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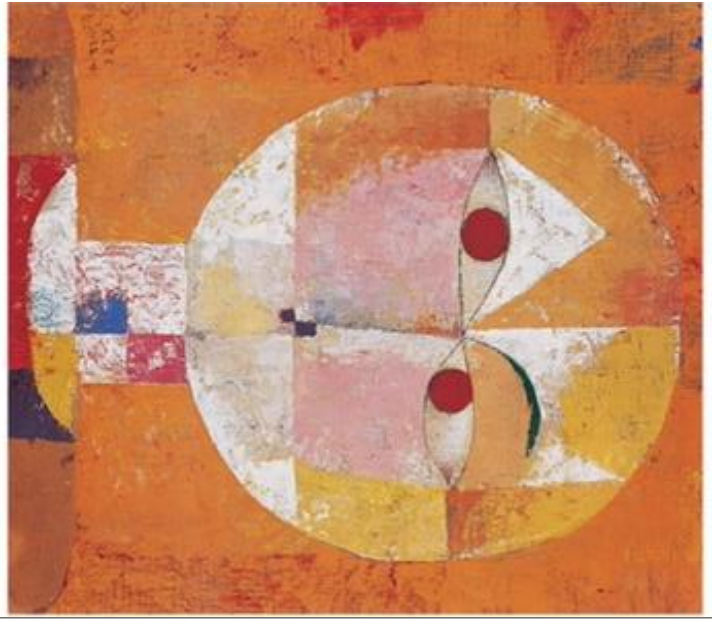

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The development of meta-competencies in undergraduate students using personality development theory

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Abstract

The purpose of this research is to determine the successful stages of competence development of students in the higher education system through the lens of the personal development theory. A qualitative assessment of the development of the students' professional competencies was carried out in accordance with Bloom's taxonomy

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of educational objectives. It was demonstrated that 70 % of the changes in the development levels of the professional competencies were conditioned by the meta-competency levels and 30 % by other factors. In conclusion, the development of meta-competencies determines the choice of actual development trajectory as the ability to translate an immense potentiality into reality.

Keywords: Meta-Competency, Labor Market, Development, Meta-Education.

El desarrollo de metacompetencias en estudiantes universitarios utilizando la teoría del desarrollo de la personalidad

Resumen

El propósito de la investigación es determinar las etapas exitosas de desarrollo de competencias de los estudiantes en el sistema de educación superior a través de la lente de la teoría del desarrollo personal. Se realizó una evaluación cualitativa del desarrollo de las competencias profesionales de los estudiantes de acuerdo con la taxonomía de los objetivos educativos de Bloom. Se demostró que el 70% de los cambios en los niveles de desarrollo de las competencias profesionales estaban condicionados por los niveles de metacompetencia y el 30 % por otros factores. En conclusión, el desarrollo de metacompetencias determina la elección de la trayectoria de desarrollo real como la capacidad de traducir una inmensa potencialidad en realidad.

Palabras clave: Metacompetencia, Trabajo Mercado, Desarrollo, Metaeducación.

1. INTRODUCTION

The transition from a material to a knowledge economy entails changes in the higher education system (FLAVELL, 1976). However, the trends in obtaining higher education and a lifetime profession are becoming less important (ABD & BEHADILI, 2019). Increasingly,

there are more adherents of the Lifelong Learning Model that involves the passage of many phases in an individual's life, each of which is characterized by a change in career (FADEL & GROFF, 2018; HAMOUD & HUMADI, 2019). In the context of the constantly changing technological and labor market needs, universal competencies—that is, meta-competencies—have become more significant (VOLCHIK & MASLYUKOVA, 2019). Meta-competencies enable individuals to change their profession quickly and adapt to a new workplace, and they are integral to the ability of employees to execute their functions effectively (KUMAR ET AL., 2019).

Meta-learning—or learning to learn—constitutes the fourth dimension of education, and helps students cope with learning tasks, as well as the professional and personal challenges that they will face during their lifetime. Given the increasing importance of these competencies, this study seeks to substantiate the relationship between the development of meta- and professional competencies of undergraduate students. Focusing on undergraduate engineering students, this study examined the following scientific research problems (BOGO ET AL., 2006; BIGGS, 1985).

2. MATERIALS AND METHODS

To ensure the reliability of the one-dimensionality of meta- and professional competencies, this study assessed the level of formedness

of competencies in machine engineering students through a questionnaire survey. The study object was formed through a sample of 300 second, third, and fourth-year undergraduate students majoring in Engineering at Moscow Automobile and Road Construction State Technical University. The study was conducted separately for each year to ensure sample homogeneity; i.e., that there were identical conditions for competency formation.

Determined using Equation 2, the minimum requirement for the sample size for a large general population, which is the number of engineering students in the Russian Federation, is 273 people. The sampling population for the survey in the framework of this study was 300 people, which meets the minimum sufficiency criterion and indicates the representativeness of the research results. The sufficiency of the student sample for assessing the development of competencies in the article was calculated using the following formula (GAVRILINA ET AL., 2014):

$$S = \frac{Z(p)^2 \cdot v \cdot (1-v)}{e^2}, \quad (1)$$

Wheres constitutes the minimum sampled population size sufficient to ensure the representativeness of the research results, and Z(p) is a normalized deviation. The permissible confidence level whereby the research results are representative and statistically significant is 90 %. At this confidence level, the normalized deviation is 1.65, p is the confidence level, v is a sampling variation, and e is an acceptable error level.

The stages of competency development in students were identified using the induction method. More specifically, they are considered as a special kind of internal change through which both new elements emerge and the structure connecting the elements changes. This change cannot be attained by simply adding and subtracting, but by establishing a new principle that rebuilds the relationship between the parts and elements of this structure in a new way (BLOOM, 1956; BOLARINWA, 2015: SAHIM ET AL, 2018: SHEKO & SPAHO, 2018).

3. DATA ANALYSIS

The reliability of the proposed questionnaire for assessing the level of development of professional competencies was demonstrated by the fact that there was an expressed direct relationship between the student performance and the number of points obtained by the results of the assessment. The correlation coefficient between these two indicators for the entire sample of students was +0.98. This means that the tasks proposed for the assessment of the professional competencies reflect the level of knowledge and skills of students based on the high level of expert competence, a statistically significant sample, and the reliability of the questionnaire.

The expert evaluation method was used to define the level of formedness of professional and meta-competencies of the participants; generate a list of questions and assignments to test the participants; and

assess their expertise, knowledge, and skills. The results were evaluated using the expert proficiency level expressed as a coefficient, as follows:

$$K_i = \frac{\sum_{i=1}^{m} e_{ij}}{m}, \quad (2)$$

Where K_i is the coefficient of the competency of the i-th expert; e_{ij} are expert evaluations equivalent to 0 if an expert considers another expert incompetent and does not deem it expedient to include them in the expert group, and equivalent to 1 if an expert expresses the need to include another expert in the group; and m is the number of experts. To assess the strength of the relationship between the formedness levels of professional competencies and meta-competencies, a paired correlation coefficient was used Andreas (2018), as follows:

$$r_{xy} = \frac{\sum_{i=1}^{m}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{m}(x_i-\bar{x})^2 \cdot \sum_{i=1}^{m}(y_i-\bar{y})^2}}, \quad (3)$$

Where, r_{xy} is the coefficient of correlation between the formedness levels of professional competencies and meta-competencies, x_i is the formedness level of meta-competencies, y_i is the formed ness level of professional competencies, $\bar{x}$ and $\bar{y}$ are the mean values of the indicators of the formedness levels of professional competencies and meta-competencies over the period under study, and

m is the number of periods. The correlation coefficient value |0.1|–|0.3| is equivalent to a low strength relationship, |0.3|–|0.5| is equivalent to moderate strength relationship, |0.5|–|0.7| to a noticeable strength relationship, |0.7|–|0.9| to a high relationship, and |0.9|–|1| to a very high strength relationship.

Correlation and regression analysis were used to demonstrate the one-dimensionality of the development of the meta-competencies and professional competencies. More specifically, this study used the following two-factor linear model (Bogo, 2014):

$$Y = a_0 + a_1 \cdot t + a_2 \cdot \mu, \quad (4)$$

Where, Y is the level of professional competencies, μ is the level of meta-competencies, t is the time factor, a_1 and a_2 are the values of independent variable held constants, and a_0 is a constant term. The parameters of the regression model (a_0, a_1, a_2) were evaluated by the least square method. The principle of this method is to select model parameters whereby the sum of the squared deviations of the actual values of the dependent variable from the predicted values is minimized (Cubas et al., 2016), as follows:

$$\sum_i^N (y_i - \bar{y_i})^2 \rightarrow min, \quad (5)$$

Where, y_i is an actual value of the level of professional competencies in the i- th period, $\overline{y_i}$ is a predicted value of the level of professional competencies in the i- th period, and $i = 1,2, \dots, N$ the use of data of different dimensions when building a regression model regarding the influence of the formedness levels of competencies regarding the development of professional competencies necessitates data standardization in order to bring them into a comparable form (Anysz et al., 2016), as follows:

$$X_{st} = \frac{X_i - \bar{X}}{\sigma}, \quad (6)$$

Where, X_{st} is the standardized indicator value, X_i is the actual indicator value, $\bar{X}$ is the average indicator value, and σ is the mean-squared deviation of the indicator.

4. RESULTS

The horizontal-vertical development of the student competencies within the framework of ego development theory can be presented in the form of a three-pronged vector direction, as illustrated in Figure 1. The upper vertical vector is transformation; a vertical development that is ensured by cognitive competencies and meta-competencies. The horizontal vector indicates movement within the same stage. The lower vertical vector indicates

temporary or permanent regression in the formation of competencies.

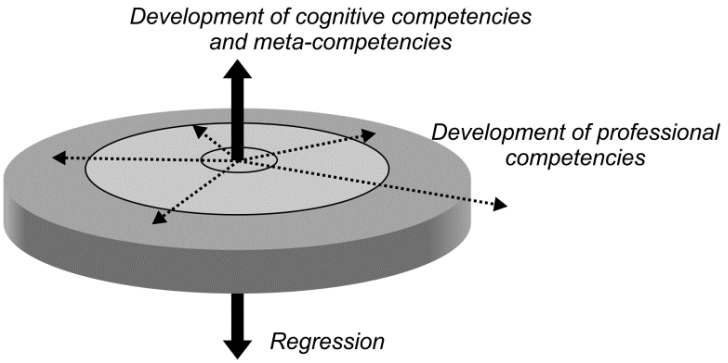

Figure 1: Vector direction of competency formation in the educational system

Additionally, to confirm the proficiency of the experts who had defined the survey questions, a proficiency coefficient was calculated with a value no less than 0.8 for each of the experts and a minimum acceptable level of 0.5. A face-to-face survey was conducted with the participants, the results of which are illustrated in Table 1.

Table 1: Results of the assessment of the formedness levels of professional competencies and meta-competencies

Indicator	2nd year, 1st semester (t_i=1)	2nd year, 2nd semester (t_i=2)	3rd year, 1st semester (t_i=3)	3rd year, 2nd semester (t_i=4)	4th year, 1st semester (t_i=5)	4th year, 2nd semester (t_i=6)	Maximum possible score
Formedness level of a professional competency	7	11	17	28	31	32	36
Formedness level of a meta-competency	3.5	4.6	5	5.75	7	9	23
Structure coefficient	2nd year, 1st semester (t_i=1)	2nd year, 2nd semester (t_i=2)	3rd year, 1st semester (t_i=3)	3rd year, 2nd semester (t_i=4)	4th year, 1st semester (t_i=5)	4th year, 2nd semester (t_i=6)	-
Formedness level of a professional competency	19	31	47	78	86	89	-
Formedness level of a meta-competency	15	20	22	25	30	39	-

The quality levels of professional competency development increased by 70 percentage points: from 19 % to 89 %. In terms of the formedness levels of the meta-competencies in second-, third- and fourth-year Moscow Automobile and Road State Technical University (MADI) students, there was an increase of 24 percentage points from 15 % to 39 %. The correlation-regression model was built according to the survey data using the software program, Statistica 10.0, as follows:

$$Y = -0.16 + 0.09 \cdot t + 1.23 \cdot \mu \tag{7}$$

To build the model, standardized data were employed to make the variables—the development levels of professional competencies, meta-competencies, and the time factor—comparable. The model is adequate in terms of the F-test because the calculated value of the test (11.85) exceeds the tabulated value (9.55). The model's adequacy indicated its applicability for further calculation in the study.

The next phase of this study excluded the influence of factor μ from Equation (7) in order to estimate the dynamics of the professional competencies in isolation from the influence of meta-competencies. The value $\mu = 0$ was used in Equation (7), and the value of the resulting indicator, Y, was then calculated (Figure 2).

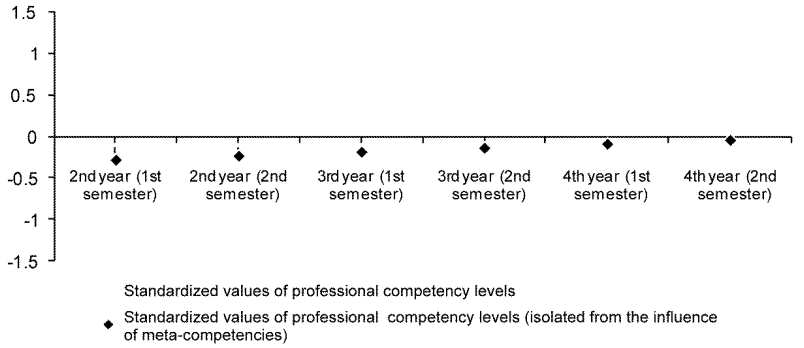

Figure 2: Dynamics of the students' professional competencies, disregarding the effect of the level of development meta-competencies.

Figure 2 reflects the dynamics of the professional competency levels in students, taking into account the influence of the meta-competencies. The absolute rise in the standardized values of the actual numerical score of professional competency levels in fourth-year students in comparison to second-year students was 2.32, while the increase in the score of competency levels without the influence of meta-competencies was 0.24.

The more effective the formation process of professional competencies, the more effective the development of the metacognitive skills—ensuring the vertical development of a student both as a future professional and as a personality within the framework of a one-dimensional measurement. At the same time, the move of professional competencies from one level (stage) of development to another ($y_1 \Rightarrow y_n$) is sequential and subject to meta-competency levels ($k_1, k_2, \ldots, k_n$), increasing to reach critical values. In turn, the progression of meta-competency development levels (μ) depends on that of professional competencies ($y \Leftrightarrow \mu$; Figure 1). Figure 3 illustrates the dependence of the development levels of professional competencies (y) on the personality development level (d) and the meta-competency development levels (μ).

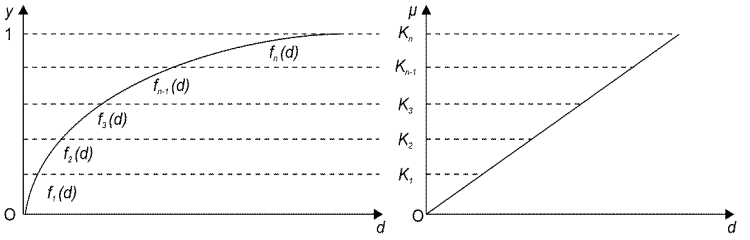

Figure 3: Development levels of professional competencies based on the development levels of meta-competencies in higher education.

In Figure 3, the development levels of professional competencies are represented by the range [0; 1], where 0 is equivalent to the absence of a formed professional competence, while 1 stands for the highest degree of development of professional competence. The process of forming professional competencies under the action of meta-competencies is expressed analytically by the following system:

$$y = \begin{cases} 0, \mu_1 = 0 \\ f_1(d), 0 < \mu_1 \leq k_1 \\ f_2(d), k_1 < \mu_2 \leq k_2 \\ f_i(d), k_{n-1} < \mu_i < k_n \\ 1, \mu_i \to k_n \end{cases} ; \quad (8)$$

Where y_i is the development level of a professional competency; i is the ordinal number of a competency formation stage; $i \in [1; n]$; $y \in [0; 1]$; 0 is the lack of a formed professional competency; 1 is the highest degree of development of a professional competency; μ_i is the level of development of a meta-competency; and k_i is critical levels of meta-competency development, promoting its move to a higher level of professional competency development.

The development process of meta-competencies and professional competencies in the course of one-dimensional development is described by the following system:

$$\begin{cases} \mu_1 \Rightarrow \mu_2 \Rightarrow \mu_i \\ \mu_1 \to k_1 \Rightarrow f_1(d) \to max \\ \mu_2 \to k_2 \Rightarrow f_2(d) \to max \\ \mu_i \to k_i \Rightarrow f_i(d) \to max, y \to 1 \end{cases} \quad (9)$$

The transition from one professional competency development level to another is possible if the critical development level of meta-competencies is reached ($\mu_i \to k_i$), maximizing the development level of professional competency in this segment ($f_i(d) \to max$). A professional competency is fully formed ($y \to 1$) subject to the passage of all stages of development, which is accompanied by the development of meta-competencies ($\mu_1 \Rightarrow \mu_2 \Rightarrow \mu_i$).

Table 2 presents a matrix of the response estimation and determination of the liminal values of a competency development stage. The stages of the vertical development of the competencies in higher education are presented in Figure 4.

Table 2: Matrix of liminal values of formedness of student competencies according to development stages

Question number	Competency development stages					
	Impulsivity	Apology	Conformist	Rationalist	Strategy	Congregation
No. 1	No. 1.1	No. 1.2	No. 1.3	No. 1.4	No. 1.5	No. 1.6
Max score	1	2	3	4	5	6
No. 2	No. 2.1		No. 2.2			
Max score	1	1	2	2	2	2

No. 3	No. 3.1		No. 3.2			
Max score	1	1	2	2	2	2
No. 4	No. 4.1		No. 4.2	No. 4.3	No. 4.4	No. 4.5
Max score	1	1	2	3	4	5
No. 5	No. 5.1		No. 5.2	No. 5.3	No. 5.4	No. 5.5
Max score	1	1	2	3	4	5
No. 6	No. 6.1		No. 6.2		No. 6.3	
Max score	1	1	2	2	3	3
Liminal values	6	7	13	16	20	23

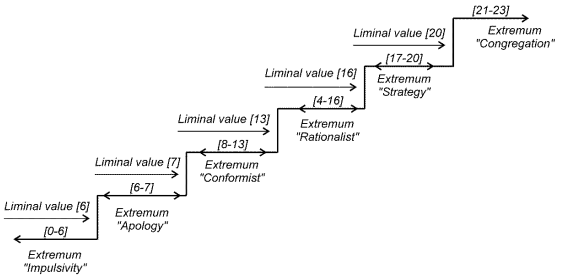

Figure 4: Stages of the vertical development of competencies in undergraduate students.

The extremum of 0–6 points is equivalent to the development stage Impulsivity; 7 points is equivalent to the Apology stage; 8–13

points to the Conformist stage, 14–16 points to the Rationalist stage, 17–20 points to the Strategy stage, and 21–23 to the Congregation stage.

5. DISCUSSION

This study substantiated the development of professional competencies and meta-competencies in undergraduate students using the concept of vertical personality development and the hypothesis of one-dimensional development. The competency-based approach in education has three vector trajectories, and its vertical development is ensured by the formation of meta-competencies in students. This approach enabled this study to identify the integration of professional and meta-competencies in higher vocational education.

The vertical development trajectory of meta-competencies is determined by the fact that it reflects the personal characteristics of an individual, which is associated with the vertical development of their ego (HALAWEH, 2019). Having a vertical formation trajectory, meta-competencies contribute to the development of other competencies, and allow students to acquire more and more new skills, and thus, move to a higher development level. The assessment of the development levels of competencies of engineering students conducted by this study provides practical evidence of the complementarity of the development of the thinking process of knowledgeable students.

Given the above, students' readiness for meta-competency formation is based on the following: a sustainable motivational attitude, the acquisition of professional skills and abilities for independent activities, and the ability to implement effective communication strategies and interaction tactics. The value-motivational component in the structure of student readiness to form meta-competencies is highlighted by the fact that motivation is a key component in individual self-organization and the essential criterion of a meta-competency.

6. CONCLUSION

The substantiation of the one-dimensionality of the meta-competencies and professional competencies of students enabled this study to identify the stages of their vertical development—Impulsivity, Apology, Conformist, Rationalist, Strategy, and Congregation. These do not only reflect the professional development of a student. The liminal values of the development levels of student competencies for each stage were determined as 6, 7, 13, 16, and 20 points, respectively. Higher education competencies based on meta-learning are developed along a trajectory from knowledge to synthesis skills. This reflects an internal change in which new elements of knowledge emerge, while the structure of competency connecting the elements of new skills also changes. At the same time, professional competencies provide a student with a more or less wide range of options. The development of meta-competencies determines the choice of actual development trajectory as the ability to translate an immense potentiality into reality.

This research has certain limitations. First, the restricted nature of the sample hindered generalizability because it includes only a single population. Second, it did not consider the connection between the structural components of professional competencies in higher education and meta-competencies. Third, it did not examine the components of meta-competencies and the features of their development in terms of student age groups and gender, or the effective methods of their development, and so on. This study believes that these aspects of the competency-based approach are worth studying comprehensively and on an individual basis, and their priority should be established in further research efforts.

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