The Development of Social Responsibility of Technical University Students in the Process of Professional Training

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The study emphasizes the importance of social responsibility of the engineer in the modern post-industrial society. We reveal the essence of the phenomenon of social responsibility, determine its structural components, and define the criteria for its development. Also, we theoretically substantiate and experimentally test the influence of pedagogical conditions on the development of social responsibility of future engineers in the process of professional training. These conditions include (1) increasing positive motivation of students to develop social responsibility; (2) ensuring a responsible attitude of students to perform tasks in various types of professional training (academic, extracurricular, and research activities); and (3) encouraging students to study the concept of social responsibility on their own. Besides, we describe methods of teaching social responsibility (special course, discussion, simulation, case study, etc.). The conducted analysis of the results of the experimental work confirmed the effectiveness of the proposed methods. Finally, we experimentally prove the impact of pedagogical conditions on the formation of socially responsible engineers in the process of their professional training.

Keywords: social responsibility, future engineer, technical university, professional training, pedagogical conditions

INTRODUCTION

Currently, the level of education and socialization of young people is often determined by forming a set of specific competencies, such as professional, economic, environmental, legal, computer, communicative, and many other skills. However, even people with all these competencies cannot be fully developed without some basic qualities, such as spirituality and morality. In addition, many employers pay particular attention to the personal qualities of the applicant, such as their ethics and responsibility. That is

why spirituality and morality seem to be the key values of the 21st century, as opposed to the hyper-technologization of society. Moreover, searching for new practical tools for developing ethics and spirituality among young people receiving an education is still a task of strategic importance.

Today, to protect society from destruction, any scientist and inventor should be responsible for the possible adverse results of their work. According to the researchers (Gorokhov & Rozin, 1998), three main types of global crisis contribute to the negative consequences of irresponsible engineering activities: (1) the destruction of nature (ecological crisis); (2) the change and collapse of human nature (anthropological crisis); and (3) uncontrolled changes in the activities of enterprises and social infrastructure (development crisis).

The development of students' social responsibility [SR], which in the future will encourage them to act in the public interest, predict, and evaluate the consequences of their actions, is an essential task of higher education institutions.

Although the role of technology as an engine of human progress is undeniable, not all engineers are aware of its ethical component. Many centuries ago, Leonardo da Vinci, presenting a drawing of his submarine, expressed concern about the possible undesirable consequences of his invention and did not want to make public his idea "because of the evil nature of human, who could use it to sink ships and kill their crew" (Stepin, Gorokhov & Rozov, 1996). This case can serve as one of the first examples of engineering ethics, with professional and social responsibility as a critical component.

Nevertheless, today many students entering higher education institutions have an insufficiently developed SR. For example, according to the pilot study results, only 32% of students (out of 360 tested) have a sufficient level of this quality.

This study aims to determine the impact of theoretically substantiated and experimentally tested pedagogical conditions for the development of the SR of future engineers on the quality of this feature in the process of professional training.

According to the aim of the study, we identified the following tasks:

- Reveal the essence of SR engineers;
- Determine its structural components;
- Theoretically substantiate and experimentally test the pedagogical conditions for the development of the SR of future engineers in the process of professional training;
- Specify the criteria and indicators of the level of SR development.

MATERIALS AND METHODS

To achieve the research aim, we used (1) such theoretical methods as analysis of philosophical, psychological, pedagogical, and methodological literature to compare different views on the problem; (2) such empirical methods as psychological and pedagogical diagnostic methods (survey, testing, interviews, etc.), observational methods (observation, self-observation, self-assessment); pedagogical experiment to test the research hypothesis; (3) methods of mathematical statistics for quantitative and qualitative evaluation of the results of experimental work.

Based on the analysis of the phenomenon of responsibility, we can note that SR is a crucial concept of professional ethics in any field, including engineering.

There is an extensive ethical infrastructure in the leading industrial countries, which is based on ethics committees. Such committees work in many areas of the economic sector. Furthermore, the cost of creating and maintaining an ethical infrastructure quickly pays off, because all businesses want reliable partners (White, 2007).

There is an extensive network of ethical resource centers in the West that study issues of professional, business, and corporate ethics. The leading research institutes of this kind include (1) the Canadian Center for Ethics and Corporate Policy, and (2) the Edmond J. Safra Centre for Ethics at Harvard University, (3) the Erasmus Centre for Behavioral Ethics (Erasmus University, Rotterdam).

The Society for Philosophy and Technology has been operating in the United States since 1976. It is an international body, because it regularly holds international conferences on engineering ethics and publishes their proceedings. These conferences regularly emphasize the importance of training socially responsible engineers through all possible university disciplines, including humanities and social sciences (Safonov, 2011).

Scientists consider SR in various aspects, in particular, as (1) a set of requirements put forward by the society to its members (Muzdybaev, 1983); (2) the ability of an individual to adhere to the generally accepted norms of their society (Abulkhanova-Slavskaya, 1991); (3) the ability of an individual to defend the interests of the country, nation, family, and professional society; or (4) an indicator of social maturity of the individual (Dementy, 2005).

Although technology has a huge positive impact on human well-being, Schuurbiers (2010) sees it as the cause of unpredictable risks, social conflicts, environmental pollution, and the depletion of natural resources. Therefore, making informed decisions and working in the public interest is an important requirement for engineers (Kubrushko & Kozlenkova, 2019; Lysenko & Nazarova, 2019).

Avery (1970) suggests that since both doctors and engineers make vital decisions, it would be appropriate for graduates of technical universities to take an oath similar to that given by doctors and promise never to use their knowledge for war, the production of weapons, or harmful actions against society and the environment.

The technological activity of modern human became a part of the natural evolutionary process, and human beings, as its participants, are responsible for the future of humanity. Jonas (2004) formulated a categorical imperative that emphasizes, "Make sure that the consequences of your activities are not destructive to the future life on Earth." An engineer like no other should be guided by this imperative.

Therefore, social responsibility can be characterized from different points of view, such as external, internal, individual, or collective, depending on the subject of responsible actions. These subtypes, integrating with each other, form the concept of *social responsibility*, which manifests itself at different levels: the level of (1) an individual (micro-level), (2) a social group (meso level), (3) a specific society (macro-level), or (4) humanity (mega level) (Adamek, 2013).

In many developed countries, numerous engineering societies promote a system of professional values and ethics in technical education. These organizations established codes of ethics for engineers that put the safety, well – being, and health of society above all else (Shabanov, 2013).

Researchers S. Jastram (2007), D. Matten & J. Moon (2004), N. C. Silver & L. A. Witt (2008), C. Williams & R. V. Aguilera (2008) argued that SR development should be integrated into the curriculum at all levels of engineering education. Thus, the students can get information about various social and ethical aspects and the consequences of their future activities.

To solve the problem of SR development, some universities introduce such courses as (1) business and society, (2) business ethics, (3) environmental management, (4) corporate social responsibility, (5) corporate citizenship. Besides, leading technical universities use such educational tools to design additional modules and include them in the curriculum, conducting issue-related seminars, conferences, and other special events. This experience should be expanded and assimilated by other universities, especially in those countries whose economies suffer from a lack of responsibility among their employees.

Thus, summing up various approaches to understanding the phenomenon of SR, it can be broadly defined as (1) an integrative quality of people; (2) an indicator of their social maturity, which determines their behavior and is based on the awareness and acceptance of social norms and values of society; (3) the ability to predict and evaluate the consequences of their actions, which should be formed in institutions of higher professional education through various disciplines.

Taking into account the specifics of engineering, we present the structure of the SR of engineers as a set of the following interrelated components: (1) *motivational* (the desire to act for the benefit of a person and society); (2) *cognitive* (professional, ethical, environmental, economic, and legal knowledge, which form a professional and ethical worldview); (3) *reflexive* (the ability to analyze social facts and make informed decisions); (4) *volitional* (self-regulation of actions and behavior); (5) *conative* (citizenship, patriotism, discipline, honesty, dignity, social maturity, social activity, etc.).

Considering this structure of the SR, we define the pedagogical conditions for its development in the process of professional training as follows:

- Increasing the positive motivation of students to develop SR;
- Ensuring their responsible attitude to the performance of tasks in various types of professional training (academic, extracurricular, and research activities);
- Encouraging students to study the SR on their own.

L. Kuchirkova et al. note that students' motivation is crucial, as it serves as a kind of internal drive that pushes students to do something to achieve their goals. External motivation caused by external factors is fundamental, for example, the need to pass an exam, material reward, or the possibility of future work or travel (Kucirkova, Alipichev, Vasbieva & Kalugina, 2017).

To prove the effectiveness of these conditions, several technical universities conducted a pedagogical experiment. The experimental study involved 641 students, of which three experimental groups (E1, E2, E3) with a total of 320 students and a control group (C) consisting of 321 students were formed.

At the ascertaining stage of the experiment, a comprehensive diagnosis of the initial level of SR of students in groups E and C was carried out according to the selected criteria and indicators.

The experiment participants from the E1 group (155 students) had a responsible attitude to their studies but were not socially active and did not always have a clear social position. The group E2 (100 students) included students with an insufficient level of motivation, who had difficulties in self-determination in moral choice situations.

The group E3 (65 students) comprised students who were characterized by a lack of responsible attitude to their studies, did not realize the social mission of their future profession, were indifferent to social activities and had an uncertain social position. The features of these groups were considered at the stage of the experiment formation. The experimental work was carried out on the material of both special disciplines and humanities.

To implement the first condition, we used the following tools: discussions, debates, round tables on social and professional topics ("What is professional duty?", "Business interests and personal interests: when do they coincide?", "What does it mean to adhere to the principles?", "Responsible people: what are they?", and other questions). Video training occupied a special place ("This could not have happened," "From the scene of an accident," etc.), where students could see the consequences of the irresponsible attitude of road industry experts to their professional duties.

During the ecology classes, students watched and discussed popular films about global environmental problems such as *An inconvenient truth* (2006), *Story of stuff* (2007), *Home* (2009), *Wall-e* (2008), *Life after people* (2010), and *How to destroy the world* (2010). Subsequent collective discussion motivated the students to gain a deeper understanding of SR in their future professional activities. The emotional perception of the films helped to verbalize the problems and find different ways to solve them. Besides, students-ecologists took part in a competition of their video clips dedicated to the environmental problems of their residential area or city.

Students with majors in transport discussed issues related to road safety, namely, (1) the advantages and disadvantages of various modes of transport, environmental pollution, congestion, and noise; (2) statistics on road accidents and their causes; or (3) measures to improve the behavior of road users.

To solve the research problems, a special course "Social Responsibility of Engineers" was developed. The main goal of the course was to deepen students' knowledge of SR, to develop practical skills and personal qualities necessary for socially responsible behavior.

The course included an information component designed to inform students about social responsibility in engineering; an educational component designed to develop the perception and skills of SR.

The information component comprised mini-lectures on the conceptual principles of the SR, its international standards, the UN Global Compact and Corporate Social Responsibility, and analysis of the codes of ethics of engineers in developed countries.

The training component was implemented using several interactive techniques such as (1) the method of unfinished sentences ("Professional culture is ..."; "Ethics is ..."; "Universal ethics is ..."; "Professional ethics is ..."; "Professional ethics of an engineer is ..."; "Professional competence is ..."; "The spirituality

of a professional is ..."); (2) brainstorming; (3) roleplaying; and (4) solving ethical dilemmas. Students developed the code of ethics for engineers of their profile in which they implemented their ideas of SR.

The methods of discussion were especially useful for turning SR into a stable personal quality. Here is an example of an organized discussion on the topic "Using administrative law in road control quality." The students were divided into two groups, one of which was asked to support the strengthening of administrative legislation, and the other argued that administrative control should be loosened.

Throughout the discussion, the students proceeded from getting acquainted with the facts to making sound judgments. They found new facts, came to a deeper understanding of the phenomena and sought to know the opponent's point of view and reasoning.

A series of debates on the following topics gave a significant impetus to the development of moral values: "Can you be free from society while living in it?", "Heroes of our time: what are they?", "What cannot be bought or sold?", "What is a person's duty?", "Business interests and personal interests: when do they coincide?", "What does it mean to adhere to principles?", "Responsible people: what are they?", "Discipline and success in life."

To implement the second condition for the development of SR, students of the group E were involved in various professional training types (academic, extracurricular, and research activities).

We widely used simulation modeling of profession-related situations (case study), requiring quick and responsible decisions. For example, such simulation games as (1) "How to reach the place" was aimed at solving the problems of traveling around the city and required students to make informed and responsible decisions; (2) "Humanus" (the students were expected to solve global problems of the future of humanity); (3) "Shipwreck" (the students developed their version of the organization of the social system); (4) "Road Construction Company" (the students had to "pave the road" by making the most of the available resources). Hence, the students were involved in professional activity, in the situation of making independent decisions. They had to take responsibility for their actions, improve their foreign language proficiency in various fields.

The students were actively engaged in research activities. They carried out projects involving the study of various technological problems in the context of social and professional responsibility (for example, "Environmental problems and environmental engineering," "Trends in road infrastructure development," and "Environmental safety of modern vehicles").

The results of the research were presented at conferences at national and international levels. They could also be published in the annual student journal *Students. Science. Foreign Language* (published at Kharkiv National Automobile and Highway University in 2008–2020).

To implement the third condition, which assumed the encouraging of students to study the concept of SR on their own, such measures as informing students about the role of self-education in the development of personal and professional qualities were taken in the experimental groups. For this purpose, discussions on such topics as "Professional self-improvement," "How to know yourself better," "Ways of professional self-development," and many other activities were organized.

Since *Web 2.0 technology* became an integral part of our daily life, we could not do without them in our experimental work.

We tried to incorporate social media tools into SR training whenever possible and appropriate. They helped create a student-friendly, relaxed, and collaborative learning environment. Moreover, they encouraged communication inside and outside the classrooms. As a result, the students' interest, motivation, and academic engagement increased.

We used *Web 2.0* tools such as (1) visual data to support the educational process; and (2) online discussion boards, forums, blogs, and *Facebook*. These tools enable students to communicate and collaborate through social media in a virtual community, enhancing their social skills.

RESULTS

At the control stage of the experiment, we summed up and analyzed the results of the experimental work.

We defined the following criteria for the development of the SR of future engineers: (1) motivational (social orientation of the motivation of professional training); (2) cognitive (knowledge and skills of a socially responsible engineer); (3) personal qualities (those that characterize a socially responsible engineer).

The main methods of data collection during the experimental work were (1) observation of participants; (2) interviews and conversations; (3) homogeneous sampling; (4) surveys with test scores; (5) the use of literature search – and – retrieval techniques; (6) questionnaires with closed and open questions, dichotomous questions, and multiple-choice questions; (7) rank ordering; (8) rating scales; (9) tests performed by the researcher; (10) methods of mathematical statistics.

The experimental work based on the motivational criterion was evaluated by such an indicator as forming socially-oriented motivation in professional activities. Table 1 shows the trends in this indicator.

TABLE 1
TRENDS IN THE SOCIALLY – ORIENTED MOTIVATION OF PROFESSIONAL ACTIVITIES (%)

Groups Level of formation	**E_1 (155 students)**	**E_2 (100 students)**	**E_3 (65 students)**	**C (321 students)**
High	+60	+50.1	+46.4	+14.1
Medium	-42.0	-29.6	-22.7	-9.2
Low	-18.0	-20.5	-23.7	-4.9

These data suggest that at the beginning of the experiment, the students of the experimental and control groups had almost the same quantitative indicators of the development of SR according to the motivational criterion. The results obtained at the control stage showed a positive trend in the formation of the quality under study.

Table 2 presents the trends in the development of SR according to the cognitive criterion.

TABLE 2
TRENDS IN THE DEVELOPMENT OF KNOWLEDGE AND SKILLS NECESSARY FOR A SOCIALLY RESPONSIBLE ENGINEER (%)

Groups Level of development	**E_1 (155 students)**	**E_2 (100 students)**	**E_3 (65 students)**	**C (321 students)**
Development of knowledge				
High	+55.2	+42.3	+50.3	+28.9
Medium	-24.5	-12.8	-11.9	-0.8
Low	-30.7	-68.9	-38.4	-28.1
Development of skills				
High	+56.1	+42.1	+50.1	+28.7
Medium	-24.0	-11.5	-11.9	-0.3
Low	-32.1	-30.6	-38.2	-28.7

Table 3 shows the quantitative indicators of the dynamics of the formation of personal qualities (the criterion of personal qualities) that characterize the social responsibility of an expert (human decency, honesty, integrity, etc.). They demonstrate more positive dynamics in the formation of personal qualities that characterize a socially responsible expert among the students of the experimental groups compared to the control ones.

TABLE 3
TRENDS IN THE DEVELOPMENT OF PERSONAL QUALITIES THAT CHARACTERIZE A SOCIALLY RESPONSIBLE EXPERT (%)

Groups Nature of manifestation	E_1 (155 students)	E_2 (100 students)	E_3 (65 students)	C (321 students)
Stable	+73.8	+69.7	+31.4	+4.0
Situational	-44.4	-30.6	+22.9	+25.9
Almost do not manifest themselves	-29.4	-39.1	-54.3	-29.9

A wide range of interactive methods that encourage students to show tolerance, conflict resilience, or empathy can explain these results.

DISCUSSION

The modern post-industrial society differs from the previous ones by the rapid development of science and technology, in which many experts see a hidden danger. All economies are based on technologies and, hence, on the results of engineering activities. Under the conditions of an anthropogenic civilization, the results of engineering activities can become global, so the idea and the scope of social responsibility of engineers should be revised.

In a technical university, it would be useful to include the elements of engineering ethics into the content of not only specialized disciplines but also the social sciences and humanities; they should be "saturated" with both positive and negative examples of researchers' attitudes to SR.

Unfortunately, not all countries have a tradition of creating engineering societies. Therefore, the higher education institutions of the relevant profile in these countries are fully entrusted with the task of developing the ethical competence of future engineers.

We believe that the methods of putting students in various situations, when they have to argue, prove their point of view, show integrity, social activity, initiative, empathy, personal involvement, and other qualities, are essential for the development of SR.

The experimental data allows us to assert that in the experimental groups, compared to the control group, we observed more positive dynamics in all the criteria for the development of SR. The methods of mathematical statistics confirmed the reliability of the results of the experimental work (changes in the statistical characteristics of the experimental and control samples were analyzed according to the test of significance).

The positive effect of the selected pedagogical conditions on the level of social responsibility is experimentally proved. Thus, in the experimental groups, the number of students with a high level of social responsibility increased by an average of 52.4%, and in the control group – only by 17%. At the same time, the number of students who showed a low level of social responsibility decreased on average in the experimental groups by 35.2%, and in the control group – by 24.6%.

The study has not yet fully examined all aspects of this problem. There is still much to learn about the set of methods for diagnostics and the formation of socially significant qualities of students of technical universities, on which the further development of our civilization will depend.

CONCLUSION

Thus, we revealed the essence of the social responsibility of engineers and determine its structural components. Besides, we scientifically substantiated the pedagogical conditions for the development of social responsibility of students of a technical university in the process of professional training. These conditions include (1) increasing the positive motivation of students to develop social responsibility; (2) ensuring the responsible attitude of students to the implementation of tasks in different types of professional

training (academic, extracurricular, and research activities); and (3) encouraging students to study the concept of social responsibility on their own. Additionally, we specified the criteria for the development of social responsibility of future engineers and the corresponding indicators are specified. Also, we proposed methods of teaching social responsibility (special course, discussion, modeling, case study, etc.). The conducted quantitative, qualitative, and statistical analysis of the results of the experimental work confirmed the effectiveness of the described methods. Finally, we experimentally proved the impact of pedagogical conditions on the level of development of socially responsible engineers in the process of professional training.

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