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Multi-criteria Approach to the Analysis of the Quality of Training of Specialists in Educational Institutions

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The multicriterial approach to the analysis of quality of preparation of experts in educational institutions is offered. Thus the "affinity" of the multielemental "standard" functional, which reflects the necessary level of preparation of trainees, to really received during their training with application of ranging of subjects is estimated.

The quality of goods and services is entirely determined by the professional preparedness of the people who invent (design), manufacture and deliver them to consumers. In a market economy, the high quality of goods and services is the key to the economic prosperity of the country and civil society.

To give the student that maximum of information and useful knowledge that he is able to understand and assimilate well is the main task of any educational institution (EI), or, in the language of mathematics, this is the functional goal of the entire educational process.

For higher educational institutions (HEI), the task of training specialists of the highest level is updated many times, because these will be specialists who ensure the integration of their countries into the Global Information Society, the Society of the 21st century[1].

We will assume that we have a certain model of a "standard" of a specialist (bachelor, master or engineer) aimed at working in a certain position (or with a certain set of equipment), and achieving a possible "proximity" to this standard is the goal of studying at HEI. Let's represent this standard in the form of a multi-element functional:

$$F_э = F(y_1, y_2, \ldots, y_N), \qquad (1)$$

where y_i - various digital indicators of knowledge of the studied disciplines, skills, as well as psycho-professional characteristics.

It goes without saying that functional (1), written in implicit form, with reference values of indicators (characteristics) has its own digital extreme (minimum or maximum) value, indicating full coincidence with the reference. The deviation from the reference value of the functional Fe is equivalent to the deviation from the reference. The higher this deviation, the lower the degree of preparedness of the student for his subsequent professional activity.

Let us further consider a possible mathematical model of the factors that form a specific numerical value of the functional Fe. Initially, we define the reference value of the functional (1) as its value, which takes place at the reference ($\tilde{y}$) values of all its components, i.e.

$$F_э = F(\tilde{y}_1, \tilde{y}_2, \ldots, \tilde{y}_N). \qquad (2)$$

Each real (actual) characteristic yi, in turn, is a function of the student's readiness to study at the HEI, which we will call his "resource" (ai), but it should be remembered that the student spends only part of this resource (xi) to achieve the purpose of obtaining the appropriate qualification, and the rest of the "ai - xi" - he spends to achieve his other life goals.

In this way:

$$y_i = f(x_i, a_i - x_i), \qquad (3)$$

progress, of course, depends not only on previous preparedness, but also on what part of this general "preparedness" the student spends on studying, on obtaining new knowledge and preparing himself as a professional.

Students, and they are overwhelmingly young people, face a very difficult psychological task of finding a compromise between the requirements of the current moment and the prospects for achieving a high professional level, potentially allowing to achieve a better "quality of life". Young people, due to good health and great energy, are inherently maximalists, they solve their optimization problem in life - to have the maximum from life at the moment ("instant" maximum) or in the upcoming future ("dynamic" maximum). Striving for the maximum (one way or another) and relying on their little life experience, students themselves, in relation to their living conditions and opportunities, intuitively set the limit, which in mathematical terms can be represented as λi - the coefficient of interest in this subject: physics, biology, mathematics, psychology, etc. Obviously, λi can lie in the range from zero to 1.

Thus, a kind of "depth" (or "strength") of the student's assimilation of the required material in the i-th program discipline (ý i) can be estimated by the following expression:

$\acute{y}_i = f(x_i, a_i - x_i)\lambda_i$, (4)

which may be at some "distance" from the reference value ($\tilde{y}_i$).

A general assessment of "proximity" to the standard is possible only on the basis of the regularization of the task, which can be performed by ranking the disciplines related to the training of a specialist of a certain profile. All disciplines should be divided into blocks, which is already widely used in practice. We believe that the number of such blocks should not exceed seven, because, as established by psychologists [2, ..., 5], the "operational" memory of an ordinary person is focused on 7 stimuli. Apparently, for the same reason, the simultaneous (in one semester) study of more than seven subjects by students is not fruitful, "saturation" and loss of the quality of assimilation of all subjects at once may occur.

The only correct way to carry out the above-mentioned ranking of disciplines, in our opinion, may be the way of questioning a statistically representative number of respondents [6]. Respondents in this case should be recognized qualified production specialists with sufficient work experience - in other words, people who are the most informed in this area and have great professional intuition [7]. As a result of processing the questionnaires, a certain number of preferences should be obtained in terms of the importance of subjects (disciplines) studied by students in the process of professional training.

It is possible that it would be more logical to make a double row for each discipline, i.e. take into account the importance of the discipline not only for the direct application of knowledge and skills in the specialty, but also the importance of the discipline in terms of the formation of the general erudition of a specialist.

After all the subjects (disciplines) studied by students are lined up in a series of preferences (in the direction of decreasing, starting from the maximum element), the "discrepancy" of each indicator with the reference one becomes easily calculated:

$\Delta yi = \tilde{y}\, i - \acute{y}\, i$, (5)

and if normalized initial values (in relative units) are used, it becomes possible to apply the simplest matrix norms when calculating generalized indicators for several disciplines [8]. In any case, after regularization, we are able to talk about a kind of dominant part of the Fe standard and about one degree or another of compliance with the standard. Below we explain this idea with mathematical calculations.

We will assume that compliance with the standard with an "excellent" rating means the deviation of the new functional (φ) for the established dominant sequence of "n" members ($n \leq N$) will not exceed 0.15 (i.e. 15%):

$\varphi(\Delta y1, \Delta y2, \Delta y3, \ldots, \Delta yn, 0, \ldots, 0) \leq 0.15$. (6)

The absence of the last "N – n" elements in the newly presented functional (6) may mean that the characteristics corresponding to them (coordinates, objects) turned out to be orthogonal [8] to the characteristics already taken into account, or their significance in relation to the characteristics included in the dominant sequence, an order of magnitude lower. Functions similar to (6) can be compiled for "good" and "satisfactory" grades. If the deviation from the standard φ (...) ≥0.45, then the student should be certified as "not mastered" the curriculum.

Properly selected functionality with a complete sequence of "N" elements can be used in testing in the 2nd qualifying round, and when the requirements for the standard itself are tightened, subject tests should be built according to the principle "from simple to complex", "from elementary skills to the highest skill" and, accordingly, shift the boundaries of subject tests towards more fundamental knowledge and skills.

By analogy with the ideas of [9], the following factors can be the reasons for student failure:

the student does not have sufficient resources (poor pre-student training) - ai is small;

ineptly organized study - $y_i = f(x_i, a_i - x_i)$ is not enough;

low interest in studying the subjects necessary for the specialty - λ_i is small.

Transitioning to machine (computer) testing of students' knowledge and using all the wealth of information technologies in this area, HEI teachers should focus maximum efforts on the process of "giving" knowledge to students, on their own personal and educational impact on the student audience.

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