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Quality Management Competency as an Essential Component of Professional Qualification of Engineering Graduates

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The authors focus on developing quality management competencies conducting the case study of education programme "Materials Science and Technology of Materials". The authors consider the skills of quality management to be crucial for today's engineering graduates and suggest enhancing Bachelor and Master of Engineering curricula with practice-oriented disciplines, modules, and practices, with relevant examples given.

Key words: quality of education, engineering education, quality management, competency development, curriculum design, engineering education programmes.

In the past decades the issues of engineering education have been actively discussed. Among these issues methods and tools of its quality enhancement as well as ways of their implementation into university functioning are particularly debated. It is commonly agreed not only in Russia, but also in the world that development of only special professional competencies does not meet employers' requirements for engineering graduates. In our opinion, one of the competencies necessary for a graduate engineer is a competence of quality management. This article considers the question of this competence development using the example of students of "Material Science and Technology of Materials" profile.

In 2011, when universities started students' training including engineering ones, in accordance with the State Federal Educational Standards of Higher Education, the universities and departments gained large discretion in designing both curricula and syllabi of the subjects. In doing so, it was necessary to ensure students' cultural and professional competencies. This trend is supported by the educational standards of the latest generation FSES 3+. As a rule, the design of curricula (i.e. inclusion of subjects in curriculum, their content and volume, a set of competences produced by each definite subject) is performed by graduate departments of university. Leaving some subjects beyond the curriculum and transfer to the competence-oriented education, on the one hand, facilitated the work of graduate department, on the other hand – complicated. Historically, the graduate departments are mainly focused on inclusion of mostly field-specific subjects in the curriculum when developing engineering curricula, as they are responsible for training students for their main professional activity (application of knowledge about materials, research methods, testing and diagnostics of materials, products, processes of their production, skills of engineering process modeling, etc.). In addition, some professional competencies are acquired in reduced and generalized form, as a part of more significant, in the graduate department's opinion, subjects. This approach leads to very superficial knowledge of "non-major" subjects and results in problems of engineers' adaptation in the workplace. Therefore, the graduate departments face the daunting task: despite the established tradition, to design curricula and syllabi to acquire the entire set of competences registered in the standard.

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At the moment, the issues of quality management are of key importance, as industry, on the one hand, should timely respond to the changes in consumer demand under the condition of continuous reduction in time between innovative development and its implementation and, on the other hand, should manufacture zero-defect products (which is of special importance, for instance, for the space and defense-related spheres) and meet consumer's expectations. Development, implementation, and support of quality management system have become a necessary condition of competitiveness and cooperation with domestic and international partners for many enterprises. Moreover, the international standard ISO/IEC 15288:2002 (and corresponding national standard RF GOST R ISO/MEK 15288-2005) defines the processes of life cycle of any system produced by a man including engineering one only by 40% as those related to engineering activity, the other processes being referred to project and business management (50% of both forms of processes) and contracting (10%) [1, 2]. Hence, the requirements for engineers' relevant skills are sure to result from the standards. It turns out that modern economy needs a graduate who is not just technically competent specialist, but an engineer-manager, and potential research-engineer in future. Based on the mentioned above, the engineering profiles referred by the Education Ministry Order to the priority ones are largely focused on inclusion the issues related to production quality and skills of corresponding document design in the training process.

Most standards of engineering profiles include, in various contexts, the issues of quality (metrological assurance production service, paperwork and participation in quality management system functioning, etc.). Besides, it should be noted that in the third generation education standards great attention is paid to graduate's commitment to participate in certification of processes, engineering tools etc.

Let us consider the former version of the Federal State Education Standard FSES 3+ in detail for the "Materials Science and Technology of Materials" profile. In the education standard of the considered profile, both for Bachelor's and Master's degrees, among the fields of professional activities there is as follows: "processes of producing materials, parts, half-finished parts, details and items, as well as managing their quality in different spheres of engineering and technology". Moreover, as a part of professional activity the standards of both levels (Bachelor and Master) determine "methods and techniques of quality management of materials, films and coverings, half-finished products, parts and tools" and "normative-engineering documentation and certification systems of materials and products, engineering processes of their production and treatment" [3, 4]. Let us turn our attention to some competence constituents which a Bachelor of this profile should have taking into account the type of professional activity at which Bachelor curriculum aims [3]:

a) Research and analytical constituents:
- commitment to apply modeling methods in standardization and certification of materials and processes;
- commitment to make complex research and tests when studying the materials and products including standard and certified ones.

b) Production and project constituents:
- commitment to apply technical means of measurement and control necessary for standardization and certification of materials;
- ability to apply knowledge about technical production preparation, quality, standardization, and certification of products and processes in industry using economical analysis.

c) Management constituents:
- ability to use principles of production and personnel management.

For Masters of the same profile, the following competencies (or their constituents) are detailed [4]:

a) Research and analytical constituents:
- ability to use methods of modeling, optimization, standardization, and certification to assess and predict material properties and efficiency of technological processes.

b) Production and project constituents:
- ability to use standards and instructions of engineering production, quality, standardization, and certification of products and processes in technological processes and operations.

c) Management constituents:
- commitment to implement production quality management system in the sphere of engineering activity.

Thus, there is a clear necessity of due attention to the disciplines training in quality management at the level of education standards. However, along with inclusion of these disciplines into curriculum, it is important as well to consider their content, focus on learning definite application of quality management means and methods as well as examples of quality management system (QMS) implementations.

It should be also noted that FSES competences of "Materials Science and Technology of Materials" profile for Bachelor and Master degrees are focused on different aspects of quality management. For example, future Bachelors are to have the ability defined as "be ready for activity related to production quality management". For future Masters this ability increases up to participation in processes of production quality management of a company. This fact should be taken into account in designing discipline content, particularly that of Master curriculum.

In case of inclusion of the discipline developing quality management competence into the curriculum, it is often tempting to maximally decrease the number of credits or hours and generally outline the principles of quality management, ISO 9000 standards, algorithm of certification for both materials, processes and QMS. Nevertheless, when an engineering graduate starts to work at an enterprise, he/she has to practically acquire quality standards, namely, clearly defined means and methods of control, management, and improvement of production quality. It should also be noted that the priority of a university is to give students a sound academic background, i.e. satisfaction of interested parties with education service. In our opinion, the interests of the parties mentioned could be equally accommodated: students; state or company investing in education; employers hiring the university graduates; parents' committee; university itself; society [5]. Therefore, it is essential not only to comply with the formal requirements of educational standard and "fill in" the curriculum with important, from the graduate faculty's point of view, disciplines, but also take into account the real employers' demands for an engineering graduates' competency.

The educational standards of the latest generation include definite requirements for classes intended for profile training, for example, for engineering profiles the number of lecture hours, as a rule, should not increase 30-50% of other forms of classes. We suggest the general issues of quality management to be studied independently, but the curricula of the corresponding disciplines should be focused on practical application of studied theoretical concepts.

Using an example, let us show possible content of disciplines developing competencies of quality management taking into account specific engineering activity.

As a result of theoretical training, a Bachelor should acquire:
- general knowledge about approaches to quality assurance at an enterprise with due consideration of specificity in different production life cycle stage: management of communication with consumers, design and development, purchase, production, and service;
- the concept of process (including technological and production), essential parts of the process;
- idea of enterprise (company) function in the form of process network (so called process approach);

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- information about main tools of quality management;
- knowledge of bases of metrological production assurance;
- awareness of competent standardization and certification of materials and processes.

As for practical training, along with application of described theoretical knowledge in practice, it is not of less importance to acquire skills in production quality management, and, consequently, application of statistical methods to assess production quality, process control, accuracy analysis, manageability and sustainability of the processes (for instance, assessment of checklists and various charts) and methods used on selected production quality management.

In our opinion, according to the competencies, Bachelor or Master of material science also needs, perhaps in the form of internship, to learn a really functioning QMS at a definite company of relevant industry (including the possibility of visiting this company, examining some documentation, participating in workshops held by quality service representatives and students' independent design of some documents). Moreover, at the internship Masters' attention should be focused on studying management and other processes resulting in the increase of production quality.

In our opinion, it is important that having practical skills in quality management, future engineer would quickly adapt to the real production conditions where he/she would be involved in improvement of production, processes etc.

Hence, to meet the requirements of modern industrial society, we believe it is necessary to include practice-oriented disciplines, parts of disciplines and practices in Bachelor's and Master's curricula to endow students with quality management competencies.

Let us consider implementation of the statements mentioned above using the example of Bachelor students training.

It is suggested to separate a section related to development of students' knowledge about production quality management system and skills of implementing this system as a part of internship. In our opinion, it is useful for students to acquire knowledge, including theory, necessary for developing relevant skills and competencies, or its part before the internship. Therefore, firstly, it is appropriate to define one or more disciplines or their units in the curriculum preceding the internship and containing relevant theory (for instance, "Metrology, standardization and certification", "Bases of quality management" etc.). Secondly, before the internship the students have review lectures and their level of theory knowledge in the sphere of quality management is tested. After that, a company with appropriate science and technology structure and using the methods of production quality management (preferably with QMS) is chosen for internship. Thus, thus internship would contribute to acquiring both professional engineering skills (the main part of practice), and skills in quality management of a given industry (the section suggested by us). As a result, students can develop the most complete idea of both local engineering processes, equipment, material properties etc. and global issues of production, functioning and organization with due regard of quality assurance. At the end of internship one can test theory again to define the effect of practical skills on the level of students' training concerning the quality issues.

The key aspect related to the quality of production is documents of engineering processes. Therefore, we suggest students' mastering knowledge on process engineering and quality as a part of profile discipline related to the study of engineering material and structures. In this case the skilled mentioned above are suggested to be acquired at seminars or laboratory works. For example, one of the laboratory works (or one of practical tasks at seminar) can partially or completely include description of the GOST format for engineering documents.

Thus, on the one hand, the list of questions on the given theme is given to the students to study independently. It includes the relative normative documentation, which allows the lectures to be delivered on the basic professional issues. On the other hand, engineering documents are mastered by the students at one of classes, which allows a teacher to check their independent work and a student to monitor and test their skills in real production condition.

Hence, we have grounded the necessity to include practice-oriented disciplines (or their sections) and internship enabling development of quality management competence into the curriculum of Bachelors and Masters as well as identified the potential ways of achieving this goal.

It should also be noted that the research problem implies further development of necessary educational technologies and methods that, on the one hand, make information easier for the students and, on the other hand, develop students' quality management competence.

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