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Methodological foundations of engineering education

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Abstract

A problem of methodology choice for engineering education is considered. The Authors focused on matching it with purposes of maximal efficiency and effectiveness of schooling engineers and maximal satisfying needs of society and economics in competent cadres.

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Keywords: Methodology, method, creative engineer, creation.

1. Introduction

One of the fundamental problems of higher school is perfecting of methodological foundations of engineering education. Deep changes occurred in all spheres of our society, including higher education, during the last 20 years. Attempts of reformations in professional schooling are going on till now. These transformations are essential events in the lives of teachers and students, and it is important to analyze and generalize an international theoretical and practical experience in that area. For instance, such methodologies are spreading as American pragmatism, Japanese "Kaizen" (perpetual improvement) (Masaaki, 2001), Triple helix, (Henry, 2001) Bolognese model of education, etc. Many authors are anxious about dysfunction of traditional educational system: it does not support but even suppresses inborn creativity of students (K. Robinson (Robinson, 2013), S. Pavlina (Pavlina, 2013), R. Ackoff (Ackoff, 2008), D. Stiglitz (Stiglitz, 2002), et al.)
Our aim is to make certain contribution in considering the methodology of engineering education: we will discuss a problem of which option of the methodology suits most to achieving maximal efficiency and effectiveness of engineering schooling and to satisfying requirements of the society and economy to qualities of its graduates.

It is necessary to take into account that the engineering community is an essential context for personal and societal development: every member of engineering community is a holder of professional and social qualities.

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Professional qualities include engineering competencies, but society demands from engineers to be adequate to its interests and necessities.

We show that there exists in the university engineering schooling a possibility to solve a problem of finding a methodology that satisfies all the necessary requirements: this methodology must be oriented at the preparing specialists who are creative engineers.

1.1. Problems

First, we believe that the main problems in reforms of higher school stem from the lack of conceptual pedagogic approach to development of the innovative system of higher education.

Second problem is a failure of attempts to introduce in the pedagogical process working elements of scientific research and its practical applications. The idea of such a method was proclaimed in (Kirillov, 2006) in 90's. Then it was formulated as the teachers' task "to learn teaching and to learn learning!"; now this task becomes acute even more. Ultimately, almost everything depends on whether both, teacher and student, are able to combine innovative purposes of education with innovative educational means. The innovative educational purpose is a mass production of creative professionals; the innovative educational means is a didactic teaching of cognitive-practical activities.

The idea of teaching the method is not new. In history of philosophy, science and education there are many relevant publications. Each scientific-pedagogical school have made its certain contribution; for instance, Tomsk school of philosophy and pedagogy gave works of S.I.Gessen and P.V.Kopnin (Kopnin, 1973). It is necessary to actualize all those contributions.

1.2. Formation of the method

The proclaimed and promoted here *method* consists of combining two activities in the educational process as essential parts of both, teaching and learning: cognitive scientific research and practicing its application. Such approach to defining "the method" was proposed by G.V.Kopnin (Hessen, 1995). This means that in studying every particular theme of the course teacher and student use particular rules and procedures, peculiar to the theme.

The method becomes a way of learning as for student and for teacher. It motivates students to creative behavior in their future professional activities. The following principles of mastering the method are described in (Kirillov, 2008):

- Methodology of activities embraces not only your professional specialty but also its paradigm, philosophy as well.
- Remember that philosophy is not just abstract view of the world but it defines a methodology of your profession.
- Strive to make your cognitive activity to have less speculative, more practical character.
- Strive to make your developing paradigm to become an ideal type of your professional and civil behavior.
- Deliberately continually improve purposeful aspects of the method.
- Always be ready to permanent improving changes in methodological paradigm: they are outcomes of cognition process.
- This list of principles may be prolonged by everyone mastering the method.

It is useful to remember always that studying the method is based on "three whales": Philosophy, Science, and Pedagogy. Mastering the method goes along the usual steps of cognition – from phenomenology to analysis to synthesis to wisdom. Various tools are used in the process, such as discussions, seminars, role games, briefings, presentations, etc. But the method of cognitive-practical learning must always be the systemic core of the activity. And here the pedagogical culture and competency of teacher becomes the most significant component of educational process. Lack of them is most negative factor for results of education.

2. Developing creativity as a principal didactic basis of education of modern engineers

The coherent and correct performance of pedagogical technologies by all members of educational process is not enough for achieving goals of modern engineering education. It is necessary to add the innovative direction to the process, pursuing fostering want and ability to creativity in graduates. Traditional and some new methods do not pursue this goal.

It does not mean that creativity is absent in education. Some specialties are creative by their nature: arts, literature, economics, science, governance. But in them creativity is a sort of congenial ability or talent (sometime genius). A question arises: is it possible to learn creativity?

Many consider creativity as mysterious and unknowable phenomenon of psyche. But we believe that the engineering creativity may be taught. At different levels creativity is potentially inherent in all human beings, and this potential may be fully revealed during bringing them up. Teachers must help students in such revealing.

Hence, creativity in its didactic aspect is not only ontology, but also gnosiology, axiology, and praxiology. So, it is necessary to consider the creativity dialectics and social cognition premises of creative thinking of man.

Certain professional specifications are gained a firm hold in engineering community, among them – engineer, scientist, entrepreneur, pedagogy worker, designer, manager, politician, etc. The community is expecting from its members possessing with not only professional competencies, but also with civil virtues and merits.

Engineer-pedagogy worker is not only an expert in a taught discipline, but a master in didactics and methodic of teaching engineering.

Engineer-scientist not only performs research professionally, but is competent in managerial activities connected with production and promotion of technologies and devices invented by him.

Engineer-businessman is able not only to produce technical goods and services, but is also competent in other aspects of engineering.

Engineer-politician is a specialist in governance and law oriented on promotion and lobbying interests of the engineering community.

Engineer-designer is directly connected with producing and customizing art engineering entities of various types.

Activities of engineers today depend to a larger degree on external to engineering factors than on internal and personal ones. Having intention to reorient engineers from cognitive to societal aspect of professional behavior, we propose a sort of generic matrix for developing and perfecting engineering professional community.

Conclusions:

- The ultimate purpose of engineering education is bringing up specialists as creative individuals.
- Creativity is means for professional self-development.
- The idea of teaching the method is the most important component of educational process.
- Methodology of fostering creativity is an imperative of modern engineering education.
- Creativity is in opposition to the destructive and asocial tendencies of consumerism.
- The cognitive foundation of engineers' success is the universal matrix.
- Accent in education on student's self-learning is aimed at supporting their talents and developing their creativity, proactively behavior, success ability, socializing.
- The author is implementing all these ideas in his pedagogical practice at Tomsk Polytechnic University for more than 20 years. Today's transformation of TPU into National Research University makes those activities even more actual.

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