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The Issues of Development of a Creative Professional

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Abstract

The article covers the issues of engineering education. The authors take as a premise that the most important quality of an engineer is his/her creativity, therefore the goal of engineering education is to form and develop students' creativity. This article evaluates the opportunity of developing the creative constituent of engineers' skills. The authors draw the conclusion about the lack of disciplines that would favor the development of creativity. They focus on the over-disciplinary function of the *Philosophical and Methodological Problems of Science and Engineering* discipline; the function allows to regard the history and methodology of science as a foundation for development of creative skills that ensure the innovative activity of future engineers.

Keywords: creativity, innovations, over-disciplinary, philosophy, methodology.

1. Introduction

> A professional is similar to dental abscess – their completeness is one-sided.
>
> Aphorism 101 of K. Prutkov's *Fruits of Thoughts* gnomology

Innovations in education have many aspects. First, these are the innovations relating to the state education policy; they are of crucial nature and affect system changes of the educational process. Innovations relating to the organizational structure of universities, to management, finances, efficiency, etc. Innovations in teaching: methodology and didactics, where the efficiency of the educational process depends on many factors, but mainly on teacher and student. This article covers the methodology of teaching philosophy, in particular teaching the *Philosophical and Methodological Problems of Science and Engineering* discipline for masters in the field of engineering.

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1.1. Objectives of engineering education

Under the present-day conditions, a creative professional, an engineer capable of innovative activity, becomes more and more demanded. "As the world spins faster and faster, organizations everywhere say that they need people who can think creatively, communicate and work in teams: people who are flexible and quick to adapt. Too often they say they can't find them."

The needs of the society determine the objectives for modern universities. Development of creative professionals is the goal of engineering education and it is defined in international documents, mission statements and objectives of modern technical universities. For instance, it is said in the mission statement of the National Research Tomsk Polytechnic University: "To contribute to Russia's prosperity through the pursuit of education, learning, and research at the highest international levels of excellence thus building and enhancing the competitive position of our country. We place special emphasis on advanced engineering education, generation of new knowledge, innovative ideas, creation of resource-efficient technologies, internationalisation and integration of research and academic activities. Our winning formula is synergism based on professionalism, creativity and harmony".

Contemporary Russian engineering education has the goal of bringing the education in the country to the level stipulated by the international standards.

1.2. Skills of engineers

TPU Basic Educational Programs Standard (BEP) was created on the basis of the Federal State Educational Standard (FSES) as well as on the international engineering education standards (Robinson, 2013). It is supposed to achieve the set objective by means of developing a certain set of skills. TPU BEP Standard defines skills as preparedness, i.e. having motivation and personal qualities that would allow using one's abilities in order to successfully carry out a professional activity. The abilities include knowledge, skills and experience.

As a part of this research, we will examine the problems of developing common cultural and universal skills that underlie students' creativity.

For our research, we used TPU institutes' curricula. We have analyzed the ratio of the developed skills and the set of disciplines that are to provide the development of these skills.

The records on coherence of the training results (professional and common cultural skills) according to the basic educational program of bachelors' training in various institutes reflect the following results of education, i.e. the activities university graduates should be prepared for upon getting their master's degree.

The following skills are marked as the professional ones: to use natural scientific and mathematical knowledge in order to solve scientific and engineering problems and produce new materials; to use deep special knowledge in order to solve cross-disciplinary engineering problems; to set and solve innovative problems of the engineering analysis; to carry out innovative engineering projects; arrangement and carrying out of theoretical and experimental research, critical assessment of the obtained data and drawing conclusions; design supervision of the processes of design, implementation and operation.

The following skills are marked as the universal ones: to use project management knowledge in order to carry out the innovative engineering activity; to be able to communicate in the professional environment and society; presentation and defense of the innovative engineering activity results; efficient work both individually and as a member or leader of a group while solving innovative engineering problems; to show personal responsibility and the responsibility for the work of the supervised group; readiness to comply with the corporate culture of the company; commitment and readiness to comply with professional ethics and standards of carrying out the innovative engineering activity; to show the ability for self-education and constant self-improvement in the engineering activity; the ability for teaching; to display deep knowledge of social, ethical and cultural aspects of the innovative engineering activity and sustainable development competence.

Comparing the records on coherence of the BEP education results with the main employers of various institutes, one can note that the same skills are demanded by the employers. The main skills are divided into the common cultural and professional ones. The professional skills are divided into engineering, research, management and design skills.

The universal skills include the common cultural skills: project management skills; communication skills; the ability to present and defend the results of the innovative engineering activity; efficient work both individually and as a member of a team; knowledge of professional ethics and standards of carrying out the innovative engineering activity; the ability for self-education and self-perfection and the ability to teach.

Therefore, both professional and universal skills of masters are aimed at the development of engineers' ability to carry out the innovative engineering activity, i.e. implementation of their creativity. Creativity is a set of personal qualities that include such characteristics as creative thinking, critical thinking, the ability to comprehend and assess information, to develop one's own opinion on the basis of the given data, the ability to present one's ideas, self-control and self-development skills.

1.3. Disciplines that provide the development of skills

The skills mentioned above are formed and developed within the framework of professional and common cultural disciplines.

Professional disciplines include the ones that can be further divided into the disciplines providing theoretical material and the disciplines that include practice and methodology of the engineering activity, the ones that give the general idea of a problem. The conducted research has revealed the following.

Methodological disciplines: History and Methodology of Chemical Engineering, Computer Techniques in Science and Education, Mathematical Models, Experimental Approaches in High-Current Electronics, History and Methodology of Mechanical Engineering, Experiments and Mathematical Methods of the Results Processing, Basic Research Techniques in Organic Chemistry, Theoretical and Experimental Research Techniques in Chemistry, etc.

The disciplines that give the general idea of a problem: Contemporary Issues of Chemical Engineering, Contemporary Scientific Issues of Mechanical Engineering, Urgent Issues and Innovations in the Instrument-Making Industry.

The liberal constituent of the curricula consists of philosophical and management disciplines and the disciplines that develop creative thinking.

Philosophical disciplines of the curricula: Philosophical Issues of Natural Science and Engineering; History and Methodology of Science and Engineering; Philosophical Issues of Natural Science, Humanities and Engineering; Philosophical and Methodological Issues of Science and Engineering.

The disciplines that develop management, self-management and project activity skills: Management.

The disciplines that develop creative thinking: Methodology of Scientific Work, Planning and Arrangement of Research and Development Work. The research and development during academic terms and preparation of a master's thesis that are included in the curriculum do not presuppose class hours.

While methodological and philosophical disciplines are included in the curricula of almost all technical fields of specialization, the disciplines aimed at the development of such important skills as project management, management and self-management, creative thinking and methodology of scientific work, are included in the curricula of only several fields of specialization.

1.4. The issue of skills development

Having analyzed the set of skills of a contemporary professional and the curricula of the offered disciplines, we can conclude that certain skills simply cannot be obtained under this set of disciplines. The problem is how to

give a future professional the opportunities for fully-fledged personal development, development of his/her creativity and of all the skills that are stipulated by BEP, with the set of disciplines we have.

The set of professional and universal skills suggests that merely special disciplines in the professional set cannot fully develop the presented skills. Development of these skills is a problem that should be solved in the framework of the liberal disciplines.

However, there are not enough liberal disciplines in order to develop such skills as the ability to think critically, creative thinking skills that provide opportunities for carrying out the innovation engineering activity, public performance skills that allow to communicate in the professional environment and society in general, etc.

The drawback of liberal arts education reveals itself not only in the skills development difficulties, but also in the absence of general culture of speech, low literacy rate, ignorance of the history of science and methodology of scientific research. The problems that the students studying philosophy have are the inability to express their thoughts logically, the inability to perform in public, to make and carry out presentations, to work with texts.

Reduction of hours for teaching philosophical disciplines does not allow working on the development of creative and critical thinking skills and the ability to express one's thoughts, as well as it does not allow to present information comprehensively. However, it is not the only issue; there are problems that can be solved if the methods of teaching philosophical disciplines in technical universities are adjusted. For example, one of these problems is rejection of the humanities in general and philosophy in particular. One of the reasons for that can be high school fields of specialization. We can also point out such a peculiarity of technical university students as a special way of thinking, which is characteristic of them, their wish to see clear logic and structure in philosophy textbooks and lectures. Another, and, in our opinion, the most important reason is the nature of philosophical range of problems, their abstractness from specific targets of future engineers.

Teachers do not always coordinate the level of their demands to their disciplines with each other. In other words, here we speak of multitasking and, as a consequence, the lack of time to complete the tasks given by the teachers properly.

2. The role of philosophy in the process of development future engineers' creativity

2.1. Over-disciplinary function of philosophy

The issue of multitasking can be solved if one uses the over-disciplinary approach to teaching philosophy. The over-disciplinary function of philosophy reveals itself in the very nature of philosophy, in its ability to see the reality comprehensively, in its consistency and interconnection. This very approach allows students to consider all aspects of the studied discipline, including history and methodology of its study, while working on their master's theses.

The students are interested in the subject matter of the humanities and consider liberal disciplines necessary for a future engineer's development. A survey was conducted among TPU postgraduates in order to find out about their preferences in the topics of the humanities. The survey has revealed that the following issues of the liberal disciplines are considered interesting and useful by the students: ways and methods of scientific and technical research; history of scientific and engineering activities; ways of creative thinking development; forecasting of the technological progress consequences; meaning and value of human life; arousing interest in a project among workers; management and design of one's life; the ability to present one's ideas, plans and projects.

One of the liberal disciplines that still remains on the curricula of the technical fields of specialization is the *Philosophical and Methodological Problems of Science and Engineering* discipline. There exists a work program for teaching this discipline that stipulates the main topics and issues for lessons but also includes some space for a creative approach to the selection of methods and didactics. The *Philosophical and Methodological Problems of Science and Engineering* discipline consists of six modules: Philosophy, Science and Engineering; Forms and

Prospects of Interaction; Methodology of Scientific Work; History of Science and Engineering; Scientific and Engineering Creativity; Philosophical Issues of Engineering; Ethical Dimension of Science and Engineering.

These modules correlate with such skills of engineers as development of the ability to carry out the innovative activity, development of creativity, public performance skills, etc., and are implemented by means of theoretical and practical constituents.

2.2. Basis for the development of creativity

G.S. Altshuller's idea about the fundamentals of the inventive activity presented in the Theory of Inventive Problem Solving (TRIZ) serves as the basis for the students' creativity development in the framework of the *Philosophical and Methodological Problems of Science and Engineering* discipline. The inventive process consists of two complementary sides. First, this is the material, object side: knowledge of history of the engineering progress, comprehension of the main laws of the engineering progress, analysis of actual inventions. Second, the mental one: observation of the process of inventors' creative work, assimilation of innovators' experience, experimental research of the inventive creativity process.

G.S. Altshuller suggests a way of increasing the level of the creative skills development. It is analytical skills training. In order to do this, it is supposed to know the investigated field of engineering in its alteration and development, to understand dialectical laws of its development. The ability to carry out logical analysis and to analyze earlier inventions systematically is essential. Important elements of success in creativity are knowledge of the history of engineering, the volume of engineering knowledge, the volume of actual factual material, investigation of typical solving techniques (the usage of prototypes from nature and other fields of engineering); search for new solving techniques by means of alterations: within the system, in the external environment, in the adjacent systems.

Therefore, the concept of development of creative thinking includes the ability to think in various ways, to see the diversity of problem solving, to find non-standard solutions. Knowledge of the history of science is an essential constituent of the scientific activity.

2.3. Methodology of teaching

In order to implement the over-disciplinary function of philosophy we have attempted to unite the tasks that postgraduates have in terms of work on their master's theses and in terms of studying philosophical and methodological issues of science and engineering.

The subject matter of the philosophical research was presented by the topics of master's theses, which solved the problem of multitasking; the students understood the appropriateness of studying philosophy and saw the opportunity to use the obtained knowledge in order to solve actual problems of their scientific and academic research. Therefore, implementation of the over-disciplinary approach takes place when students present their highly specialized topics using the philosophical approach to the problem.

The lessons were conducted in the following way. When the students studied the discipline (philosophy), they had already determined the topics of their master's theses. Nevertheless, the opportunity to discuss the topic with the students of the same year allows them to see other aspects of the investigated issue. During practical lessons, they got acquainted with other students' topics, learnt the background of the issue, analyzed the used methods, planned the actual work, adjusted goals and objectives in accordance with the philosophical point of view. During practical lessons, the brainstorming and the six thinking hats methods were used.

The result of this activity is the definition of objectives, determination of the line of further research. The mind map method (Edward de Bono, 2013) is used in order to plan a master's thesis. In these maps, students define the problem, object, subject, goal and objectives of the research, include the main chapters of the thesis, information

concerning the background of investigation of the issue, methods of investigation, results of other researchers, their own exploratory work and the ethical constituent of the research.

The students make presentations and choose the topic for these presentations on the basis of the objectives they set in their master's theses in terms of the philosophy subject matter. One of the tasks the students solve at this stage is the skill to present the topic of their work in a way that is easily understandable both to professionals, i.e. their groupmates, and to a person who is far from the technical subject matter, i.e. their teacher.

3. Conclusions

Therefore, such parts of an academic course as the history of science and methodology were efficiently used while preparing master's thesis projects, thus implementing the over-disciplinary approach. The methodology of philosophy and the subject matter of highly specialized scientific works were synthesized, the practical relevance of philosophy was implemented and philosophy was regarded as a method that facilitates work on a master's thesis.

The project method was also implemented, since the philosophy task corresponded to the prime objective of the postgraduates, i.e. preparing their master's theses.

The method of interactive teaching was implemented: the subject matter of the lessons was determined by the students; they were given an opportunity to design their own educational path by themselves; some elements of self-management took place; the process of studying was arranged asynchronously with the priority to independent work of students, when students determined the subject matter of the lessons and the teacher's task was only to help, correct and direct.

Education of a successful engineer is, most significantly, education of an engineer who possesses creative thinking skills. This is an over-disciplinary issue. We can solve this issue by unifying the ideological, philosophical, methodological, management underpinnings with theory and methodology of a specific science, and by interconnecting them with practice. Finally, the most important thing is to unite the efforts of students and teachers. The innovative approach to education is aimed at developing knowledge, abilities and skills that are essential not only for the reproductive activity, but, primarily, for the productive activity on the basis of the epistemology and eurikology methods.

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