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The Main Difficulties in Using the Expert Approach for Assessing the Ownership of Knowledge Factors in Modern Higher Education

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Abstract

In the article, a mathematical model of the structuring of the educational material of the discipline is exam based on the set-theoretical approach to factor clusters of knowledge. To formalize the construction of a test system, the division of the knowledge factor into certain micro-sciences is considered. For the purpose of an independent evaluation of micro-knowledge, they are assign certain attributes - attributes of elementarily, independence and completeness.

Key words: *Test system, knowledge cluster, knowledge factor, micro-knowledge.*

Introduction. One of the most promising forms of evaluation tools that meets the above stated requirements is testing, which allows measuring the degree of achievement of the established learning outcomes. This is because testing is a means of feedback, allowing the teacher of the university to assess the level of preparedness of students, to optimize the educational process, as well as to increase their own level of professional competence. In turn, the development of information technology makes it possible to automate the entire process of controlling knowledge from the development of test and measurement materials to analyzing the results of testing and adjusting the learning process because of the data obtained.

However, despite certain achievements in the development of methods and forms of testing, there are a number of problems widely discussed in scientific and pedagogical circles related both to the technology of their development and to the formation of evaluation tools in higher education institutions.

First, the problem is related to the fact that at present preparation of test tasks is an extremely time-consuming process, which requires the author of the test to have certain knowledge and skills in testing.

Studies on the evaluation of the required test volume and duration of testing indicate that an effective knowledge control test contains between 40 and 250 assignments. A test containing fewer than 40 tasks does not provide the required level of reliability and reliability of the results obtained because of the probability of simultaneous presentation of the same task to several subjects. Thus, the volume of the database of test tasks should at least an order of magnitude greater than the volume of the test, and this requires a large labor and temporary resources of teachers.

Despite the high complexity and laboriousness, preparation of tests is often not pay to the teacher as an independent work, so interest in test technologies and professional competence of university teachers in the field of their use in the educational process grow slowly. In connection with this, the task of formalizing the construction of test tasks and the development of an accessible and universal test design methodology is very relevant.

To solve this problem, it is necessary to investigate the most important properties of the testing process as a form of assessing knowledge, skills and habits. The following point is devoted to this investigation.

Problem Statement. If you systematically analyze the process of building a test for any technology, it becomes clear that it is a process of dismembering some single knowledge into its constituent elements, which in fact form test questions. These elements are naturally regarded as knowledge factors [1,2], because they together create the studied knowledge or its specific area. Thus, the main condition for building a testing system is the presence of decomposition of the studied material $\mathcal{M}$ (or topic $\mathcal{T}$, or section $\mathcal{R}$) to a multitude of less complementary, complementary forms of knowledge mutually complementary, which we will call *factor clusters of knowledge* (FCK). For example, to create a test for assessing the knowledge of the conditional volume of a material $\mathcal{M}$ there must be a partition of it into subsets of the following form:

$$\forall i \in [1, m] \rightarrow \mathcal{F}_i \subset \mathcal{M}: \mathcal{F}_i = \{f_{ii} | \mathrm{i} = \overline{1, \dots m_i}\}, \cup_i \mathcal{F}_i = \mathcal{M}. \quad (1)$$

Here $\mathcal{F}_i$ – FCK, isolated in the material $\mathcal{M}$ (or in its constituent parts $\mathcal{T}, \mathcal{R} \subset \mathcal{M}$), i - index FCK. The condition $\cup_i \mathcal{F}_i = \mathcal{M}$ shows that some number of clusters m completely determines the content of $\mathcal{M}$ (or $\mathcal{T}, \mathcal{R}$). Each cluster $\mathcal{F}_i$ is composed of m_i *knowledge factors* (KF), denoted by $f_{i\mathrm{i}}$. Each *i*-th KF phase reflects some part of the i-th FCK, and in aggregate m_i KF reflect the full knowledge of i-th FCK.

Recall that as a cluster of knowledge, it is planned to choose an arbitrary subset of some material $\mathcal{M}$, which can be chosen as topic $\mathcal{T}$, section $\mathcal{R}$, or even the full content of discipline $\mathcal{D}$. However, as we see, already at the stage of the general definition of these concepts we have to apply rather complex indexing. Therefore, in the future, to simplify the symbolism, we will assume that the testing problem for some abstract FCK $\mathcal{F}$, which consists of m KF $f_i, i = \overline{1, m}$. Then the mathematical model of the structure of the tested knowledge from the general form (1) is transform to the following form:

$$\forall i \in [1, m] \rightarrow \mathcal{F} = \{f_i | i = \overline{1, \dots m}\}, \cup_i f_i = \mathcal{F}. \quad (2)$$

Thus, for a specific development of the test system, FCK $\mathcal{F}$ acts as the test material $\mathcal{M}$.

Each KF f_i can be compared with the question q_i, the answer to which a_i can more or less reveal its essence. A measure of the degree of disclosure by the answer of the essence of the KF is a definite formed estimate e_i of the degree of possession of this essence - *the estimation of possession* (EP) as a factor of knowledge. On these basic concepts, a *test system* (TS) of *knowledge assessment* (KA). From its structure F within the framework of (2), the objectivity and effectiveness of the TS and the testing process as a whole largely depend on it.

Obviously, the process of partitioning $\mathcal{M}$ into $\mathcal{F}_i$, or $\mathcal{F}$ into f_i, and the process of EP generation by a particular KA is heuristic, and its exact mathematical model is unlikely to be constructed. Therefore, the task of formalizing the acquisition of the EP KA is the development and application of some general rule that, if it does not claim to be true, at least will ensure the objectivity of the assessment [3].

Possibilities for assessing the ownership of knowledge factors using an expert approach. Such a rule, for example, can be the method of expert assessments [4]. With its help, each test task is assign weight coefficients that indicate the evaluation for the past test question. In addition, depending on the form of the test question, an estimate is form for each answer to the test question. If testing was, conduct-using tests with the choice of one correct answer, then the evaluation is formed dichotomy, which is, 1 point is award for the correct answer and 0 points for the wrong answer. This approach is rational, since the processing of the obtained results becomes simple and, most importantly, this approach is the most objective [5].

If the tests used multiple-choice tasks or other types of test tasks, then a political evaluation of the test task, proposed by Avanesov [6], when the maximum number of points $\mathfrak{e}_{max}$ is set for a completely correctly performed job and zero for an incorrect job. For every mistake in the assignment, a score is take. In this case, the subject gets an estimate of $\mathfrak{e} \in [0, \mathfrak{e}_{max}]$.

ISSN 1512-1232

In view of the complexity of the procedure for evaluating test questions with multiple choice, Chelyshkova proposed to evaluate the tests for dichotomous evaluation, for a completely completed task with the choice of several correct answers to give 1 point and 0 points for, at least one, the wrong answer, thus simplifying the evaluation procedure [7]. However, such an assessment leads to a decrease in the accuracy of the measurement of knowledge due to the inability to evaluate the partial knowledge of the subjects. In the same vein, Pereverzev, in whose works the method of "partial score" is describe. According to this method, 1 point is given for each correctly selected answer, for an incorrect answer - 0 points [8].

With a specific volitional decision of the task of selecting any number of points for assigning them for the execution of a test task, it becomes difficult or impossible to correct evaluate other tasks, and to ensure a correct balance of estimates for the entire set of tasks in the test [8]. This is because the evaluation of a different number of points of test questions, on the one hand, increases the differentiation of issues, but, on the other hand, reduces the objectivity of the assessment. Proposals of apologists for assigning a variety of points to different questions are based on the following arguments:

• assignments of different difficulties are assessed by different number of points;

• different tasks require different numbers of operations.

However, here you can argue that, having tasks in the test for increasing difficulty, you can take into account the difficulty of the task, each succeeding point is extract with great effort. In addition, it should be borne in mind that operations are rarely the same in difficulty, because Actions within the job are not uniform in complexity [8].

Thus, the method of expert evaluations makes it possible to automate the process of forming tests, but there remains the problem of formalizing the evaluation of tests with multiple choice of answers.

This and other difficulties in applying expert assessments are discuss in the next paragraph.

The use of an expert approach for assessing the ownership of knowledge factors. The procedure for the work of experts in constructing an evaluation system for answers to test questions of varying complexity is very difficult. Usually experts in the process of evaluating the significance of the content of the test on some proposed scale, for example:

0 - unjustified inclusion of the task in the test;

1 - the grounds for including the assignment in the test are questionable;

2 - not significant task;

3 - low-value task;

4 - quite significant task;

5 - the most important supporting element.

At the same time, a fairly thorough complex of the following major works is carried out during the examination [9,10]:

1. Each task is executed in the test (the correct answer is indicated; the solution of the task is indicated where necessary);

2. The formulation of the task is analyzed (the correctness of the statements is verified);

3. The content of assignments for their thematic affiliation and level of complexity (basic, elevated and high) are analyze;

4. Comments are formulated for each of the tasks, in a constructive form with suggestions on what and how to change;

5. A conclusion is made about the suitability of the test for use.

It is clear that such a procedure for assessing the assessment of the test, intended for use in higher education, should be conduct by university professors. In addition, it is desirable that they have a sufficiently large scientific and pedagogical experience in the field of the material being evaluate in the discipline on which the tests are compiled [11].

ISSN 1512-1232

Along with this, experts should also be competent in the development of qualitative and, preferably, scientifically validated measurement diagnostic techniques. Moreover, preference to workers who have methodological experience in compiling tests [12].

At the same time, for the objectivity of the expert opinion, it is necessary to involve those teachers who did not participate in the development of the test as experts. It is considered expedient, for example, to involve in the expert groups the teachers of other universities.

Finally, in connection with the need to apply statistical methods to the results of the examination, sufficiently stringent requirements are also imposed on the representativeness of the expert group. Since it is desirable to assess not only the "average" opinion of such a group, but also the scatter of opinions on the points to be exhibit, the number of its participants must be at least three people. However, from the standpoint of the representativeness of the results, it is desirable that it be more than 5 (in general, a population of at least thirty data is considered to be a statistically representative sample [13], but such a number makes the idea of expert estimates utopian).

To all the above-mentioned difficulties in organizing the examination of test systems, it should be added that the curriculum of any direction for training specialists in the university contains dozens, and sometimes more than hundreds of subjects. Most of them need, for successful mastering by students, in the application of the TS, at least for effective current knowledge control. It is easy to calculate that the number of experts needed to build professionally based scales for assessing the answers to questions of these TS should significantly exceed the number of trainees.

Thus, in view of the limited number of specialists with the necessary competencies, and often their complete absence from universities, the procedure for using the expert approach to assess the test is very, very difficult, and, in fact, simply unrealizable.

The knowledge factor as a composition of micro-knowledge factors. In connection with the difficulty shown above in organizing expert groups in different disciplines, it is desirable to have a methodology for the ranked assessment of the KF available to each test developer in their discipline.

In this paper, it is proposed to provide a solution to this problem by introducing the concepts of "micro knowledge" and the corresponding micro-knowledge factor (MKF). It is assumed that it will be easier to form the KF of the MKF as an element of knowledge than for the KF as a whole. To solve the problem of uniform, and, therefore, objective (which does not necessarily mean "the best") formation of the evaluation of possession of micro knowledge as an element of knowledge, it must be given a number of specific attributes - attributes. In this paper, it is assumed that the essence of the formation of MKF is the allocation in the KF of its elements that are characterize by the following mandatory attributes for MKF:

1MKF. First, they must be so elementary that they can be allowed to demonstrate their mastery by one correct answer, and demonstration of their ignorance by one wrong answer (attribute of elementarily);

2MKF. Secondly, MKF should be as independent as possible, i.e. Possession of one of them does not guarantee unequivocal possession of another, and conversely, ignorance of any MKF does not exclude the knowledge of the other (attribute of independence);

3MKF. Thirdly, their aggregate, isolated from the KF, must guarantee, with all correct answers, a complete characterization of the KF (completeness attribute).

To clarify the essence of the introduced notion of MKF, the logic of its formation and use, in the next section we give a comparatively simple example of the classical TCS, which is compulsory for studying, and the notion of transfer function (TF). Which is comprehensible for those who have mastered this section, and the notion of mastering its understanding through MKF.

An example of the isolation of micro-knowledge factors from the knowledge factor. A clear example of a phase that contains MKF, and satisfying the formulated properties, is the determination of the transfer function (TF) of the dynamic link (DL) as an automation device or an automatic control system element. This definition to have the following form.

ISSN 1512-1232

Definition of TF: A fractional-rational function that is a ratio of the Laplace image of the output signal DL as a function of time to the Laplace image of the input signal DL as a function of time, with zero initial values of these functions is call the transfer function of the DL.

If we systematically investigate this definition, treating it as a TF, then the list of both necessary and sufficient properties can be decomposed into the set of individual properties listed below, which correspond to the formulated attributes of MKF.

Variant A of the decomposition of the TF as a KF on MKF:

A.1. The TF is a fractional-rational function (yes - true, no - false);

A.2. The numerator of the TF is the Laplace image of the output signal of the DL as a function of time (yes - true, no - false);

A.3. The input and output DL signals are formed at zero initial conditions (yes - true, no - false).

It is not difficult to see by checking the fulfillment of the conditions in parentheses that the formulated micro-knowledge corresponds to the attribute of elementarily. The second attribute of independence A.1, A.2, A.3 as separate knowledge is also obvious. Finally, the given positions are sufficient for reproducing the TF definition, since the recognition by the numerator of the "Laplace image of the output signal of DL as a function of time" uniquely determines the essence of the denominator and the provision on the completeness attribute is satisfied.

It is also easy to see that such a partition is not unique. Indeed, the following variant B of the composition of MKF also possesses the first, second and third attributes of the formation of KF as "Definitions of the KF ".

Variant B of TF decomposition as KF on MKF:

B.1. The TF is a fractional-rational function (yes - true, no - false);

B.2. The denominator of the TF is the Laplace image of the input signal DL as a function of time (yes - true, no - false);

B.3. The input and output DL signals are formed at zero initial conditions (yes - true, no - false).

It is possible to propose a third scheme for decomposition of this KF into MKF.

Variant C the decomposition of the TF as a KF on MKF:

C 1. The TF is a fractional-rational function (yes - true, no - false);

C 2. The fraction is the ratio of the Laplace image of the output signal to the Laplace image of its input signal as a function of time (yes - true, no - false);

C 3. The input and output DL signals are formed at zero initial conditions (yes - true, no - false).

It should be note that it is natural to consider the solution of the problem of KF decomposition on MKF as a positive factor, since this generates variability of test questions formed based on KF, and, consequently, increases the security of the test system from guessing and unintelligible memorization.

Thus, it becomes clear that the KF, most likely, can always be represent through MKF, the assessment of ownership of which within the KF may well be dichotomous. The question arises of generalizing this approach to such a level that the issues of the KF can be objective solved without the participation of special experts and their groups, but the basis of their inherent properties inherent in MKF.

Factor of knowledge as a combination of factors of micro knowledge. Thus, the mathematical model (MM) of the phase separation on the MKF by structure should be close to MM (2). If, according to this analogy, systematically analyze the process of constructing a test for mastering the KF, it turns out that it also represents the process of dismembering its specific knowledge into its constituent elements, MKF in essence which should form test questions. Since for these elements a completeness property (3 MKF) is define, they together create the studied knowledge - KF.

ISSN 1512-1232

Relying on this paradigm, one can proceed to a mathematical description of the test in terms of the concepts of the KF and the components of its MKF. Obviously, in order to create a test for assessing the ownership of the KF there must be a breakdown of each *i*-th KF as a set of f_i into m_i j-th elements of the MKF in the following form:

$$\forall j \in [1, m_i] \rightarrow f_{ij} \in f_i : \cup_j f_{ij} = f_i, \cap_j f_{ij} = \emptyset. \quad (3)$$

Here m_i – is the amount of MKF f_{ij}, that make up the that make up the KF f_i. This is represented by the relation $\cup_j f_{ij} = f_i$ and describes the "completeness attribute" - 3MKF. Similarly, the ratio $\cap_j f_{ij} = \emptyset$ describes the "attribute of independence" - 2MKF.

Each MKF f_{ij} can be compare with questionq_{ij}, the unambiguous answer to which is - a_{ij}, will either fully reveal its essence, or show the lack of possession of the testers of this MKF. This position is a consequence of the simplicity of the FMZ content as a particle of knowledge in accordance with the "attribute of elementarily" - 1MKF. As a measure of the degree of disclosure by the answer to the essence of MKF, therefore, a dichotomy-generated estimate $e_{ij} \in [0, 1]$ of the degree of possession of this essence is MKF.

Conclusion. On such a basic concept, a *test system* (TS) can be construct without using the expert assessment method, cumbersome and characterized by hard-to-evaluate reliability. Thus, relying on the axiomatically introduced attributes 1-3 MKF, using the considered example and set-theoretic models (1) - (3), it is possible to form a universal algorithm for decomposition of the original material under study into a TF, isolate in these clusters the KF, and decompose them into MKF.

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