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## Identification of Criteria, Features and Levels of Economic and Managerial Competencies Development for Bachelors in Mechanical Engineering

Vladislav Lizunkov, Veronika Marchuk\*, Elena Podzorova

*Yurga Institute of Technology, 26 Leningradskaya, Yurga, 652055, Russia*

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### Abstract

During research the inquiry and analysis of employers in mechanical engineering industry were done, based on which the key and lacking competencies for mechanical engineering bachelors were identified, according to opinion of employers. The modified and amended list of economic and managerial competencies for mechanical engineering bachelors, consisting of general cultural and professional competencies, including designing, computational and managerial, and entrepreneurial activities. The basic criteria and respective features are selected, the methods for their diagnostics are suggested. The indicators of economic and managerial competencies development of mechanical engineering bachelors are given.

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### 1. Introduction

Analysis of engineering and pedagogical publications and the practice of higher professional education assume the methodological tools for evaluation of economic and managerial competencies development of mechanical engineering bachelors.

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\* Corresponding author.

E-mail address: [tika75-1977@mail.ru](mailto:tika75-1977@mail.ru) (V. Marchuk).

Based on analysis of pedagogical researches on the subject of pedagogical measurements (Bloom, 1974; Verbitsky, 2009; Korobov, 2005; Kreslavskaya, 2009; Minin & Lizunkov, 2014; Mikhailova, 2008; Subetto, 2006; Tatur, 2004 and other), we specified the basic elements of such methodological tools: criteria, features, the means and methods for diagnostics of economic and managerial competencies development of mechanical engineering bachelors.

## 2. Subject and methods of research

The researches devoted to the problem of development of economic and managerial competencies by mechanical engineering bachelors (Lizunkov & Sushko, 2015), (Lizunkov & Minin, 2014), (Lizunkov & Sushko, 2014) showed that the science accumulated a certain experience in developing the criteria basis for evaluation of their development by students. Criterion is a characteristic, based on which the evaluation or classification of something; degree of judgment, evaluation of some phenomenon (Lizunkov & Sushko, 2015).

For identification of criteria and respective features, analysis of employers' wishes is required.

During research the inquiry and questionnaires were carried out with 67 employers, who represent 24 machine-building enterprises, located in such federal districts of the Russian Federation, as: Siberian, Ural, Southern and Central, and who employ mechanical engineering graduates, trained in different institutions of the country, Table 3.

Primary list of questions, containing economic and managerial competencies, was taken from CDIO Syllabus – developed within framework of CDIO initiative with participation of industrial and accreditation representatives (Lizunkov & Sushko, 2015), (Chuchalin, et al., 2014).

Based on inquiry among employers who employ mechanical engineering bachelors, having approximately equal training, we formed a list of the required and significant competencies in the area of economy and management, which mechanical engineering bachelors are in deficit, Table 1.

Table 1. Key and lacking competencies of mechanical engineering bachelors, according to employers.

Key economic and managerial competencies	Lacking economic and managerial competencies after completion of training program
1	2
1. Mastering of the culture of thinking, ability for communication, analysis, information perception, ability to think competently and logically, formulate verbally and in writing, put goals and select way of achieving them.	1. Ability to evaluate conditions and make organizational and managerial decisions, develop management methods, participate in implementation innovative approaches to management.
2. Ability to work in team, effectively using the management methods, skills of business communication for more effective presentation of decisions and ideas, to realize the consequences of managerial actions and bear responsibility for them.	2. Ability to develop business plans, to start up, develop and manage new organizations.
3. Ability to use the earlier acquired knowledge and skills, critically evaluate their own abilities and drawbacks, aspiring to personal and professional improvement.	3. Ability to perform collection, analysis and processing of data for achieving the economic and financial objectives.
4. Ability to carry out production and technical economic calculations, analyze and evaluate manufacturing and non-manufacturing costs, solve problems with creation and reorganization of work areas, plan the personnel work and salary fund.	4. Ability to organize the team work, plan the performed work well, be responsible for managerial decisions and analyze the quality of performed tasks.
5. Ability to analyze, carry out feasibility study and manage projects.	5. Ability to carry out production and technical economic calculations, analyze and evaluate manufacturing and non-manufacturing costs, solve problems with creation and reorganization of work areas, plan the personnel work and salary fund.
6. Ability to evaluate economic and social conditions for business, start up and manage new organizations.	6. Ability to analyze, carry out feasibility study and manage projects.

Questionnaires of employers (CEO of enterprises, heads of sections, shops, production supervisors, and head foremen) demonstrate the deficit of economic and managerial training of mechanical engineering bachelors after

graduation from higher educational institution, the desirable economic and managerial competencies are given in column 1 of Table 4, in column 2 of Table 4 – the deficit of economic and managerial competencies after graduation from employers' questionnaires. Analysis of table shows that most of economic and managerial competencies, which mechanical engineering bachelors should have, from the number of those desirable by employers, are in deficit (Zamyatina, et al., 2015), (Lizunkov & Minin, 2014), (Lizunkov & Sushko, 2014).

Analysis of Table 1 allowed forming a list of lacking economic and managerial competencies of mechanical engineering bachelors, based on the existing competencies with competencies added by employers.

Table 2. Modified and amended list of economic and managerial of competencies mechanical engineering bachelors.

Competencies	Description of competencies
1	2
General cultural competencies (GC)	Ability for communication, analysis, information perception, to think competently and logically, formulate verbally and in writing, put goals and select way of achieving them
	Ability to use the earlier acquired knowledge and skills, critically evaluate their own abilities and drawbacks, be able to aspire to personal and professional improvement
	Ability to work in team, effectively using the management methods; skills of business communication for more effective presentation of decisions and ideas, to realize the consequences of managerial actions and bear responsibility for them
Professional competencies (PC)	
	Ability for communication, analysis, information perception, to think competently and logically, formulate verbally and in writing, put goals and select way of achieving them
	Ability to use the earlier acquired knowledge and skills, critically evaluate their own abilities and drawbacks, be able to aspire to personal and professional improvement
	Ability to work in team, effectively using the management methods; skills of business communication for more effective presentation of decisions and ideas, to realize the consequences of managerial actions and bear responsibility for them.
Project and designing activity	Ability to analyze, carry out feasibility study and manage projects.
Computational and managerial activity	Ability to calculate the social and economic, and financial performance criteria by means of basic methods, describing the activity of business units of the enterprise.
Entrepreneurial activity	Ability to evaluate economic and social conditions for business, find and assess market opportunities for business ideas, have practical skills in starting up and managing new organizations.

Table 2 gives a modified list of economic and managerial competencies for mechanical engineering bachelors, structured in the format of third generation FSES, and added with new competencies, according to employers requirements (project and design, computational managerial and entrepreneurial activity).

Considering the research of employers' wishes, conducted by us and aimed at development of economic and managerial competencies of mechanical engineering graduates.

We think it is possible to specify the following criteria: organizational and managerial abilities, technical and economic skills, project skills, entrepreneurial knowledge and skills of economic and managerial competencies development of mechanical engineering graduates, based on studying the course "Economics and Machinery Production Management", which is practically the only discipline for the training profile 150700 Mechanical Engineering, Bachelor's degree, providing the economic and managerial competencies for mechanical engineering bachelors (Lizunkov & Minin, 2014), (Lizunkov & Sushko, 2014), (Minin & Lizunkov, 2014).

The selected criteria fully reflect the complexity and multiple aspects of the researched phenomenon.

### 3. Survey results analysis

To perform the evaluation and diagnostic procedures, the criteria of economic and managerial competencies development should be defined for mechanical engineering graduates. Criterion is the data by which development and progress of something can be judged (Minin & Lizunkov, 2014). The author's variant of features of economic and managerial competencies development for mechanical engineering graduates with account for specified criteria was developed, based on the conducted analysis of employers' requirements, the National Research Tomsk Polytechnic University for Mechanical Engineering training profile, under the international CDIO Initiative (Zamyatina, et al., 2015).

Table 3. Criteria and features of economic and managerial competencies developed by mechanical engineering bachelors.

Criteria	Features	Tools and methods of diagnostics
1	2	3
Organizational and managerial abilities	Able to evaluate conditions and make organizational-managerial decisions, develop methods of staff management, participate in implementation of innovative management approaches, manage personnel on a modern level, solve conflict situations, be responsible for managerial decisions and analyse the quality of performed tasks	The Author's test, based on the following tests: T. Ehlers's test (Motivation to Success) T. Ehlers's test (Motivation to Avoid Failure) Test of D. Marlowe and D. Crown
Project skills	Able to analyze, carry out feasibility study and manage projects	Completion of practical assignment
Entrepreneurial knowledge and skills	Knowledge of economic and social conditions for business, be able to assess market opportunities for creation of business ideas, have practical skills in starting up, developing and managing of new organizations	Development of business plan

The identified criteria of economic and managerial competencies of mechanical engineering bachelors are given in column 1, in column 2 - indicators, allowing diagnostics of readiness level, tools and methods of diagnostics of economic and managerial competencies of mechanical engineering bachelors are given in column 3 (Podzorova, et al., 2015).

Suggested combination of criteria and indicators was agreed with experts of OOO "Yurga Machine- Building Plant" of various positions (Deputy Director for production, heads of production shops, senior foremen and foremen) in terms of their completeness and significance evaluations.

The selected criteria, features, tools and methods of diagnostics for economic and managerial competencies development of mechanical engineering bachelors allowed specifying the levels of economic and managerial competencies development regarding each specified criterion: high, medium and low.

This research can be used for higher education practice. In addition to defining indicators of economic and managerial competencies development of mechanical engineering bachelors along with development of assessment tools arises the necessity in development of tools and methods for diagnostics and indicators. Indicator is an element reflecting the state of the observed object. Indicator is an index, showing variation of some parameter of controlled technical process or object in the most convenient form for direct perception by a human.

Indicator is a tool, using which the change of condition of economic and managerial competencies of mechanical engineering bachelors can be detected by the developed criteria. Assessment of training quality is one of the main activities in the area of higher education (Chuchalin, et al., 2014).

Table 4. Indicators of economic and managerial competencies development of mechanical engineering bachelors.

Criteria	Indicators of development		
	High	Medium	Low
1	2	3	4
Organizational and managerial abilities	Able to make organizational and managerial decisions	Not always can make organizational and managerial decisions	Unable to make managerial decisions
	Able to manage the staff	Weak mastering of staff management methods	Unaware of staff management methods
	Able to solve conflict situations	Not always participates in solving conflict situations	Unable to solve conflict situations
	Able to be responsible for decisions		
Technical and economic skills	Able to perform analysis and processing of technical and economic data;	Doesn't know all methods for analysis and processing of technical and economic data;	Knows only several methods for analysis and processing of technical and economic data;
	Able to perform technical and economic calculations;	Not always able to perform technical and economic calculations;	Practically unable to perform technical and economic calculations;
	Able to estimate effectively manufacturing and nonmanufacturing costs	Not always able to estimate effectively manufacturing and nonmanufacturing costs	Unable to estimate effectively manufacturing and nonmanufacturing costs
Project skills	Able to analyze project solutions	Not always able to analyze project solutions	In rare cases can perform analysis of project solutions
	Able to carry out feasibility study	Not always able to carry out feasibility study	Low level of project feasibility study
	Able to manage projects effectively	Able to manage not all projects effectively	Unable to manage projects effectively
Entrepreneurial knowledge and skills	Able to evaluate market opportunities for business ideas	Evaluation of market opportunities is not always effective	Unable to evaluate market opportunities for business
	Able to develop business plans;	The developed business plans are of medium level	Develops business plans for unprofitable activity
	Has ability for development and management of new organizations	Not always able to develop and manage new organizations	In rare cases manages the organizations effectively

It is obvious that mechanical engineering bachelors practically do not have the basics of economic and managerial competencies, as previous disciplines in Mechanical Engineering Educational Program to a small degree include economic and managerial competencies. Competencies, given in Table 4, prior to training in “Economics and Machine-Building Enterprise Management” can be taught to mechanical engineering bachelors by means of life experience, work during practical training and personal initiative of students.

#### 4. Conclusion

First, the key and lacking competencies of mechanical engineering bachelors after graduation were identified, based on the questionnaires of employers in the machine-building industry.

Second, the list of economic and managerial competencies of mechanical engineering bachelors was modified and amended in the context of third generation FSES, based on employers' wishes.

Third, criteria and respective indicators, including organizational and managerial abilities, technical and economic skills, project skills, entrepreneurial knowledge and skills, were specified.

Fourth, indicators for economic and managerial competencies development of mechanical engineering bachelors, based on the identified criteria, were developed.

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