Engineering Thinking Formation and Negative Formality Effect in the Students' Knowledge

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The article describes the competences for the modern engineer to have. Engineering thinking formation problems and formalism knowledge causes are identified. Basic ways of fundamental and professional knowledge integration aimed at overcoming the knowledge formalism are discussed.

Key words: *the engineer, engineering thinking, a formalism of knowledge*

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Engineering education improvement and prestige are the state strategy objective in Russia. Highly qualified and competitive engineers with the innovation and reasonable approach, capable to integrate the ideas from various scientific and engineering fields and fully apprehend the production process are needed for the stable development of the modern industry. According to the mass media statistics, 555 universities train students, and 200 thousand specialists, on average, are graduates. But only 1\3 works according to their major, because the salary does not meet the specialists' requirements. Moreover, 50% of all engineering positions are occupied by the specialists without the university-level technical education. This really has a negative impact on the work and output quality of the enterprises.

Modern society standards need qualified engineer training but there came problems due to the high technical education diversification, low background university entrants' knowledge, self-sufficiency, motivation for successful training and future professional activity, demographic decrease, high school skilled lecturers flight, obsolete equipment and teaching methods, advanced information technology scarcity.

Modern research analyses made by Bakharev N.P., Bobrikov V. N., Belonovskaya I.D., Petruneva R.M., Pecherskaya E.P., Pokholkov Y.P., Prikhodko V.M., Selesneva N.A., Tatura Y.G., Fedorov I.V., Chuchalin A. I. indicate the growing interest to the quality of engineering education and its problems.

Taking into account the demands of the employers, requirements of the third generation educational standard (analyzing the state-of-the-art technologies and own professional experience) the following competences,

necessary for a modern engineer, were distinguished to solve quality education problems (general view).

1. Proficiency in fundamentals:
- engineering thinking (professional mobility and determination to self-development, mental outlook, humanitarization – ability to subject any technical research to be harmless to people and nature);
- knowledge, abilities, and practical professional skills;
- communicative competence (initiative, activity, leadership, discussion skills).

2. Market knowledge:
- informative competence (specific skills to use technical devices – from the telephone to the PC and computer network); to get information from various sources including electronic communication links, to understand information, to structure it, to evaluate it and use effectively; to know the analytical processing methods and dataflow in the subject field.

3. Psychological availability to competitive behavior (to act in the contest situations, mobility, opponent activity prediction, ability to assign priorities, professional intuition):
- necessity of successful activity (the objective realization, organization skills);
- responsibility (vital energy to complete the work, response reaction, participation in public affairs).

4. Starting position (fundamental knowledge, experience, level of culture, natural gifts):
- creativity – ability to create new specific ideas and answers, sensitivity to unusual details, contradiction and uncertainty, flexibility to switch over to something different, ability to work in various environment, to use associations for expressing the thoughts, and skill to see the complex in the simple and simple in the complex) .

5. Ability to self regulation, self organization and adequate consideration, professional and personal qualities self evaluation:
- engineering consideration (wish to critically self-evaluate the results of own activity, knowledge of the matter and the purpose of the engineering consideration; self-development necessity understanding; ability to analyze the activity and evaluate the professional potential, to predict self-development);
- independency (interest and persistence in solving engineering problems, skills to use rational solving methods).

6. Social and legal competence:
- legal competence (interest and persistence in the law knowledge and the ways of solving law problems; knowledge how to solve them).

One of the main obstacles influencing the modern successful engineer formation is student knowledge formalism.

The term "formalism" means the form isolation from the content. The form becomes a key aspect in the education and training problem solving. These processes are going on without regard for essential mechanisms and sometimes contrary to them. The problem solving achievement is only for show claimed as a fact [1, c. 3].

When analyzing the technical university students' training process in fundamental disciplines we came to the conclusion that knowledge formalism occurs for some reasons: discipline area – short time period to study; complication (fundamental education is done apart from the special disciplines, so, students get "dead knowledge", useless in solving professional problems); interdisciplinary absence or lack of interdisciplinary relationship

(most students can't understand the connection between the fundamental, technical and special disciplines); didactic methods are unsuccessful (teaching methods are obsolete); insufficient resource base of the institute; insufficient science language work; professional – weak future students' professional knowledge and relationship between the fundamental disciplines and future profession; personality – no motivation to study, subconscious future profession choice, insufficient use of the student creative potential, no differentiation in training; social – poor interest and needs accounting, practical training impossibility. Military service avoidance and higher educational diploma are the only reasons for the motivation to study.

To overcome knowledge formalism in the educational process it's necessary to integrate fundamental and special disciplines. The principle way to realize this is through the relationship between the up-to-date fundamental science achievements and advanced technologies of the subject matter; solving professional problems in the laboratory work, organization of mini research on the base of some disciplines; the student involvement in the professional project realization in the department, institute or enterprise.

Knowledge formalism prevents future engineers from the opportunity to use the university knowledge in their future work. So, this diminishes the study interest. Thus, to overcome the knowledge formalism through the engineering thinking is the urgent problem.

Engineering thinking is a special thinking formed and revealed during technical problems solving; that provides quick, accurate and original solving aimed at meeting technical knowledge, ways and technique demands to create technical means and technologies having the following structure: **technical thinking** – skills to analyze composition, structure of a device, its principle of operation in the changed environment; **constructive thinking** – problem solving model design ability, i.e. skill to combine theory and practice; **research thinking** – innovation problem identification, skills to compare, prove and conclude; **economic thinking** – process quality consideration and activity result due to the market requirements (not only the knowledge in the major but also skills to present the students' potential and activity results are necessary).

Engineering thinking of the future specialist is identified by the following 3 stages:

- low stage – ability to use the required minimum of technical information, but inability to understand in corpora the importance of technological knowledge for the professional growth; no competitive persistence; occupies the position of "a forced leader (assigned)", no wish to self-organize and to be a team-leader for the successful activity; goes from one extreme to another; absence of creative ideas, is taken aback, hard to switch over to another activity; regular help is necessary; can't overcome problem- disputed situations;

Table 1.

Development levels	Technical thinking result evaluation	Constructive thinking result evaluation	Research thinking result evaluation
Low	13 %	60 %	76 %
Middle	41 %	30 %	19 %
High	46 %	10 %	5 %

- middle stage - ability to use the major part of the required minimum of technical information, able to understand the importance of technological knowledge for the professional growth; adequately oriented in the competitive situations, creative, desire to oppose his "own idea" though it can't always be realized in corpora; occupies the position of "a situational leader"; needs help in unconventional situations, slow to switch over to another activity; can't solve tricky problems.
- high level – wide mental outlook, broad-minded person, capable to persist in his\her opinion, has effective personal work system, knowledge and new product sure-method of use and creation; ability to present the result; sensitive to unusual things, quick-minded, independent.

To identify the engineering thinking formation problems, component-specific test was introduced. It covered the students of engineering-economics and automechanic departments at Volzhskiy Polytechnic Institute. Bennet's test was used to identify the technical thinking level [2, p. 305 - 320]. The very test is aimed at evaluating blueprint reading, technical circuit and the operating principles understanding, the simplest physical and technical problem solving.

For designing and research ability identification, the secondary school mathematics test was used. The following amount of tasks was included: 30% - aptitude for checking out process, 30% - for research aptitude and 40% - for designing aptitude [3, p.148]. Checking out designing abilities was the foreground test because of technical requirements claimed to the engineering specialities. Analytical data results are given in Table 1.

Test results showed that the 1st year students had weak designing and research skills; level of technical thinking was insufficient.

To know the student thinking level in economics, A.P. Vyatkin method was used [4, p. 99-102]. So, testing proves that students don't yet have an active economic thinking; situations for rational solving are ignored if a guaranteeing problem solving is a competitive one.

To form the engineering thinking during the future engineers training, the following activities are required: teaching material should be aimed at raising the knowledge level; level tasks due to didactic, methodical and personal conditions which allow for motivation of independence, to create ways and methods, to make optimal activity layout, to analyze the results.

To overcome knowledge formalism, educational activity should be creative, favorable atmosphere oriented; knowledge development, skills and experience – self-organized; activity increase and independence in problem solving – critically self-assessed.

To solve the engineering staff deficiency problem it's necessary to create favorable conditions where the engineer will be socially protected by the quality and professional opportunities due to his\her education and by the adequate salary.

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