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Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Satbayev University

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Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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INFORMATION APPROACH TO TESTING FOR ADEQUATE KNOWLEDGE ASSESSMENT

Abstract. Adequate assessment of knowledge in the course of testing is one of the main conditions for successful educational process as it has an effect on the examinee's training motivation, informs a teacher about the extent of material digestion and gives a possibility to the supervisory authorities to estimate correctly the quality of training. The present work considers the process of testing as two sequential processes: 1 - a process of formation of a trainee's answer to a test; 2 - a process of formation of an expert assessment of an answer. Considering application of a cybernetic approach and activity of constituent elements, the process of testing is described as a process of information transfer through two series-connected channels with a noise. The first channel displays a process of an answer formation by a trainee: an input is a probability vector of a trainee's knowledge level (proficiency level), an output is a probability vector of an answer level. The second channel displays a process of formation of a trainee's answer assessment by an expert. An input of the second channel is a probability vector of answers quality level, an output is a probability vector of probable estimates. The work offers noise control measures (upon obtainment of an adequate assessment) for open and closed testing.

Key words: an active element, a training system, a cybernetic approach, a channel with noise, an open testing, a closed testing, an assessment formation noise, an answer formation noise.

Introduction. Development of information-oriented society requires solution of a number of problems in the sphere of education [1]. It is generally accepted, that synthesis of different sciences is one of the methods for successful generation of new ideas. In the work [2] it is marked that consideration of educational system from the point of cybernetics provides a possibility to apply laws, principles and mechanisms known in the modern control theory for its optimization. Bespalko's works are widely known for their proposed decisions for technological issues of training with an application of basic information system concepts of information transfer relationship to communication channels throughput.

In conditions of a universal computerization we can see a growing role of the training system [3] as an educational system element.

Training system objectives:

1. To arm future experts in the shortest time with knowledge and skills to put such knowledge into practice.

2. To get in the shortest time an information about adequate digestion of knowledge and skills to put such knowledge into practice.

The attention should be paid to a trainee which is a basic element of the training system. A trainee's objective does not always coincide with an objective of the system, i.e. he/she is an active element [4] and depends on a psychological profile. Today interest to psychological and social profiles of a trainee is constantly growing due to training customization. This interest can be traced in a set of publications on

this subject [5,6,7]. The issues of self-reported grades test results application are described in [8]. The work [9] considers how the students' motivation affects the use of outcomes tests to measure institutional effectiveness. Grade point averages for English and math as well as cumulative grade point averages were also used in the analysis. [10] highlights methods of detection of cheating on classroom tests by error-similarity analysis procedures using multiple answer-sheet forms. Thus, the work [5] highlights the results of polling according to which 72% of students live from session to session, i.e. knowledge acquisition is not a primary task (a student should have a finger in every pie). Just 38% of respondents consider that the present-day student should aspire to new knowledge. Thereby, we can divide all students into two categories.

The aim of the students falling into the first category is to pass their knowledge examination with maximum success and less training as they do not have any interest in obtaining of new knowledge and skills.

The aim of the students of the second category is to gain new knowledge and skills as much as possible in the course of training and to use all gained knowledge and skills for successful examination.

The first type of students is not interested in obtainment of knowledge, only in getting a good mark (at least fair mark is enough in the absence of knowledge) [11-14].

In general, researches on test efficiency improvement can be divided into two main groups:

2- Development of test work out rules [15, 16].

3- Development of rules for assessment, adjustment of test points [17,18,19] (for guessing, correlation of test level to the level of trainees, etc.).

Methods. Cybernetic approach to description of a test system. Considering the test system from the point of view of cybernetics [20], the following main elements should be detached: **a trainee** (student) and **an expert** (teacher). Figure 1 shows the test system comprising of series-connected elements: a trainee, an input (adjustable) which is represented by a test, an output which is represented by an estimation. Feedback is presented by the most common option - adaptive testing.

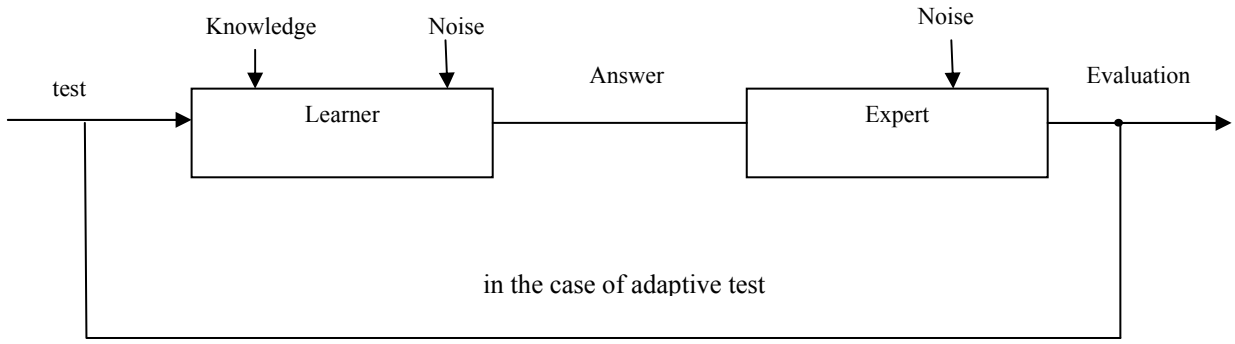

Figure 1 – Evaluation formation rules

An output of the first element, which is a trainee, is an answer formed on the basis of external interferences:

- knowledge obtained by a trainee;
- test conditions (level of comfort, a possibility of getting a prompt message, roulette game, etc.) let us call them an answer formation noise.

A trainee's answer shall be an input of the second element and estimation shall be an output. The estimation adequacy is influenced by the following:

- knowledge estimation rules
- competence of an expert.
- an expert situation (level of comfort, personal sympathy to a trainee, etc.), let us call it an assessment formation noise.

Thus, the considered system conditions are determined by knowledge of a trainee, an answer formation noise, knowledge estimation rules and competence of an expert.

Test performance procedure can be split into two main processes:

1 – a process of a test answer formation by a trainee;

2 – a process of an answer assessment formation by an expert.

Consequently, the factors which disturb making an adequate assessment of knowledge can have an influence on:

1– an answer of a trainee (an answer formation noise)

2 – an assessment formation by an expert (an assessment formation noise).

According to the considered scheme an estimation reliability is influenced by existence of two noises: an answer formation noise and an assessment formation noise.

In the theory of information a notion "*thesaurus"* is applied for definition of the whole data set possessed by an individual.

It is obvious that the test result – an estimation depends on relationship of a trainee's thesaurus of knowledge, a test and an expert competence. Thus, we shall hardly get an unbiased assessment if a test thesaurus significantly exceeds a thesaurus of knowledge of a trainee and a thesaurus of knowledge of the latter, i.e. a thesaurus of an answer is higher than an expert competence. Present-day developments in the sphere of testing assume consideration of a discrepancy of a thesaurus of knowledge and a thesaurus of test (IRT – technologies) [18,19,21].

A test subsystem as a communication channel with noise. Let us assume that a scale of answers assessment has *m* number of possible values.

Thereby, a level of answer showing its quality can be determined based on *m* possible values and, respectively a level of knowledge can be presented by *m* possible estimates.

The test system given in Fig.1 can be considered as series-connected channels with noise.

The first channel (channel 1) displays a process of an answer formation by a trainee: an input is a probability vector of a trainee's knowledge level (proficiency level), an output is a probability vector of an answer level. The second channel displays a process of formation of a trainee's answer assessment by an expert. An input of the second channel (channel 2) is a probability vector of answers quality level, an output is a probability vector of probable estimates.

Assessment in a closed form test has a high level of formalization, i.e. a noise in channel 2 is almost absent.

Therefore, a solution of the test adequacy problem can be seen in a struggle against an answer formation noise, i.e. check of only channel 1.

In the open testing an assessment formation noise takes a dominant position. Therefore, the test adequacy problem solution can be seen in a struggle against an assessment formation noise, i.e. check of only channel 1.

Let us consider a trivial description of a communication channel with noise. A source condition is determined by a probability vector $p(a_i)$ i = 1..m. (For channel 1 this vector determines probable qualification level of trainees, for channel 2 this vector determines probable answer quality levels).

If we transfer *m* number of signals A and expect to get *m* number of signals B, noise influence in the communication channel is completely described by a channel matrix [22]. On the part of a message source a channel matrix describing a communication channel looks as follows:

a/b	b_1	b_2	….	b_j	…	b_m
a_1	$P(b_1/a_1)$	$P(b_2/a_1)$	…	$P(b_j/a_1)$	…	$P(b_m/a_1)$
a_2	$P(b_1/a_2)$	$P(b_2/a_2)$	….	$P(b_j/a_2)$	….	$P(b_m/a_2)$
….	….	….	…..	….	….	…
a_i	$P(b_1/a_i)$	$P(b_2/a_i)$	….	$P(b_j/a_i)$	….	$P(b_m/a_i)$
…	….	….	…..	….	….	….
a_m	$P(b_1/a_m)$	$P(b_2/a_m)$	…..	$P(b_j/a_m)$	…..	$P(b_m/a_m)$

$P(b_j/a_i)$ values shall be determined as conditional probability of b_j receiver state at transfer of a_i source condition.

(For channel 1- a conditional probability is to get an answer of quality b_j at proficiency level (level knowledge) a_i; for channel 2 - a conditional probability is to get an estimate of level b_j at answer quality (level) a_i.

Diagonally stretching probabilities determine a correct receipt, other probabilities determine a false receipt. Value of numbers in the channel matrix columns usually decrease while they are farther from the main diagonal. And in case of complete absence of noise all values except for the ones located along the main diagonal are equal to zero [14].

In the test system the diagonally stretching probabilities are:

1) For channel 1 - probabilities of adequate answers, answers coinciding with the level of knowledge,

2) For channel 2 - probabilities of adequate assessment, i.e. an assessment coinciding with the level of answers.

Other conditional probabilities are connected with information transfer distortion:

1) For channel 1 - probabilities of information transfer distortion appear in the course of answer formation by a trainee (an answer formation noise)

2) For channel 2 - probabilities of information transfer distortion appear in the course of score assigning by an expert (an assessment formation noise).

Today the credit education system provisions an 11-point scoring system of knowledge assessment ranging from 4 to 0 (see table 2).

Table 2 – Student knowledge assessment

Score	Literal equivalent	In percentage terms, %	In points
Excellent	A	95-100	4
	A-	90-94	3.67
Good	B+	85-89	3.33
	B	80-84	3.0
	B-	75-79	2.67
Fair	C+	70-74	2.33
	C	65-69	2.0
	C-	60-64	1.67
	D+	55-59	1.33
	D	50-54	1.0
Poor	F	0-49	0

Thus, the considered matrix is equal to 11 and conditional probabilities determine the process of information distortion. For channel 1 these distortions estimate discrepancy of an answer with knowledge and for channel 2 - discrepancy of assessment with an answer. It should be noted, that the purpose of the teacher is performance of a test with identity matrix, i.e. with a matrix with ones on the main diagonal. The student's aim is an identity matrix with ones in the first column (on condition that a_1 is the highest knowledge score 4….. a_{11} is the lowest knowledge score 0; b_1 is the highest score 4 ….. b_{11} is the lowest score 0).

Results. *A proposal for organization of a closed testing.* In a closed test noise in channel 2 is almost absent due to high formalization.

The main reasons for " the answer formation noise", noise in a channel are as follows:

– outside help – a prompt message, a crib, etc.;
– "roulette game" at choosing an answer.

The work [3] proposes a game method of testing as a method of struggle against the outside help (prompt message) [23].

In a closed testing fight against roulette game or a possibility of guessing is the main reason for inadequacy of the answer to knowledge.

The work gives an analysis of the results considering "roulette game" at knowledge assessment. Thus, [17] offers test points adjustment. Three-parameter Birnbaum model is proposed for assessment in conditions of probable guessing. [18-19].

The test forming is proposed in [24].

For the fight against "roulette game" it is possible to apply the same methods which are used in information systems for noise control:

- redundant encoding;
- filtration.

Let us consider the main idea of redundant encoding: during transfer additional (adjusting) bits are added to information bits. They detect and correct transfer errors. The simplest method is a double transmission of message and comparison of the received messages on receiving end. In case of received messages equality we can say that the transfer is reliable.

We shall analyse a process of the closed testing when a trainee by a reason of lackness of knowledge chooses one of the proposed answers by chance. We assume that there are proposed 5 answers and only one is correct. In this case of 1/5 probability it is possible to pass a test by random choice (roulette game). If a testee passes a test only in case of correctly answering two questions closely related to a subject, then a probability to pass a test at "roulette game" is equal to $(1/5)^2$, etc. Let a be an event at which an examinee doesn't know an answer to the first question; b – an event at which an examinee doesn't know an answer to the second question. The questions must be selected in a way that $p(b/a) = 1 - \varepsilon$, where ε is a small value, i.e. ignorance of one question almost obligatory leads to ignorance of another one.

Continuing the reasoning, we can put three questions and consider the answer correct if the correct answers were chosen for all three questions. In this case a probability to pass a test with ignorance of material (roulette game) is already equal to 1/125.

The second method of fight against information distortion in the channel with noise is filtration. For test system it is equivalent to a multilevel testing. In this situation the first given question is more simple (for getting a fair mark) and if a correct answer is specified then it is offered to answer more difficult question (for getting a good mark), etc. In this case a probability to pass a three-level test by chance is equal to the product of conditional probabilities, i.e. it is less or equal to 1/125. Meanwhile, the questions must be on the same subject and the second question should be more difficult than the first one.

Proposals for an open test arrangement. The first problem of an open test is a problem of giving of marks for the answers. A number of works is devoted to the issues of an open test results assessment. If to consider that an answer formation noise is absent, then a task of an open test reliability improvement results in a fight against assessment formation noise, i.e. a noise in channel 2.

As it was highlighted in the paragraph - a trivial method of noise control is an antinoise coding (a repetition at its simplest form) and filtration. Therefore, it is obvious that for successful mark allotment:

- it should be proposed to the expert to assess the same answer repeatedly for many times (as a procedure - it can be a proposal for consideration of a test for several times at different time periods with rather big time intervals or among rather large number of other tests without information about the person by which the test was developed).

- to assess the same answer by the specialists with different levels of expertise where an expert with the lowest level of competence (thesaurus) either estimates an answer as unsatisfactory or gives answers with the lowest marks to an expert with higher level of competence who has a right to put a higher mark, etc.

Conclusion. As a final point of educational process, testing is one of its most important components. The main questions related to test arrangement are - test development and assessment of an answer to it.

This work considers the test system from the point of view of cybernetics. The test process is described as two sequential processes: a process of an answer obtaining from a trainee and a process of assessment by an expert. There are distinguished the factors which have a negative influence on adequate assessment of knowledge of a trainee. They are: an answer formation noise (a result of the trainee's activity) and an assessment formation noise. Generally, in order to solve an issue of noise control it is proposed to consider the test system as two sequential communication channels with noise. The work compares two main test system types - open and closed. As the technology of the closed test holding assumes that the main reason for assessment inadequacy is an answer formation noise and a technology of an open test holding assumes that the main reason is an assessment formation noise, we consider one channel with noise.

This allows to offer for the test noise control the same methods that are used in information systems for detachment of a "correct" signal from noisy signal: redundant encoding and filtration.

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ТЕСТІЛЕУДЕ АДЕКВАТТЫ БАҒА АЛУДЫҢ АҚПАРАТТЫҚ ТӘСІЛІ

Аннотация. Тестілеуде адекватты баға алу – оқыту үдерісі жетістігінің негізгі шарттарының бірі, өйткені сынақтан өтушіні білім алуда ынталандыруға әсер етеді, материалды меңгеру дәрежесі туралы оқытушыны хабардар етеді және бақылаушы инстацияларға оқыту сапасын бақылау мүмкіндігін береді.

Мақсатына жету үшін (оқыту жүйесінің мақсаттарына да) оқытушы келесі негізгі міндеттерді шешуі керек:

1. Студентті ұсынылған материалды білуге қызықтыру;
2. Қарастырылатын тақырыпты түсіну үшін материалды жақсы түрде ұсыну;
3. Қысқа уақыт аралығында студент беріліп жатқан білім туралы көп ақпарат алатындай білімді тексеруді ұйымдастыру.

Білімді тексеру білім беру процесінде маңызды орын алады, өйткені оның нәтижелері:

- пәнді оқудағы мотивацияға әсер етеді;
- материалды игеру дәрежесі туралы оқытушыға хабарлайды;
- қадағалау органдарына оқыту сапасына бағалау мүмкіндігін береді.

Бұл жұмыста тестілеу процесі екі тізбекті процесс ретінде қарастырылған:

- тестке білім алушының жауабын қалыптастыру процесі;
- жауапқа сарапшының баға қою процесі.

Тест құрастыру және тест нәтижелерін бағалау кезінде келесі жағдайды ескеру қажет:

- сұрақтың күрделілігі;
- жауап уақыты;
- тестілеу шарттары.

Сұрақтың күрделілігі мен жауап беру уақытын анықтау әдістері студенттерді қатыстыруға байланысты, демек, олар тестілерді бағалау нәтижесіне әсер етеді. Білім алушылардың бір тобына бірдей тест сұрақтарының күрделілігі орташа дәрежеде, ал екінші топқа жоғары болуы мүмкін. Тестілеуді түрлі тәсілдермен жүргізуге болады. Жұмыста, сондай ақ, тест тапсырмаларының жіктелу жолдары келтірілген.

Білім алушының білімін дұрыс бағалауға теріс әсер ететін факторлар анықталды. Олар – жауапты қалыптастыру (білім алушының белсендігі нәтижесі) мен бағалауды қалыптастыру шуылы. Жалпы алғанда, шуылмен күресу сұрақтарын шешу үшін тестілеу жүйесін шуылы бар тізбекті екі байланыс каналы ретінде қарастыру ұсынылады. Тестілеудің жабық формасын жүргізу технологиясы дұрыс бағаламаудың негізгі себебі – жауапты қалыптастыру шуылы, ал тестілеудің ашық формасын ұйымдастыру – бағаны қалыптастыру шуылы ретінде есептеуге мүмкіндік беретіндіктен шуылы бар бір канал қарастырылады.

Бұл жағдай шуылмен күресу үшін ақпараттық жүйелерде шуыл сигналдан дұрыс сигналды алу үшін артық кодтау мен фильтрацияны қолдануға мүмкіндік береді. Кибернетикалық тәсілді қолданып әрі құрама элементтердің белсендігін ескеріп, тестілеу процесі екі тізбекті қосылған шуылды арнадағы ақпаратты тасымалдау процесі ретінде сипатталады. Бірінші арна білім алушының жауабын қалыптастыру процесін көрсетеді: оның кірісі – білім алушының білім деңгейінің ықтималдылық векторы, шығысы жауап деңгейінің ықтималдылық векторы болып саналады. Екінші канал студенттердің жауабы бойынша сарапшының баға қалыптастыру процесін көрсетеді. Екінші каналдың кірісі жауаптың сапалық деңгейінің ықтималдылық векторы, шығысы бағалардың ықтималдылық векторы болып есептеледі. Ашық және жабық тестілеуде шуылмен күресу шаралары ұсынылады.

Түйін сөздер: белсенді элемент, оқыту жүйесі, кибернетикалық тәсіл, шуылы бар арна, ашық тестілеу, жабық тестілеу, бағалауды қалыптастыру шуылы, жауапты қалыптастыру шуылы.

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ИНФОРМАЦИОННЫЙ ПОДХОД К ПОЛУЧЕНИЮ АДЕКВАТНЫХ ОЦЕНОК ПРИ ТЕСТИРОВАНИИ

Аннотация. Получение адекватных оценок в процессе тестирования является одним из основных условий успешности образовательного процесса, так как влияет на мотивацию в обучении самого испытуемого, информирует преподавателя о степени усвоения материала и дает контролирующим инстанциям возможность судить о качестве обучения.

Преподаватель для достижения своей цели (а значит и цели обучающей системы) должен решить следующие основные задачи:

1) заинтересовать студента в познании предлагаемого материала;

2) представить в наилучшей форме материал для познания рассматриваемой темы;

3) организовать проверку знаний так, чтобы получить максимальную информацию о полученных студентом знаниях в наикратчайший промежуток времени.

Проверка знаний является ключевым моментом образовательного процесса, так как ее результаты

1 - влияют как на мотивацию в обучении самого испытуемого,

2 - информирует преподавателя о степени усвоения материала,

3- дают контролирующим инстанциям возможность судить о качестве обучения.

В настоящей работе рассмотрен процесс тестирования как два последовательных процесса:

1 - процесс формирования обучаемым ответа на тест,

2 - процесс формирования экспертом оценки за ответ.

При составлении тестов и оценивании результатов тестирования требуется учитывать: сложность вопроса; время ответа; условия проведения тестирования. Методы определения сложности вопроса и времени ответа связаны с привлечением обучающихся, а значит, они влияют на результат оценивания тестов. Так, для одного коллектива обучающихся одни и те же тесты могут быть средней сложности, а для другого – повышенной. Тестирование же можно проводить в разных вариантах. В работе приведены классификации тестовых заданий.

Выделены факторы, отрицательно влияющие на получение адекватной оценки знания обучаемого. Ими являются следующие:

- шум формирования ответа (результат активности обучаемого);

- шум формирования оценки.

В общем случае для решения вопроса борьбы с шумами предлагается рассматривать систему тестирования как два последовательных канала связи с шумом. Сравниваются две основные системы тестирования – открытая и закрытая. На основании того, что технология проведения закрытой формы тестирования позволяет считать основной причиной неадекватности оценки шум формирования ответа, а организация открытой формы тестирования – шум формирования оценки, рассматривается один канал с шумом.

Это позволяет предложить для борьбы с шумом тестирования те же методы, что используются в информационных системах для выделения «правильного» сигнала из зашумленного: избыточное кодирование и фильтрацию.

Применяя кибернетический подход и учитывая активность составляющих элементов, процесс тестирования описывается как процесс передачи информации в двух последовательно соединенных каналах с шумом. Первый канал отображает процесс формирования ответа обучаемым: его входом является вектор вероятностей уровней знания (состояний подготовленности) обучаемого, выходом- вектор вероятностей уровней ответа. Второй канал отображает процесс формирования оценки экспертом на ответ обучаемого. Входом второго канала является вектор вероятностей уровней качества ответа, выходом- вектор вероятностей возможных оценок.

Предлагаются меры по борьбе с шумом (по получению адекватных оценок) при открытом и закрытом тестированиях.

Ключевые слова: активный элемент, обучающая система, кибернетический подход, канал с шумом, открытое тестирование, закрытое тестирование, шум формирования оценки, шум формирования ответа.

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