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# Research of professional responsibility of students of technical specialities by means of information and communication technologies

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**Abstract.** The article is devoted to the use of information technologies for pedagogical research aimed at studying the formation of key competencies and learning outcomes in higher education institutions, in particular, the professional responsibility of students of technical specialities. The diagnostic capabilities of the ATutor system, which operates at the Ternopil National Technical University named after Ivan Puluj (Ukraine), are presented. The process of data collection involving distance learning technologies and the results of the analysis of the study are described. The state of formation of professional responsibility in students of technical specialities is determined, the main problems and difficulties in the formation of professional responsibility of future specialists in the technical field are clarified, and the possibilities and role of social disciplines are revealed. The structural and logical scheme of integrating disciplines of a humanitarian cycle in a distance learning course “Professional Responsibility of a Technical Specialist in Modern Conditions” is presented.

## 1. Introduction

Information and communication technologies are able not only to diversify methods, forms and means of teaching, to provide effective mechanisms for quality control of knowledge, but also to open new horizons for research, to form powerful diagnostic tools that can be widely used in pedagogical research. The implementation of remote communication with respondents allows an in-depth understanding of the essence of pedagogical processes. It also clarifies the content component and assesses the quality of training of future professionals. The use of virtual learning environment in higher education institutions greatly simplifies research work [13]. It is both time and money effective way to collect data on solving current and strategically important tasks set by higher education. One of such tasks, conditioned by the realities of our life, is the formation of professional responsibility of future workers in the technical field. The concept of sustainable development of socio-economic systems, which is based on the principles of social responsibility of all economic entities, is gaining popularity all over the world. This is especially true of engineers, because they improve the quality of human life and open opportunities that can drastically change the environment. Technology today involves into all sectors of society, helps to organize social, political, economic processes, and, accordingly, the role and importance of professional responsibility of those who create it.



As part of research work conducted at Ternopil National Technical University named after Ivan Pului (hereinafter TNTU) on “Personal and Professional Development of Students of Technical Universities in the Study of Social Subjects”, number of state registration 0119U001322), a diagnostic study of professional responsibility formation in students of technical specialties has been conducted with the use of information and communication technologies. The research is aimed at identifying practical problems of formation of professional responsibility in future engineers and finding ways to solve these problems while mastering social subjects.

## 2. Methodology of research

The concept of responsibility is complex and multifaceted. Domestic and foreign philosophers, sociologists, psychologists, and teachers studied and researched it. The structural type of social responsibility is traditionally referred to as professional responsibility that is the central category of our study. Professional responsibility is a system-forming professional quality. Under professional responsibility we understand the characteristic of an individual which reflects the attitude of the subject to its content and results, to other subjects and himself in the process of work. The nature of this attitude is specified by the need for clear and full compliance with the proposed requirements and rules in professional activities, as well as the willingness to report on the results of their own activities [23]. A review of scientific sources on the problem of professional responsibility shows that this phenomenon is studied from the following perspectives: professionally significant personal quality; category specified by a set of personal qualities; personal property that has individual psychological correlates (locus of control). In the context of our study, the approach of scientists M. Berulava [1], E. Ilin [6], V. Miasishchev [4] and others on the relationship between professional responsibility and the locus of control and success in the field of professional activity is the most relevant.

In the context of our study, it is important to understand the structure of the concept of professional responsibility. The systematization of theoretical concepts available in the scientific literature was carried out by M. Sadova [19]. She identified three main approaches to solving the issue: *three-component approach* (M. Savchyn [20]), *factor approach* (V. Priadein [14]) and *functional approach* (K. Muzdybaev [12]). The first approach is based on the selection of cognitive, emotional and behavioral components of professional responsibility. The factor approach emphasizes the relationship between the essence of professional responsibility and the mechanisms of its implementation. It is proposed to define professional responsibility through the functional unity of motivational, emotional, cognitive, dynamic, regulatory and productive components. The analysis of all these components indicate that there are the harmonic (balanced) and anharmonic (imbalanced) constituents of responsibility [14]. The functional approach is based on the selection and analysis of objective and subjective aspects of professional responsibility. The main components of responsibility in this case are the subject, object, instance of responsibility and its time perspective [12].

Responsibility is grounded on basic psychological formations such as self-awareness of the individual and its components such as self-esteem, I-concept of personality, as well as the relevant psychological mechanisms (self-regulation and reflection). The internal instance of responsibility is conscience [20]. Attitude to professional responsibilities depends on the vital and professional position of the specialist. With the responsible attitude to the professional duties they show the maximum activity and productivity, with the indifferent they just formally carry out the requirements, and with the negative attitude they seek to do as little as possible and do not ensure the quality of work and its outcome.

The professional responsibility of a technical specialist is of paramount importance today. E. Conlon claims that in the framework of sustainable development, modern labour market requires employees to understand the broad social context of vocational issues and the responsibility of engineers for the results of their work [3]. S. Semerikov, A. Striuk, L. Striuk, M. Striuk and H. Shalatska distinguish fifteen basic general professional competencies of a specialist in software engineering, among them there is the ability to act in a socially responsible and conscious manner [21].

In addition to the theoretical understanding of this problem, in educational practice there is a number of activities aimed at nurturing a sense of belonging to global processes and responsibility for their

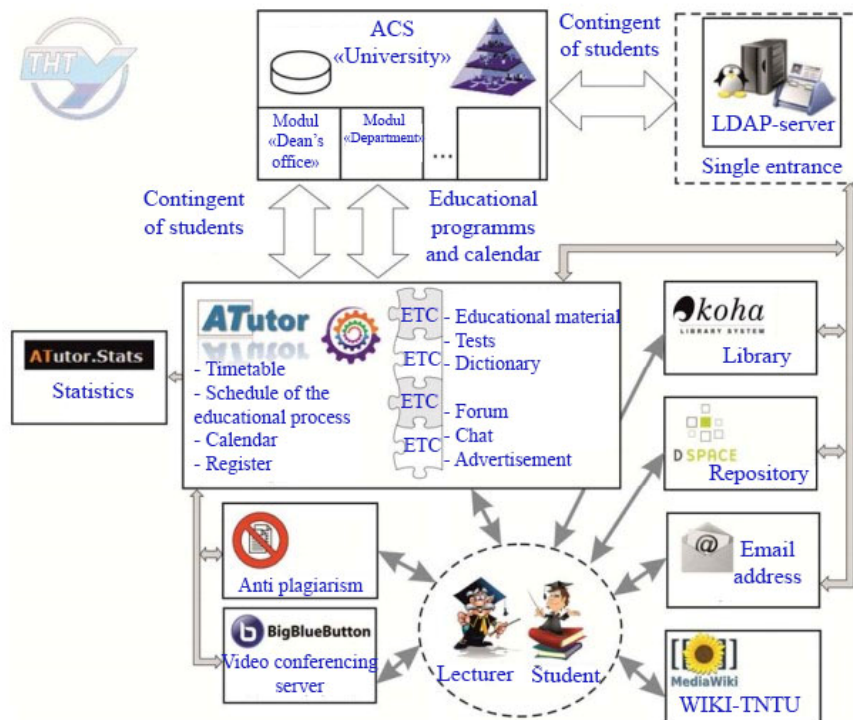
consequences in students of technical specialties. Professional responsibility is one of the main general engineering competencies and learning outcomes in higher education. In foreign professional pedagogy a new method is being developed at the University of Western Australia to determine general engineering competencies. In particular, S.A. Male offers to work not only on the formation of general or professional competencies, but emphasizes the importance of integrated general engineering competencies which include professional responsibility [8]. Sydney University of Technology implements a sustainable development program for engineers [2], etc.

Professional responsibility integrates the moral, volitional and professional qualities of future professionals in a new entity which is purposefully developed in the conditions of special training. Therefore, it is important to monitor the state of formation of professional responsibility of students of technical specialties, to develop tools and ways of its purposeful formation at the time of getting higher education. This determined the purpose of our study.

In determining the levels of professional responsibility of technical specialists, the key to our study were the four main modes of studying professional responsibility, identified by M. Sadova [19]: 1) what is professional responsibility? 2) what is a person responsible for? 3) who is a person responsible to? 4) in what way is a person responsible? In order to create diagnostic tools that would allow to determine the levels of professional responsibility, the following methods have been used: Rotter’s Internal-External Locus of Control Scale, developed by J. Rotter based on his social learning theory [18]; methods of diagnosis of responsibility, developed by V. Priadein [15], questionnaire for diagnosing the level of moral and ethical responsibility of an individual (I. Tymoshchuk) [24] and DPSR (I. Kocharian) [7].

**3. The implementation of the testing**

For data collection, a virtual learning environment of Ternopil National Technical University named after Ivan Pului was used. It has been developed on the basis of the Learning Management System (LMS) ATutor and has been successfully used to organize the learning process since 2002 (figure 1).



**Figure 1.** TNTU Virtual Learning Environment.

A questionnaire containing 65 questions and brief instructions for its use were entered into the database [9]. The questions were divided into three sets that correspond to the levels of professional responsibility defined by us:

- Formal and technical responsibility. It is characterized by a formal approach to work, lack of initiative and desire to develop and create something new. Basically, the understanding of the professional responsibility of an engineer is reduced to compliance with safety standards when working with technical devices, their proper operation. All that should be the focus of a specialist (according to students) is about reliable results, accurate calculations. They are the ones that testify to professionalism;

- Managerial and communicative responsibility. At this level the social significance of the work of a technical specialist is manifested. The main focus is on communication between the consumer and the manufacturer, relationships with colleagues and management. The responsibility is primarily treated as collective. The main features of this level are: honest performance of tasks set by management, responsibility to the end user for safe use and quality of the product, as well as to colleagues for the success of the project;

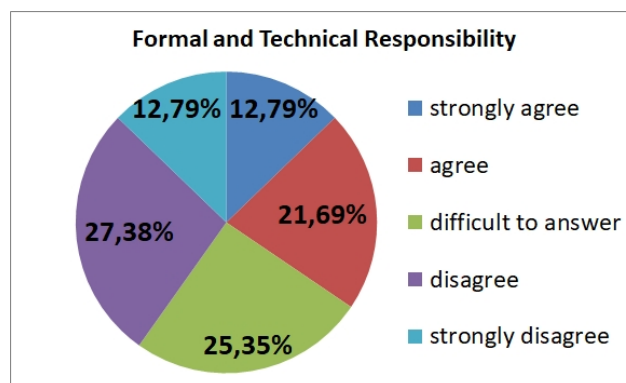
- Research and prognostic responsibility requires a comprehensive understanding of the history and significance of the future profession. This is about a sense of belonging to the outcomes of scientific and technological progress, creating a future human environment, responsibility to future generations, solving global problems through technology and more. It provides a creative approach to business, the ability to act autonomously.

Each of the sets contained 20 questions. Also, students were asked five provocative questions, the answers to which may indicate respondents' veracity. There were five possible answers to each of the questions: "I strongly agree", "I agree", "It is difficult to answer", "I disagree", "I strongly disagree". The first two options counted as affirmative (with varying confidence degrees), the last two as negative. The option "It is difficult to answer" was classified as the one that indicates the respondent's lack of interest in the question, lack of knowledge and experience, it was a sign of inability to have an opinion in order to determine the answer.

The university students of the Faculty of Computer Information Systems and Software Engineering took part in the survey. They major in *121 Software Engineering*, *122 Computer Science*, *123 Computer Engineering* and *126 Information Systems and Technologies*. The results were processed in the Excel program. The study covered 87 people.

#### 4. Results and discussions

The analysis of respondents' answers showed the following results:



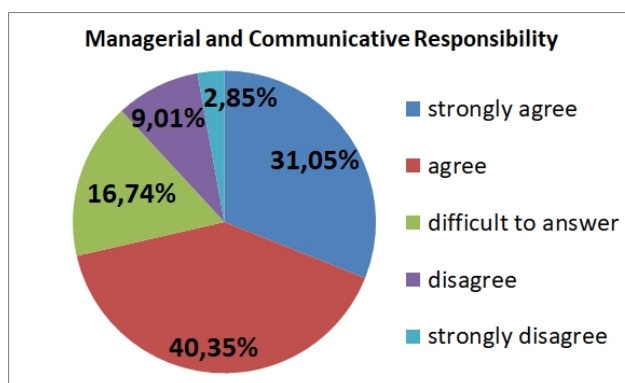
**Figure 2.** Distribution of students' answers to the questions of set 1 of the questionnaire "Professional Responsibility".

As can be seen from the diagram (figure 2), only 12.79% of respondents strongly disagreed with the proposed statements, most of which were provocative and indicated a formal approach to work. This

proves that students are focused on their own interests, they lack in creative approach to business.

Only 13,95% of respondents strongly agree that the concept of professionalism implies knowledge that goes beyond the subject area; 18,61% of respondents claim that creativity and multipotentiality is not their option, and 34,88% could not provide any answer to the question at all. 27,91% of students who participated in the survey agree that they will never need humanities in the real professional life, and 23,26% opted for “It is difficult to answer”. To some extent, the concept of “creativity” is correlated with technical specialties for 45,35% of respondents which is less than half of those surveyed. 24,42% agreed with the statement “Let scientists do scientific work. They are paid for it” and 18,60% did not provide any answer. Only 26,74% consider that it will be possible in their future professional activity to go beyond the job description. 40,7% called material remuneration to be a priority in choosing a job, 26,74% of future specialists did not come up with the answer to this question. Only 11,62% of respondents would not agree to give up their specialty for a higher salary.

Analysis of answers to the questions of managerial and communicative responsibility set (figure 3).



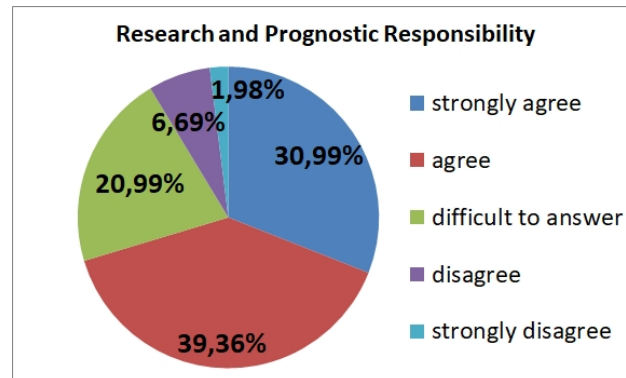
**Figure 3.** Distribution of students’ answers to the questions of set 2 of the questionnaire “Professional Responsibility”.

The level of managerial and communicative responsibility is quite high – 71,4%. This allows us to say that students are able to maintain good relations with colleagues and the management, feel responsible for the results of their work to other people. Some questions were tricky. Affirmative answer to them indicates unwillingness to work autonomously and a lack of personal responsibility. In particular, only 13,96% of respondents do not associate career growth with good relationships with management. To the question “The manager, first of all, should control employees and not rely on their responsibility” the answer “strongly agree” was provided by 22,09% respondents, “agree” – 29,07%, “difficult to answer” – 23,26%. Only 1,16 % of students strongly disagreed with the statement. Exactly half of the respondents put the blame for the failure of the project solely on the management. However, only 3,49% of respondents can be critical of colleagues’ mistakes, claiming that “everyone makes mistakes.” 19,76% of respondents allow “shortcuts” while performing the duties (what they only cared about is that no one can notice), 25,58% did not decide on the answer.

For the success of the common enterprise, 58,13% of respondents are ready to sacrifice their interests. Only 3.49% prioritize their own interests over the collective ones. 86,05% of students agreed to admit their mistakes and would be willing to rectify the problems and eliminate their consequences. Only 2,33% do not want to do this. It should be noted that with the generally high level of managerial and communicative responsibility, it is usually perceived by respondents not as a personal but as a collective responsibility.

The results of the study showed a high level of formation of research and prognostic responsibility (figure 4). This can be largely explained by the fact that purposeful work was carried out in this direction. During the study of social disciplines (philosophy, history and culture of Ukraine, political science, law) special attention was paid to the issues related to the value of the chosen specialty, personal and

professional responsibility of a technical specialist in modern conditions, understanding global processes of technocracy of public life. For comparison, in a previous survey (October 2018) [5], only 20% of respondents showed signs of research and prognostic responsibility.



**Figure 4.** Distribution of students' answers to the questions of set 3 of the questionnaire "Professional Responsibility".

The vast majority of students realize that the technical sphere today is a collective mind capable of bringing humanity to a qualitatively new level of existence. The answers were distributed as follows: "I strongly agree" – 29,07%, "agree" – 52,33%, "difficult to answer" – 15,12%, "disagree" – 3,49%, "strongly disagree" – 0%. However, 76,74% agreed with the statement that an engineer, first of all, is an intellectual, an erudite, a researcher. 89,53% of respondents agreed that technology can both help and harm people. The results of the survey shown that only 18,61% of respondents indicated that they know the history of the development of their specialty to some extent. 32,56% of students who took part in the survey could not answer the question whether they are proud of their future profession. Only 34,88% of respondents to some extent feel their belonging to the global processes of technocracy.

A large percentage (20,99%) of responses "difficult to answer" was revealed in the questionnaire.

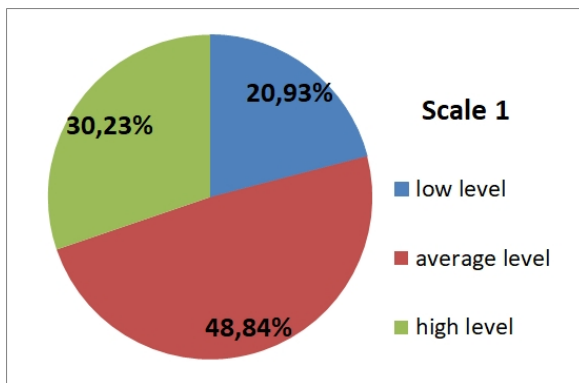
Based on the analysis of the obtained results, the main factors influencing the formation of professional responsibility of students of technical specialties are identified. They are as follows: universal cognition and capability of scientific and technical creativity; professional empathy and collectivism; priority and profession certainty; capability of autonomous activity and personal responsibility.

Four scales were created, each included 15 questions, the answers to which indicate the presence of the above factors of professional responsibility: if there are up to 5 answers on the scale, it indicates low level; from 6 to 10 is of average level; from 10 to 15 is a sign of high level.

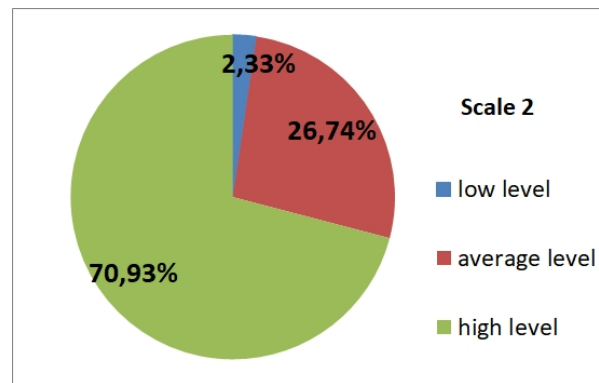
According to figure 5, the level of formation of universal cognition and ability to do scientific work and to be technically creative cannot be considered sufficient, as only 30,23% of respondents showed a high result. The formation of professional empathy and collectivism in the respondents (figure 6) is quite high which generally corresponds to a high level of managerial and communicative responsibility (figure 3). This only confirms the previous conclusions that the vast majority of students understand professional responsibility as collective. The level of formation of priority and value certainty of the profession (figure 7) is very low, as only 9,30% of respondents showed a high result. The level of capability of autonomous activity and personal responsibility of the surveyed students (figure 8) is very low, because only 8,14% of respondents have a high score.

Thus, the study revealed shortcomings in understanding the essence and content of the concept of "professional responsibility", its insufficient level in students of technical specialties. Therefore, it is necessary to purposefully form professional responsibility of future technical specialists. In this aspect, it is advisable to use the complex capabilities of social disciplines. In foreign engineering education it is often proposed to strengthen the humanitarian component. For example, H. Sjursen argues that the

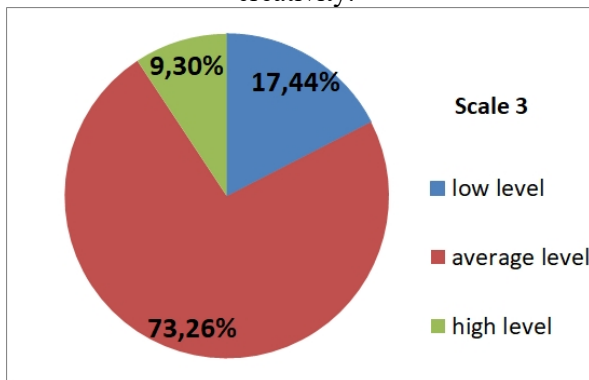
need to diversify engineering training with subjects of humanities is an imperative of our time [22]. M. Reimer develops the concept of “emotional intelligence” as a necessary component of the success of a technical specialist [16]. This quality is responsible for the formation of professional qualities of an engineer, important in the modern technogenic world in general and responsibility for the results of their work, in particular. The problem of humanization of technical knowledge was also addressed by D. Missingham [11], P. Vohra, R. Kasuba, D. Vohra [25] and many other scholars. In our opinion, the experience of the Massachusetts Institute of Technology is very interesting. They offer a two-degree training program with a bachelor’s degree in the humanities or technical sciences or the humanities and natural sciences. The introduced program provides a generally balanced training.



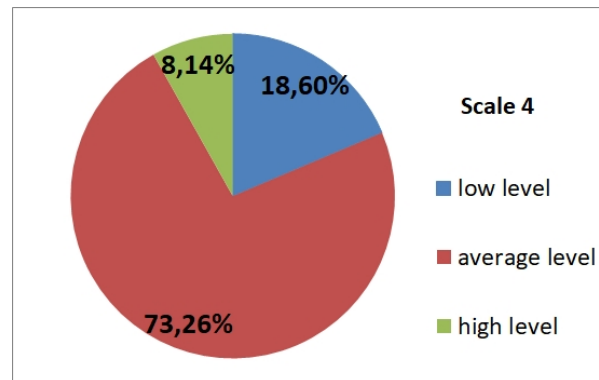
**Figure 5.** Formation of universal cognition and capability of scientific work and technical creativity.



**Figure 6.** Formation of professional empathy and collectivism.



**Figure 7.** Formation of priority and value certainty of the profession.

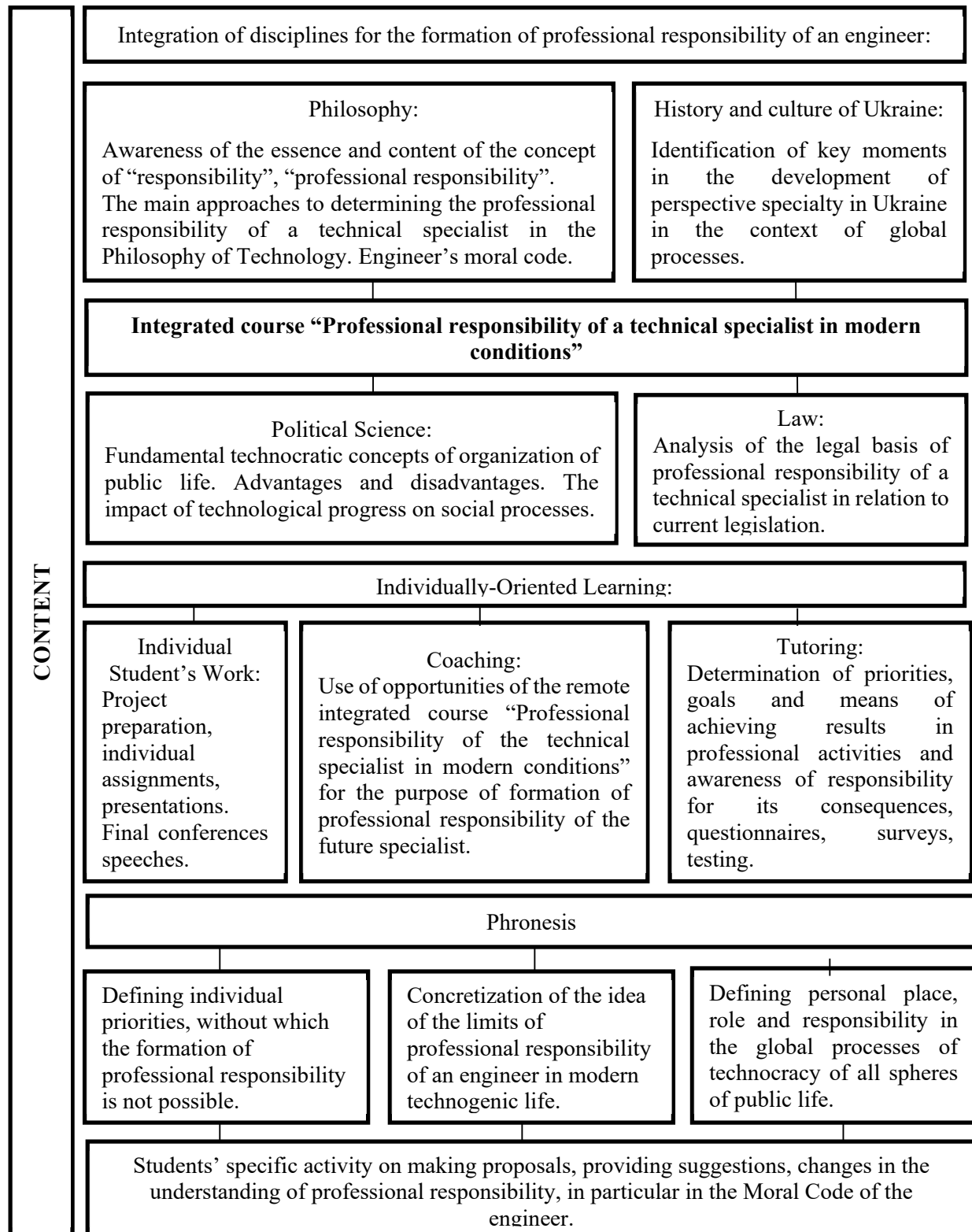


**Figure 8.** Formation of the capability of autonomous activity and personal responsibility.

Purposeful use of opportunities of social disciplines in the process of formation of professional responsibility of students of technical specialties will help future specialists to be more competitive and mobile in the world of labour market. The knowledge of humanities will lead them beyond narrow specialization and will open new horizons.

The task is complex and requires an integrated approach. What is particularly advisable is to create an integrated distance learning course “Professional responsibility of a technical specialist in modern conditions” (figure 9). The virtual learning environment provides a sufficient number of tools for effective work: the ability to post lecture notes, guidelines and presentations, a glossary of key terms used to present material, links to materials of seminars, conferences, etc., posted on the Internet. Communication of participants can be carried out by means of a forum, chat, the built-in e-mail. It is possible to use a file hosting server, perform individual and group tasks.





**Figure 9.** Scheme of the integrated distance course “Professional Responsibility of a Technical Specialist in Modern Conditions”.

The suggested course provides two modules: “Professional responsibility as a key competence of an engineer” and “Professional responsibility of an engineer in the context of global problems nowadays.” The first module summarizes the theoretical approaches to the definition of “responsibility”, “professional responsibility”, “professional responsibility of an engineer”, focuses on the philosophical understanding of these categories. The content of the second module is aimed at revealing the practical problems of the engineering profession which are studied through the prism of the history of the specialty, outlining the specifics of legal aspects of professional responsibility of technical specialists, public policy to determine the prospects of the specialty. By covering the course, students will be able to be part of the solution to global problems of today, they will familiarize themselves with the Codes, the Credo of professional ethics of an engineer (USA, Germany, France, Japan), they will form their professional position. It is also a good idea to bring the materials of international conferences, forums, symposiums, etc. for discussion.

The use of a distance learning course provides more opportunities for personality-oriented learning than classroom work. The students communicate directly with the teacher, they have the opportunity to ask questions, receive information of their interest, express their views, voice comments, suggestions and more. The teacher, respectively, through individual communication has the opportunity to take into account the psychological characteristics, abilities and interests of every student. Teachers can offer tasks that would be not only useful in terms of obtaining information, developing skills and abilities, but also interesting for a particular student. This will facilitate the implementation of subject-subject interaction in the educational process.

Problematic issues should be brought up for collective discussion. The distance learning system provides an opportunity to hold web conferences, webinars, round tables in video and audio modes, communicate in chats, exchange useful information.

Phronesis is important for the formation of professional responsibility in the framework of the study of the proposed integrated course. This approach, which indicates to a person what needs to be done for his/her own good and for the good of others, is actually a synthesis of the social and the individual defined in particular actions and is aimed not at the abstract but at the concrete common. That is, everyone knows their Truth “in general”, and can act freely, in accordance with the specific priorities set by a particular situation [17].

For broadening the opportunities of basic version of ATutor system, the Institute of Distance Learning at Ternopil National Technical University named after Ivan Pului (<http://idn.tntu.edu.ua>) has developed and introduced a number of additional modules: event planner calendar; module for importing educational material from Microsoft Word documents; module for testing knowledge by adaptive algorithms (Computerized adaptive testing CAT); module and the corresponding server of the automated authentication of educational works and materials; video conferencing server module BigBlueButton [4].

## 5. Conclusions

Today the problem of training a new generation of engineers with a formed professional position, high moral standards and competitive spirit is becoming especially relevant. Professional responsibility is the key to successful activity; it guarantees a positive result, reduces the risk of professional errors and faults. In our understanding, professional responsibility is viewed as an integral quality of a specialist’s personality. It involves conscientious performance of professional duties, it guarantees the appropriate level and quality of professional activity, even in the conditions of unpredicted difficulties.

The use of information and communication technologies can significantly facilitate and simplify the work of data collection in pedagogical research. Higher education institutions which provide opportunities for virtual learning environment can diagnose the formation of educational competencies, identify shortcomings and eliminate them. During the questionnaire involving the virtual learning space created on the basis of the learning management system (LMS) ATutor, we identified and confirmed three levels of professional responsibility of students of technical specialties (formal and technical, managerial and communicative, research and prognostic) and the main factors influencing their

formation (cognition and capability of scientific and technical creativity; professional empathy and collectivism; priority and value certainty of the profession; capability of autonomous activity and personal responsibility). They are all interconnected, complementary and determine the general level of professional responsibility of the future specialist. Based on the analysis of the results of the study, weaknesses in students' understanding of professional responsibility were identified. They include the focus on the material component of the future profession and lack of its value certainty; low level of personal responsibility and its transfer to management; ignorance about the historical aspects of the chosen specialty; low level of initiative and the inability to be creative, etc.

For purposeful formation of professional responsibility in students of technical specialties it is expedient to use complex possibilities of social disciplines which promote development of abstract thinking and the general erudition, given the chance to go beyond narrow specialization and to understand a place, role and value of the chosen profession in the modern technogenic world, consciously and responsibly. The proposed distance learning course "Professional responsibility of a technical specialist in modern conditions" integrates the possibilities of philosophy, political science, law, history and culture of Ukraine for the formation of professional responsibility of students of technical specialties, for their understanding of personal significance, their place and limits of professional responsibility in the changing technogenic environment.

We see prospects for further scientific research in the development of technology for the formation of professional responsibility of students of technical specialties in the study of social sciences.

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