Development of human capital through assessing the level of competencies of higher education programs in modern economic conditions

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Abstract. In the modern world, economic conditions are rapidly changing. It forces society to respond as quickly as possible. The key to the prosperity of states and the people living in them is the creation and development of an economy based on innovation. New technologies appear due to the accumulated knowledge, skills, abilities - the competencies of the people who create them - human capital. Management of human capital development is directly related to training and education. The article examines how the programs of higher education influence the formation of students' competencies, how the level of mastery of competencies is assessed. The research proposes mechanics for assessing the level of mastery of competencies. It describes their relationship with assessing the level of qualification of a subject of economic activity.

1 Introduction

The information ear demands information to become the main advantage and driving force. “Whoever owns information owns the world,” Notan Rothschild said back in 1814, having earned 40 million pounds sterling from it. In the process of cognition, information is assimilated and processed by a person, as a result of which a knowledge system is formed [1]. The knowledge system is a set of knowledge, abilities and skills - competencies. In turn, competencies allow the formation of systematic and creative thinking, the ability to analyze and forecast, which creates conditions for the search for new ideas and solutions, invention, innovation, and the development of progressive and advanced technologies.

Analyzing data from the Federal State Statistics Service of the Russian Federation, the number of developed advanced production technologies by type of economic activity (OKVED2 OK 029-2014 (NACE Rev. 2) for 2017-2022 showed an increase. At the same time, the growth rate in 2021 compared to 2020 was only 10%, and in 2022 already 20%, where the most significant growth (over 30%) was shown by industries related to the production of computers, electronic and optical products; computer software development; activities related to engineering design. These statistics confirms that the designated priority

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to create our own electronics and microelectronics industry, as well as modern competitive software, is being fulfilled.

Nevertheless, the level of innovative activity of organizations in the Russian Federation by type of economic activity shows that a significant increase in 2022 compared to 2021 (more than 60%) was shown by organizations specializing in the production of beverages, leather goods, and furniture. These statistics show that organizations from consumer segments react faster to the departure of competitors and actively occupy vacated positions in the market, while introducing new solutions and developments to proactively occupy the vacated niche in a highly competitive environment.

The average age of machinery and equipment available at the end of the year by economic sectors, by commercial organizations (without small businesses, at full accounting value, in mixed prices), in the Russian Federation at the end of 2022 is 11.8 years, with the “youngest” is the field of education, where this indicator is 5 years. The share of investments in machinery, equipment, and vehicles in the total volume of investments in fixed assets aimed at reconstruction and modernization by type of economic activity in the Russian Federation over the past five years has remained at the same level of 30%. However, based on statistical data, this indicator does not allow updating current equipment on the scale required by the economy.

In modern economic conditions, an important factor in sustainable development is not just the level of technology used in the economy, the age of equipment, but the level of human capital of society. It is the level of competencies (knowledge, abilities and skills) of people involved in the Russian economy that allows them to achieve high results, create new equipment, develop advanced technologies and implement breakthrough solutions.

According to the ranking of countries in the world according to the Human Development Index (HDI) [2] for 2022, Russia ranks 52 out of 191 countries with a value of 0.822, which corresponds to a high human development index. One of the indicators when calculating the HDI is the education index, which consists of indicators of the average duration of education and the expected duration of education. Moreover, until 2010, when calculating the indicator, the literacy of the adult population and the share of students among children and youth were considered. However, using only the calculation of indicators of duration of study is not enough; it is necessary to determine the quality and qualifications of human capital. This affects the employment of the population as a whole and the need to improve the quality of education at all levels, from preschool institutions to additional vocational education.

**2 Managing the development of human capital through assessing the level of competencies in higher education programs**

The modern development of society poses a task for the education system - to prepare a qualified, creative person who can adapt to a rapidly changing socio-economic environment, rationally organizes independent activities, and is capable of scientific, technical and innovative professional activities. The acute shortage of specialists in the innovation sphere who are able to effectively combine the country’s intellectual and technological resources and ensure the commercialization of the results of intellectual activity in the domestic and foreign markets makes the development of educational programs for training specialists to work in high-tech industries or carrying out innovative activities a necessary element of the education system [3].

New educational programs should form not only universal and general professional competencies, but also professional ones, not just as a set of generalized labor functions, but also a set of industry and scientific knowledge of the real sector of the economy and scientific institutions (Figure 1): fundamental theoretical knowledge, practical solutions and advanced technologies, scientific and research developments.
In 2021 and 2022, positive trends in the development of economic sectors are manifested quite clearly in connection with targeted government policy and the establishment of priorities for the formation of the country’s technological independence. At the same time, the scientific school shows a lag and general aging of the teaching staff, as well as its weak renewal, which in the future will affect the process of formation and development of human capital.

If we consider the indicators of training scientific and pedagogical personnel for the higher education system, then the average number of defended dissertations out of the number of those who completed postgraduate studies is no more than 12.7% in all branches of science. At the same time, starting from 2018, there has been a significant reduction in scientific personnel in such fields as 11.00.00 Electronics, radio engineering and communication systems, 22.00.00 Materials technology, 24.00.00 Aviation and rocket and space technology, 28.00.00 Nanotechnologies and nanomaterials. Although it is specialists in these areas that are needed to create their own new high-tech and competitive industries and further sustainable development of the country’s economy.

The modern system of higher education is based on federal state educational standards that regulate the final set of universal and general professional competencies for a specific area of training, and the introduction of professional standards developed by leading industry enterprises into educational programs. This concept allows you to integrate the competencies required by the market into the educational process. However, the procedure for developing and implementing professional standards and their further integration into the educational process is complex and time-consuming, which affects the relevance of the competencies being formed. This forces higher education institutions to involve practitioners from leading industry companies in the implementation of the educational process to develop relevant skills and abilities. On the one hand, the learning process becomes more interesting and motivates students, as they get the opportunity to learn the most current knowledge and skills first-hand. On the other hand, practitioners generally do not have the skills of pedagogical work and the ability to develop creative and analytical thinking, as well as assess the level of mastery of the required competencies by students, which is an important part of the educational process. At the same time, the introduction of such a tool as mentoring instead...
of or in conjunction with the direct inclusion of industry experts as lecturers is effective, as it allows not only to increase the motivation of students, but also to overcome internal educational deficits, and indicate ways to solve emerging barriers to self-motivation and development. And in combination with mentoring, it allows students to obtain knowledge and skills that are relevant and in demand by the economy. All the described activities directly affect the formation of the competencies of the future specialist, which leads to the need to assess the level of its development.

Assessment of the level of mastery of competencies in higher educational institutions is carried out within the framework of ongoing and intermediate monitoring of students’ progress, and the conduct of final certification. At the same time, the quality of educational programs in Russia is confirmed by government agencies during their monitoring. With the introduction of new accreditation indicators in accordance with the order of the Ministry of Education and Science of Russia dated April 18, 2023 No. 409, which will come into force on September 1, 2023, a significant contribution to the final score received by universities based on the results of accreditation monitoring of the educational program is made by the indicator on the share of students who completed 70% or more of diagnostic work tasks generated from the organization’s assessment fund. Assessment tools developed by an organization carrying out educational activities must provide a reliable and integrative (comprehensive) assessment of learning outcomes and (or) mastery of an educational program of higher education, and the tasks themselves must provide an opportunity to assess the formation of indicators of achievement of competencies (IAC) in the form of actions and (or) knowledge, skills, abilities. Diagnostic work is carried out in the form of testing lasting no more than one and a half hours, as a result of which it is necessary to determine the level of mastery of knowledge, skills and abilities throughout the educational program. In other words, to determine the level of mastery of all student competencies.

This raises the next problem that higher education institutions will face. Practice shows (this is especially obvious for generation Z and alpha) that if testing takes more than an hour, this has a negative impact on the results obtained: students simply cannot concentrate on questions and answers, especially if they involve open questions with a detailed answer or solving a case study. tasks requiring analytical and systems thinking. All this necessitates the implementation of testing systems based on the use of artificial intelligence methods. For example, an intelligent testing system based on a Bayesian mechanism for determining the level of confidence in the resulting assessment on a five-point scale, capable of maintaining the quality of the results obtained while reducing testing time compared to conventional computer testing systems, or testing systems based on expert systems or fuzzy logic.

If we consider educational programs of higher education, in particular competency matrices, it is obvious that competencies are formed not by one discipline, but by a certain combination of them. Thus, the competence itself is multi-component. In this regard, higher educational institutions are faced with the task of developing a huge fund of interdisciplinary assessment tools for competencies, and not disciplines, as is actually happening. At the same time, the formed funds of assessment tools must check all indicators of the formed competencies and the final assessment of the level of their development, which involves the use of different types of questions: closed, open, for consistency and compliance. This process is labor-intensive, limited in resources, and poorly managed.

To reduce labor costs when forming an interdisciplinary fund of assessment tools, it is rational to use the methodology for calculating the optimal number of tasks, their forms and level of complexity to achieve the required accreditation monitoring indicator of 70% or more of completed tasks. Mastering the educational program is determined on the basis of mastering the universal, general professional and professional competencies embedded in it, which in turn can be structured into 3 indicators of competence achievement: knowledge, abilities and skills, which is reflected in Figure 2.
To form a basic level of knowledge in a student (the traditionally accepted assessment is “satisfactory”), the level of mastery of a particular competency must be more than 50%. It should be remembered that for the development of human capital, it is important to apply the acquired knowledge in practice, and, therefore, the developed competencies must be practice-oriented.

We will assume that the contribution to the formation of practice-oriented competence occurs in the ratio of IAC 1 (theoretical knowledge) 30%, IAC 2 (formed skills) 30%, IAC 3 (acquired skills) 40%. At the same time, it is obvious that without the formed IDK 1 it is impossible to achieve the formation of IAC 2 and IAC 3, since without basic theoretical knowledge the formation of skills and abilities is difficult.

If we consider the 100-point assessment system used in most universities, then achieving the required level of mastery of competence is possible if a student scores 51 points. Based on the previously presented information, the role of IAC 1 is a priority, therefore it must be formed by at least 95% (in accordance with grade A in the ECTS system [4]). At the same time, it is acceptable that a basic level of mastering a competency is possible in the absence of IAC value 3 (it is equal to 0), since a teacher without it has a set of theoretical knowledge and the ability to apply them in typical situations, which allows them to carry out professional activities, albeit to a limited extent. Thus, in the described conditions, the level of formation of IAC 2 must be at least 73% to achieve the minimum threshold value of competence in general.

When conducting knowledge control in the form of testing, as a rule, the following types of tasks are used:
- closed-type tasks (choice of one or more correct answers);
- open-type tasks (written formulation of the answer to the question posed);
- correspondence tasks (determining connections between elements included in different sets);
- sequencing tasks (systematization of proposed elements according to some principle or criterion).

Theoretical knowledge (IAC 1) can be assessed using testing with closed-ended questions. With a high level of theoretical knowledge, the duration of testing will not be long. If we apply an assessment system in which 1 point is awarded for each correct answer, then to achieve the required level of mastery of IAC 1, a pool of tasks of at least 30 is required. With a testing duration of one hour, such a pool of questions relating only to IAC 1 is extremely large. This indicates the need to use adaptive testing technologies and introduce a level of difficulty of questions, which will reduce time costs and obtain high-quality results.
Assessment of skills (IAC 2), by which we mean a certain sequence of human actions leading to a planned result, is a more complex process that can also be tested during testing using closed-type questions, as well as test tasks to establish compliance or build a sequence. To achieve the threshold level of mastering a competency, the pool of questions for IAC 2 must be at least 22. The use of adaptive testing and the difficulty level of questions is also appropriate here.

Thus, the minimum pool of tasks in diagnostic work to achieve the threshold level of competence development should be at least 52 questions without considering the level of their complexity, which implies a speed of answering the question within 52 seconds. When using matching and consistency tasks, the likelihood of maintaining this response rate is low. Therefore, as part of control, it is necessary to use levels of difficulty of questions and adaptive testing. To implement the described approach, it is necessary to create a knowledge base (bank of questions) according to difficulty levels and describe the adaptive testing mechanism. Currently, there are many tools for developing adaptive tests, which greatly facilitates and automates this process [5].

In the current educational process, students can demonstrate the majority of knowledge, skills and abilities in a comprehensive manner exclusively within the framework of preparing final qualifying papers or undergoing practical training. Additional help is the “Startup as a Diploma” program (link). Its implementation helps to identify talented young people who can immediately integrate into the Russian economy. Scaling the program is still difficult, since a single unified implementation and implementation mechanism has not been developed, which allows educational institutions to interpret its implementation differently. In addition, not all educational institutions can help a student develop their own startup due to the lack of teachers with the necessary competencies. Another aspect is that “Startup as a diploma” does not provide an opportunity to evaluate the acquired level of some universal and sometimes even professional competencies. All this suggests that the requirements for the level of knowledge, skills and abilities of graduates of higher educational institutions should be closely related to the level of their qualifications.

3 Results and discussion

The qualification of a specialist in any field of training is a set of specific competencies, which allows it to be presented in the form shown in Figure 3.

![Fig. 3. Qualification of a specialist in a specific field.](image_url)

The structure diagram in Figure 3 represents the classic type of hierarchy: the decomposition of qualifications into smaller components. To determine the level of mastery of a qualification, you can use the following model presented in Figure 4 [3].
Fig. 4. Model for determining the level of qualification development.

The model for determining the level of mastery of a qualification is a hierarchy in which each competency (level of its mastery) has a connection with one of the alternatives about the level of qualification of the subject: an insufficiently qualified specialist, a sufficiently qualified specialist, a highly qualified specialist. Based on the presented model, to determine the level of qualification of a graduate, it is necessary, using the analytical hierarchy method, to calculate the relative importance of each of the alternatives, where the goal will be qualification, and the alternatives will be a conclusion about its level. In this case, the criteria will be the levels of mastery of competencies, and the significance (importance) of mastering a particular competency should be determined by experts or practitioners in a particular field based on a pairwise comparison of the priorities of competencies among themselves [6].

In the presented model, a representative of the industry in the educational program should act as an expert to take into account the relationship between the employer’s requirements and the student’s qualification level, who will determine the priority of mastering certain competencies, as well as their required level and volume. Thus, when determining the level of qualifications, the criteria will be the levels of mastery of competencies determined through diagnostic work, and the significance (importance) of mastering a particular competency will be determined by experts in a particular field based on a pairwise comparison of the priorities of competencies among themselves, which will allow us to give conclusion about the final level of qualification of the student [7].

4 Conclusion

Application of the described methodology will allow not only to assess the level of qualifications and competencies of students, but also to identify problem areas. For example,
by studying the statistics of the results of diagnostic work, it is possible to determine the tasks that cause the greatest difficulties for students, which will make it possible to adjust the educational program and timely change the learning trajectory. Thus, not only the level of mastery of competencies will be assessed, but also the development of human capital as a whole will be managed.

References


