Testing for general and inorganic chemistry in the MOODLE system

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Abstract. The current epidemiological situation in the world forces the pedagogical community to switch to the use of various forms of education using distance educational technologies. One of the most difficult problems of organizing distance learning is the problem of various forms of monitoring students knowledge. The most promising area for assessing the quality of knowledge is computer testing. Based on many years of experience in the development of computer test tasks, the basic requirements for computer test tasks and for computer tests are formulated, which make it possible to increase the efficiency of their use to control students knowledge. Examples of the correct representation of answer options in tasks with a choice of answer options (in closed test tasks) are given and ways to reduce the probability of guessing the correct answer are considered. With regard to the course "General and Inorganic Chemistry", the features of the use of various forms of test tasks are analyzed using specific examples. For the organization of computer testing of first-year bachelor degree students in the course "General and Inorganic Chemistry" the Moodle system was chosen. This system has various functions for creating tests, as well as for conducting training and control testing. For the convenience of entering test tasks into the Moodle system, these tasks must be converted into GIFT format. After that, GIFT tasks are easily imported into Moodle. Examples of different forms of test items in WORD and GIFT formats are given. The Moodle distance learning system (platform) has introduced a bank of tests for the course "General and Inorganic Chemistry", which is taught to first-year bachelor degree students of the Mendeleev University of Chemical Technology of Russia. The features of using this platform for organizing computer testing when using distance and blended forms of education are shown.

1. Introduction

The most important task of modern educational policy is to ensure the modern quality of education based on the preservation of its fundamental nature and compliance with the current and future needs of the individual and society. The quality of training of graduates of higher educational institutions can be considered as a result that fixes the acquisition by students of scientific and practical knowledge gained in the process of educational activities, allowing not only young specialists to carry out their professional activities, but also take a worthy place in society and develop harmoniously throughout their lives. The quality of training of specialists can be defined as the compliance of the level of his education with state educational standards, the requirements for a specialist in this profile, as well as a high level of his social and cultural development. Computer literacy and the ability to use modern information technologies are also integral components of a high level of training. In connection with the intensive development of
science and technology, all of the above characteristics are not absolute and fixed, since at present there is a continuous improvement in the indicators of the level of education of graduates.

Currently, the complex epidemiological situation in the world has forced the teaching community to switch to the use of various forms of education with the use of distance learning technologies. The combination of traditional full-time education with distance learning technologies in the higher education system allows taking into account the individual characteristics of students and, as a result, significantly improves the quality of education.

One of the most difficult problems of organizing distance learning is the problem of implementing various forms of monitoring students' knowledge. To conduct an effective assessment of knowledge, special forms of control should be developed based on the use of the achievements of modern computer testology [1-4]. One of the most promising and effective areas for assessing the quality of education is computer testing of knowledge, abilities and skills. Only if automated computer systems are used to assess knowledge, in particular, computer testing, can an independent system for assessing the quality of student learning be created [3].

2. Results and discussions
In the Mendeleev University of Chemical Technology of Russia, has accumulated extensive experience in the development of test items in general and inorganic chemistry [5-9] and developed systems for teaching and monitoring computer testing [4,10], which are used to organize the independent work of students in the system of full-time chemical education. Based on our own many years of experience in the development of computer test tasks [4-10], as well as taking into account the achievements of pedagogical testology [1-3] and the theory and practice of creating pedagogical test materials [12-15], we have formulated the basic requirements for computer test tasks and computer tests, allowing to increase the efficiency of their use to control students' knowledge. The most important requirements for test items are the following:

• open and closed test items are formulated as a short (no more than 10-12 words) unfinished judgment; the formulation of the task in the form of a question to a lesser extent orientates the mental activity of the student [13],
• test assignments should be composed in the same style and in such a way that the student spends approximately the same amount of time on each exercise or task (no more than 1.5 - 2 minutes).
• each test item must contain an unambiguously correct answer; test tasks should not contain erroneous (inaaccurate) data; violation of this rule can lead to a conflict situation, a frivolous attitude of the test taker to the task and the accumulation of erroneous information in memory, which is absolutely unacceptable;
• test assignments should have varying degrees of difficulty, in order to be feasible both for low-performing students and be interesting for well-performing and advanced students; it is customary to make tasks of three degrees of difficulty [3]; as a result, for each category of students it will be possible to solve problems corresponding to their level of training.

In our opinion, there is a correct and incorrect form of presentation of answer options in tasks with a choice of answer options (in closed test tasks). Let us give the following example for illustration. To test students' knowledge, for example, of the relationship of Gibbs energy with enthalpy, entropy of chemical processes incorrect formulas cannot be given as answers:

\[ \Delta G = \Delta H - T\Delta S \]  (correct answer);
\[ \Delta G = \Delta H + T\Delta S; \]
\[ \Delta G = T\Delta S - \Delta H; \]
\[ \Delta G = T\Delta H - \Delta S; \]
\[ \Delta G = (\Delta H - \Delta S)/T. \]
The test task under consideration should be formulated as follows: the Gibbs energy $\Delta G$ of the chemical reaction is

$$\Delta H - T\Delta S \text{ (correct answer)};$$
$$\Delta H + T\Delta S;$$
$$T\Delta S - \Delta H;$$
$$T\Delta H - \Delta S;$$
$$(\Delta H - \Delta S)/T.$$

With such a presentation of the answer options, the possibility of memorizing incorrect answers is significantly reduced.

- To reduce the likelihood of guessing the correct answer, you must
- use open test tasks in which the answer is entered using the keyboard in the form of a number or word;
- when using tasks with a choice of answer options, give preference to tasks with several options of correct answers;
- in matching tasks, it is imperative to use distractors to increase the number of possible answers;
- use at least four options in assignments to establish the correct sequence;
- in design assignments, use as many options as possible to choose the correct answer.

With regard to the course "General and inorganic chemistry", the following features of the use of various forms of test tasks were established.

- Open-ended tests with an answer in the form of a number are effectively used to test the ability to solve computational problems in general and inorganic chemistry. In this case, it is advisable to compose the design task in such a way that the answer in the problem is entered as an integer. As an example, we can give a calculation problem to determine the hydrogen index (pH) of an aqueous solution with a known molar concentration (M):
  - Calculate the pH value of $10^{-3}$ M aqueous KOH solution. Enter your answer as a whole number.
  - Answer: 11.

In open tasks in general and inorganic chemistry, the answer can also be entered in the form of one word:
- The name of the most common metal on earth. Enter the answer with a word.
  - Answer: aluminum.

- In closed test tasks (tasks with choosing the correct answers from the proposed options), it is better to use several options of correct answers. This will significantly reduce the likelihood of guessing the correct answer. As an example of a task with several variants of correct answers, we can give the task to determine weak (associated) electrolytes in an aqueous solution:

 Weak (associated) electrolytes in aqueous solution include

Answer options:
- H$_2$S
- H$_2$SO$_3$
- H$_2$SO$_4$
- HNO$_2$
Correct answer: H2S, H2SO3, HNO2

Closed test assignments in the course of general and inorganic chemistry are very suitable for testing students' ability to compose equations of chemical reactions - the section "Redox reactions" is always difficult for students in the first year of study. As an example of such a task, we can consider the oxidation reaction of potassium sulfite with potassium permanganate in an acidic medium:

Set the products of the redox reaction:

\[ \text{K}_2\text{SO}_3 + \text{KMnO}_4 + \text{H}_2\text{SO}_4 \rightarrow \]

Answer options:

- H2S
- S
- K2S
- K2S2O3
- K2S2O4
- K2MnO4
- MnO2
- MnSO4
- Mn (OH)2
- H2O
- H2O2

Correct answer: K2SO4, MnSO4, H2O.

In tasks to establish the correct sequence, it is advisable to use at least three to four options. Set the sequence of increasing the strength of the bases Ca (OH)2, Ba (OH)2, Fe (OH)2, Fe (OH)3.

Correct answer: Fe (OH)3, Fe (OH)2, Ca (OH)2, Ba (OH)2.

In the transition to distance learning technologies, an important factor is the choice of a technical (technological) platform - a computer control system and the practical implementation of the learning process. The most promising for this is the use of such systems that are specially designed for distance education and have proven themselves well in the higher education system. The Moodle platform (course management system) is one such system [16-23]. The Moodle system makes it possible to effectively introduce distance technologies into full-time education and has proven itself well in Russian and foreign universities.

To organize the process of teaching students in the Moodle system, it is necessary to structure the course. For the effective organization of distance learning, as well as the management of independent work of students, the course structure should include the following blocks [19]:

- motivational (stimulating interest),
- instructive (instructions, administrative documents, guidelines),
- informational (printed and electronic textbooks and study guides, tasks to complete, list of basic and additional literature, glossary),
- supervisor (tests for entrance, intermediate and final control, as well as tasks for self-control),
- communication and consultative (interactive interaction of participants in the educational process).

For the organization of computer testing of first year undergraduate and specialty students in the course "General and Inorganic Chemistry" we have chosen the Moodle system. This system has many
functions for creating tests, as well as for conducting training and control testing. Using the “Test” course element in Moodle allows setting up testing [20, 21]: time, assessment, viewing, additional restrictions on the number of attempts, etc. The Moodle system, thus, is a convenient tool for testing students at different stages of the educational process [22].

In accordance with federal state standards of higher education, the student must have the competencies established by the program (bachelor's degree, specialist degree). The competences that this discipline implements are prescribed in the discipline's work program in accordance with the main educational program and curriculum. When creating a test in Moodle, you can consolidate the implementation of the necessary competencies, depending on the type of testing being carried out.

Before entering test tasks from the bank [7, 8] into the Moodle system, it is necessary to convert these tasks into GIFT format. After that, GIFT tasks are easily imported into Moodle.

As a result of importing test items into the Moodle system, we created a bank of questions for the course "General and inorganic chemistry". The categories (sections) shown in this figure are arranged by the Moodle system in alphabetical order.

The question bank contains 800 test items in 14 course categories:

- equivalent,
- concentration of solutions,
- oxidation-reduction reactions,
- structure of matter,
- covalent bond,
- the Gillespie method,
- molecular orbital method,
- thermochemistry; Hess's law,
- entropy, Gibbs energy,
- chemical equilibrium,
- dissociation of electrolytes, pH,
- solubility, the product of solubility,
- hydrolysis;
- chemistry of complex compounds.

Test tasks in the question bank are presented in a closed form (with a choice of one or more answers), in an open form (with an answer in the form of an integer or a word), as well as for establishing the correct sequence. Examples of these tasks are presented, respectively, in figures 1, 2 and 3.

![Figure 1. Test task of the closed form.](image-url)
One of the advantages of writing test items in the Moodle system is the ability to impose penalties for an incorrect answer. This becomes especially important in the course "General and Inorganic Chemistry" in tasks related to the determination of reaction products. If one product is chosen incorrectly or not at all, then the reaction equation is considered incorrect. In this case, an incorrect answer is given to this task (in terms of the Moodle platform, a 100% penalty is imposed for the task). It should also be noted that in test items with multiple choice, the percentage of "correctness" can be divided between the answer options in any proportion, the main thing is that the sum is 100%.

Based on the created bank of test tasks in the Moodle system, various tests can be created. When forming tests, you can select specific questions from the bank, or you can use the "random question" function. When this function is selected, the number of tasks and the section (category) from which these questions will be selected are set. Thus, at the beginning of testing, the system will randomly select a given number of questions from the bank. In addition, the Moodle system provides for a random order of answers, which, together with the “random question” function, minimizes the possibility of coincidence of questions in testing among students, which makes it possible to more objectively assess their knowledge. After the students pass the test, you can see its results, which, in addition to the points scored, display the time of passing and the number of attempts (if provided by the test settings).

It should be noted that testing in the Moodle system can perform not only a controlling, but a teaching function. In the process of choosing the correct answer, the student compares various characteristics and properties of the studied objects and classifies them. This process activates his mental activity. The testing process identifies knowledge gaps.
3. Conclusion
The use of testing in the Moodle system in the educational process not only contributes to the consolidation and generalization of the acquired knowledge, but can also serve as a means of acquiring new knowledge, determining the direction of the search for new information previously unknown to the student. Thus, computer testing in the Moodle system becomes an integral part of the learning process, the most important way of implementing feedback in this process. As a result, teaching turns into a differentiated process that provides an individual learning pace for each student and implements the idea of cooperation pedagogy.

References
[1] Avanesov V S 1989 Fundamentals of the Scientific Organization of Pedagogical Control in Higher Education (Moscow, Russia: MISiS Press) p 208
[2] Mikhailichev E A 2001 Didactic Testology (Moscow, Russia: Public education) p 432
[3] Vasiliev V I and Tyagunova T N 2003 Foundations of the Culture of Adaptive Testing (Moscow, Russia: Publishing house IKAR) p 584
[4] Shcherbakov V V and Kapustin Yu I 2010 Computer Tests: Development and Testing (Moscow, Russia: Mendeleev University of Chemical Technology of Russia Press) p 164
[5] Shcherbakov V V, Artemkina Yu M and Parkina M P 2013 Computer Training Tests in General and Inorganic Chemistry: an Electronic Study Guide (Electronic edition) (Registration certificate of the obligatory federal copy of the electronic publication 30095 The state registration number of the obligatory copy of the electronic publication is 03211300797)
[6] Shcherbakov V V, Artemkina Yu M, Artemkina I M and Parkina M P 2014 Computer Control Tests on the Theoretical Foundations of Chemistry: an Electronic Textbook (Educational publication) (Registration certificate of the obligatory federal copy of the electronic publication 34860 The state registration number of the obligatory copy of the electronic publication is 0321400330)
[7] Shcherbakov V V, Artemkina Yu M and Parkina M P 2014 Database of Controlling Tests in General and Inorganic Chemistry (Certificate of state registration of the database 2014620167)
[8] Shcherbakov V V, Artemkina Yu M and Parkina M P 2014 Database of Control Tests in Chemistry (Certificate of state registration of the database 2014620168)
[9] Artemkina Yu M, Zagoskin Y D, Kuznetsov N M, Parkina M P and Shcherbakov V V 2014 Bank of computerized control tests in general chemistry Advances in chemistry and chemical technology 289(158) 92-4
[10] Parkina M P, Artemkina Yu M and Shcherbakov D V 2010 Development of a training computer testing system Advances in chemistry and chemical technology Moscow Mendeleev University of Chemical Technology of Russia 24(1) 81-5
[11] Avanesov V S 1995 Theoretical Foundations of the Development of Tasks in Test Form: Textbook Allowance (Moscow, Russia: MGTA) p 243
[12] Mayorov A N 2000 Theory and Practice of Creating Tests for the Education System (Moscow, Russia: Public education) p 352
[13] Vasiliev V I and Tyagunova T N 2001 Theory and Practice of the Formation of Software-Didactic Tests (Moscow, Russia: Publishing house MESI) p 130
[14] Chelyshkova M B 2002 Theory and Practice of Constructing Pedagogical Tests (Moscow, Russia: Logos) p 431
[15] Crocker L and Algina J 2006 Introduction to Classical and Modern Test Theory (Wadsworth Pub Co) p 527
[16] Kravchenko G V 2014 Using the blended learning model in the system of higher education News of the Altai State University 2-1(82) 22-5
[17] Kravchenko G V 2015 Pedagogical features of the organization of distance learning in the Moodle environment News of the Altai State University 3-1(87) 59-63
[18] Lavrent'ev G V 2012 Distance learning: theoretical and methodological foundations *Bulletin of the Altai Academy of Economics and Law* 2(25) 133-4

[19] Kravchenko G V and Lavrent'ev G V 2013 Building a distance course and organizing training for higher school students in the Moodle system *Izvestia of the Altai State University* 2(78) 26-9

[20] Kravchenko G V and Volzhenina N V 2012 *Working in the Moodle System: User Manual: Tutorial* (Barnaul, Russia: Altai State University Press) p 116

[21] Sychev O A and Terekhov G V 2016 Tools to help the author of regular expressions for test questions in Moodle LMS *Open Education* 20(3) 43-50

[22] Budnikova I K and Priymak E V 2016 Computer testing in the Moodle system *Bulletin of the Technological University* 19(10) 106-8

[23] Musifullina E V 2016 Simple, fast and effective: preparing texts for e-learning in the Moodle environment *E-learning in lifelong learning* 1 819-23

[24] Educational Portal of the Mendeleev University of Chemical Technology of Russia https://moodle.muctr.ru/