jargon, written language as well as some typical genres, e.g. reports, are important characteristics of an engineering discourse community. The concept of the discourse community will be dealt with in a greater detail in Chapter 6.

5. Engineering education

In order to solve the whole complex of ecological, demographic, energy, food, moral and other evolutionary problems of modern society coherently, a competent person, who is capable of performing the complex forms of intellectual property and who is ready to take responsibility for the fate of the world from a position of moral and spiritual attitudes and emotional holistic relationship, is needed. In this context, the profession of engineer may offer to bridge the gap between the world of engineering and economy and the future fate of the planet and humanity. However, the critical question is raised: is the modern high education and engineering education ready to solve the challenges of training and education of future experts of the 21st century?

It should be noted that the author of this work is not competent to assess the positive and negative aspects of engineering education completely because of the limited experience in this field. Nevertheless, it is important to mention a well-established opinion in scientific circles that in today's world there is the crisis of modern engineering education [10]. The study of international experience allows to assert that the crisis is caused by numbers of reasons: insufficient government funding, functional illiteracy (inability to perform his/her functions despite getting education), uncertainty of the objectives of training and education, lack of motivation to learn, misunderstanding of the role of engineering education, its importance in social progress of the society. The engineering education in the 21st century should pay attention to the following reasons shown themselves in terms of the information age.

The most significant reasons are listed below:

1. The rapid updating of knowledge with sharp increase in volume - an inevitable phenomenon during the boom of the information. Engineering knowledge becomes obsolete within 3 years according to leading experts of the European Institute of Education and Social Policy [11]. Peter Drucker, "father of management", shares the same opinion noting that "*knowledge rapidly becomes obsolete.*"[12] Information loses its relevance to the student in the moment he has time to learn it because the flow of information is growing like an avalanche. There is a risk that the graduate will have outdated knowledge, i.e. outdated skills and attainments. Thus, the general claim "Education for life" is increasingly proving its weakness. On the other hand, "lifelong education" is being more and more adopted by the human consciousness, confirming the old Russian proverb "Live and learn".

2. Information “overproduction” while increasing degradation. Albert Gore in his book “Earth in the Balance” says: “*We are watching the crisis of education against the background of information overload – and it is not coincident. We gave birth to many statistics, formulas, images, documents and declarations that we are not able to digest. And instead of searching for new ways of thinking and learning of phenomena that have already been created, we continue to produce new information more rapidly.*”[13]
3. Inconsistency of the basics of education with existing realities. Constant “breakthroughs” in all areas of life and human activities lead to the fact that the current education system does not have time to react promptly to the demands of the time. In other words, the world with modern society is changing much faster than the content of education. The problem is that the educational sphere is excluded from the notion of culture, which has long been developing outside schools. It proves that the main problem is not so much in a technical field as in humanitarian one. The above mentioned inconsistencies are caused by the “degradation” of the modern expert, i.e. inattention to the humanitarian aspects of his/her activities.

The endless flow of information falling on specialists, the regular appearance of new types of equipment and events, constantly updated knowledge, the appearance of voids between the sciences and the field of humanities lead to the absolutisation of technical issues ignoring humanitarian ones.

The above given list of problems is not an exhaustive list of all problems that have accumulated in the engineering education in recent decades. The author of this work has mentioned in the introduction to this chapter that she is not competent to assess completely the positive and negative aspects of engineering education. However, despite her limited experience in this field, she tried to point out at least those problems and reasons of these problems which she herself finds to be important and of great concern.

6. Engineering discourse community

It has been mentioned in the chapter 4.4 that all engineers should have certain proficiency in English language. And here we are not talking only about vocabulary, grammar, pronunciation and punctuation of the language, and we are talking about an integrated system. This system is called English for Specific or Specialized Purposes (ESP). Such a language is a functional variety of language, the purpose of which is to provide an adequate and effective communication for its users within the specific subject area. In this communication process specific language styles used mainly in written texts, jargon and dialects, as well as some typical genres, even newly invented genres for such a type of language, are used. These specific language practices are crucial for an *engineering discourse community*.

Discourse community is a term that is used not only in applied linguistics but also in social sciences. Before we start talking about this type of a community, it is necessary to define the meaning of the term "discourse". It is important to note that there is no clear and single definition of "discourse" in spite of great attention of European linguists and philosophers of the 20th and 21st centuries. Many men, many minds. Professor Ken Hyland defines discourse in his book "English for academic purposes" as "*…different ways of representing aspects of the world , evoking the ways of thinking and talking that recur across different speakers/writers and text…discourses help to scaffold the activities of social groups and their affiliations…*".[14] Hyland's conception confirms the lexical meaning of the word because a Latin word "*discursus*" means argument, reasoning, demonstrative-mediated knowledge, based at its reception on certain grounds and rules of inference. The main idea of community is not only the principle of the interaction and sharing information and background knowledge between two or more participants, it is also the common ground where the ways of being are connected with the views we support and values we hold. If we connect two halves into the one, we will receive the whole definition of a discourse community, which is defined in the ever best way in the book "Parameters of professional discourse/ English for electrical engineering", written by Milena Krhutová. She has come to the conclusion that language is a written discourse which is used by a specific discourse community on the basis of common profession of its members. The main purpose is to transmit specific information. The discourse community uses the language for professional purposes using certain styles and genres. [15]

If I try to say in my own words what the discourse community is, I would define it as a group of people who share common goals and purposes and use specific communication to achieve these goals. It is hard to find precise boundaries of discourse communities because they

frequently overlap and sometimes have smaller, more specialized sub-communities. The engineering discourse community is in some ways different from others, and in some ways it is similar. The difference is in the way of engineers' communication, in the way of reaching an agreement on their goals.

If we look at the discourse community from the point of view of applied linguistics, the most important facet of any discourse community is the knowledge of specific language styles and genres used to help communicate the goals that bring the discourse community together. For example, engineers use a different language styles and jargon than medical doctors or lawyers. The words that they use are a part of what defines their discourse community and these words represent the main reason why engineering is a discourse community. A hip roof is a roof that slopes from all four sides of a building. This is just one of many terms used by engineers.

There are various genres which are typical for engineers, e.g. research articles, abstracts, research presentations, grant proposals, theses and dissertations. One of genres used by engineers quite often is reports. They are crucial to the life of engineers. Writing reports helps organize information among engineers, but not only with foreign colleagues but even with colleagues sitting next door, which enables that reported experiments may be available in future. There are certain guidelines and rules that engineers must follow when writing reports, to maintain the order and structure within that piece of writing, while not forgetting that reports have to be understandable for recipients. Therefore, it is desirable to express experiments or phenomena in details and using schemes, spreadsheets, figures and charts.

Another typical feature of the engineering discourse is frequent using of metaphors in the engineering discourse community. They have become a tool that is frequently used in reports; concurrently, they are an inseparable part of specific language practices that engineers use. A popular type of the metaphor is the conduit metaphor. In simpler terms, it portrays communication as encoding, sending, and decoding a message, i.e. the communication is based on codes that both a sender and a receiver have to understand. The conduit metaphor requires both technical knowledge of various fields of engineering and, at the same time, knowledge of certain language-using practices which enable engineers or technical students to understand conduit metaphors.

Writing in engineering contexts which requires a specific language style, and using the kinds of texts (both written and spoken) in which this style is used, creates a significant part of the engineering discourse community. It is the common goal of members that is talked about in the definition of the discourse community. Using metaphors and writing reports are the examples

of main genres and specific tools used for communication between engineers. They help organize data and are essential to engineers. Without sharing particular language style/styles and genres that unify the engineering discourse community, it would be impossible to label this group.

6.1 The concept of discourse community according to John Swales

John Swales is a Professor of Linguistics and co-director of the Michigan Corpus of Academic Spoken English at the University of Michigan. He is best known for his linguistic work dedicated to academic writing and analysis of applied linguistics.

"Genre Analysis. English in academic and research settings" is the crucial work written by Swales. In this book, he tries to define the nature of such concepts as "discourse community" and "speech community" and clarifies how they differ one from another. When speaking about speech community, Swales reminds readers that this term has evolved in sociolinguistics and when defining this concept, he uses words of Hymes who can see speech community as *"... a community sharing knowledge of rules for the conduct and interpretation of speech. Such sharing comprises knowledge of at least one form of speech, and knowledge also of its patterns of use.*"[16]. It follows from the above definition that e.g. language users of Australian English are people who create a speech community.

Unlike a speech community, a discourse community is a group of people who have common goals and purposes within the framework of common profession of its members. Thus, the main difference between speech community and discourse community lies in the fact that: "*a speech community typically inherits its membership by birth, accident or adaptation, whereas discourse community recruits its members by persuasion, training or relevant qualification*". [17]

John Swales defines six characteristics to identify an individual group as a discourse community [18]. If the community does not have all of these characteristics, then it is not the discourse community. Let me introduce these attributes and support them by examples.

1. *A discourse community has a broadly agreed set of common public goals.* In some cases, common goals may be prescribed in documents or they can be unspoken because they are obvious. For instance, the main goals of the professional activity of

the doctor is the saving of human life and improving its quality by providing urgent, routine and preventive health care.

2. *A discourse community has mechanisms of intercommunication among its members.* The main core is lying in the intercommunication, which constantly takes place among the members of a discourse community. Here, the intercommunication speaks for itself. The members of a discourse community hold meetings and gatherings, they write emails and reply to them, they make phones calls. All of these activities are mechanisms through which interpersonal communication takes place.
3. *A discourse community uses its participatory mechanisms primarily to provide information and feedback.* This characteristic can be understood better if it is explained by an example. College students participating in campus social life use such mechanisms of intercommunication as conversations, social networking, emails, and body language to get the information about where to go tonight, what is happening during the day and what is "cool". The aim of the mechanisms is to provide the information to the members of the campus.
4. *A discourse community utilizes and hence possesses one or more genres in the communicative furtherance of its aims.* Without any doubts, a discourse community uses at least one or more genres for intercommunication between participants of the community. A term "genre" may be understood as a type of text characterized by a particular style, form, or content. It is a functional variety of language which is used for describing how the purposes get done. Let us take into account college students, who are always in touch. They use genres which meet conditions of blogs, emails and announcements on a school web page.
5. *In addition to owning genres, a discourse community has acquired some specific lexis.* This concept includes using of special jargon, lexical items or abbreviations understandable only to participants of the certain discourse community. Electrical engineers have own specific vocabulary to explain methods and results of their research in contrast to mechanical engineers.
6. *A discourse community has a threshold level of members with a suitable degree of relevant content and discoursal expertise.* People are born and die and therefore any discourse community is subjected to changes in the composition of its members. For this reason, the above characteristic is significant because it touches on how the community reproduces itself and how new members of a community are able to come up to the community expectations. The monitoring of the ratio between beginners and experts is important in order to prevent the disappearance of the community.

In the final paragraph of this chapter, I would like to express my opinion that the discourse community is the concept in which the social role of contemporary engineers is clearly seen through the prism of their achievements. Numerous forums and meetings connected with engineering activities and Grand challenges of the 21st century announce that social status of contemporary engineers is growing rapidly. On the one hand, a modern expert is a person who needs to be able to perform and demonstrate the high level of his/her professional skills and knowledge, but on the other hand he/she also has to be able to communicate this professional knowledge through the language appropriate to his/her profession.

7. Conclusion

The aim of my bachelor thesis is to determine the role, possibilities and required skills of the engineer of the 21st century, in the era of high technology that requires the deep knowledge, high level of professionalism, diligence, honesty, discipline and places heavy demands on engineers working in this century. From a professional point of view, engineering is an integrated system which includes a number of activities, such as the invention, development, creation, implementation, repair, maintenance and / or improvement of equipment, materials or processes. For this reason, reaching the goals requires knowledge of not only technical issues, but also knowledge of political, economic, social and ethical issues. The engineer of the 21st century is a self-sufficient person who can give adequate answers to "global questions" that modern society has to face.

There is a list of challenges that have to be solved by modern engineers. They can be divided into four areas: sustainable development of civilization, human health, the vulnerability of the person and satisfaction of human life. The engineers of the 21st century must be able to respond to potential problems, such as terrorism, the shortage of energy sources, the deficit of drinking water and food, the deterioration of the infrastructure in the cities. They will be expected to solve the problems by using revolutionary tools and techniques. Therefore, the system of engineering education should respond to the high requirements of international experts. However, the engineering education is confronted with numbers of problems caused by insufficient government support, lack of personal motivation to learn, and misunderstanding of the role of the engineer in modern society.

In my personal opinion, the engineer of the 21st century is primarily a person with high moral principles, who is conscious that the future of the world depends on his/her professional activities and therefore is responsible for his/her actions. It should be noted that this profession is highly difficult because the person, who wants to be an engineer, needs to study exact sciences and, at the same time, he/she should not forget about humanitarian aspects of engineering. Accepting the fact that each of us is a part of a social community, the engineer is expected to be friendly, patient and respectful in relation to his/her colleagues in order to make climate in the team acceptable for everyone.

Professional engineering activities often include working trips abroad, making new contacts with foreign partners or the study of technical literature written mainly in English; therefore, it is necessary to know foreign languages, especially English for Specific Purposes

(ESP) which is today's scientific *lingua franca*. ESP stresses users' target goals and the need to prioritise specific language competencies demanded in engineering professions. The fact that the engineers use a different language or a jargon to communicate with one another is an important facet of an *engineering discourse community*. This term is often defined as a group of people who share certain values and engineering practices, who use certain mechanisms of intercommunication among community members. These mechanisms include special language tools used for the interaction and for transmitting scientific information to the public. The discourse community has its own characteristics, which should be kept by participants of the community.

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