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Automation of intermediate remote education student control when teaching mathematics

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Abstract — Currently, it is becoming increasingly important to use the potential of the digital educational environment in solving distance education problems. Views on ways and means of diagnosing the quality of education and monitoring student performance are changing. For the distance education students, the most significant condition for the successful testing of all control types is the ability to carry out self-organization and selfcontrol measures. Thus, the effective functioning of the distance learning system involves the organization of student targeted selfmonitoring of educational outcomes. In this study, the introduction of the self-control stage is considered as a necessary condition for solving the problems of organizing intermediate control in mathematics. Taking into account the possibility of using the Hypermethod distance education system (DES)in the Ural Federal University educational process, an intermediate control organization model was developed which provides the student self-check of the semester test tasks solving results.

The Hypermethod DES testing is considered as the main means of self-control in the process of solving and checking semester tests. The content of the test is formed by the tasks of individual test variants. Testing allows the students to check both the result of task solving and the quality of learning theoretical course material. Test automation significantly reduces the teacher workload and gives the students an opportunity to receive quick feedback at the stage of learning outcomes self-monitoring.

Constant modernization, the higher education system reforms set to automatize both online and off-line learning using information systems, the introduction of automated student performance accounting in the within the point-rating assessment system determine the relevance of the chosen research topic.

Keywords — learning automation, self-control, test control, Hypermethod, higher education, distance learning, digital educational environment.

I.INTRODUCTION

The relevance of this study is justified by the need for distance learning to improve the organization of intermediate control in mathematics.

Within the system of distance education, a large amount of student time is allocated to mastering math courses independently. Students are significantly limited in their ability to communicate with the teacher during the semester. The lack of instant feedback in the process of the material studying or problem-solving leads to the accumulation of knowledge gaps, distortion of the meaning of the learned material, and, as a result, a decrease in learning motivation.

II.RESEARCH METHODOLOGY

Problems of distance education, including mathematical education, were covered in the works of A.I. Melyukov, D.O. Pereverzentseva, O. V. Skvortsova, N. F. Stas and others [3], [5], [9]. A.I. Melyukov [3] suggested using a system of special handbooks that serve for training organization and managing the independent work of mathematics students. In the works of D.O. Pereverzentseva and N.F. Stas, special attention is paid to the development of methodological materials for the organization of the remote student control at the intermediate stages of the educational process [5]. In their studies, many scientists and practitioners actively develop the use of digital technologies, the capabilities of distance learning platforms, mobile phones, tablets, etc., [4], [6], [8], [12].

The literature analysis and pedagogical experience generalization showed that one of the key problems in the system of distance education is the organization of students' control and self-control during the intersessional period.

Current and intermediate control are of a particular importance in the system of distance learning since they perform the function of feedback, signal the student readiness for the final control, play the role of a stimulator for constant and systematic independent learning and cognitive activity.

Training control allows the teacher and the student to assess the dynamics and the actual level of educational material mastery. Analyzing the results of the control measures, the teacher can make adjustments to the educational process organization. In the course of the control tasks realization, repetition, consolidation and improvement of the acquired knowledge occur through the knowledge refinement and addition. Students rethink and summarize the material studied, use the knowledge to solve practical problems, have the skills and experience to acquire knowledge independently. Independent control organization requires student hard work, students need to process and systematize acquired knowledge, draw conclusions and bring evidence that makes a vast contribution to their development. Exercising the control properly, the teacher has the opportunity to encourage students to improve their knowledge and skills, to develop the need for self-control. Students explore the subject more deeply and more responsibly if they know in advance that it will monitored regularly. The control regularity allows timely identification and correction of errors and omissions and taking measures to eliminate them [7].

Currently, the traditional form of intermediate control organization is the students' semester examinations. They represent a system of typical tasks on the course key topics. The independence of such works is often doubted. In addition, the solution of the offered list of tasks does not reflect in the level of their knowledge of the mathematics conceptual apparatus. Most students perform the task following the model and not analyzing the theoretical basis of the actions performed and not building a strategy for solving problems.

It is obvious that the intermediate control organized in the described form does not fulfil its educational functions.

To solve the problem of improving the organization of intermediate control in the system of distance learning the following directions were identified:

1. Changing the checking tests procedure, mostly their automation.

2. Increasing the share of student self-control and selfexamination of test papers using digital technologies and teaching tools.

3. Organization of quick feedback on the student's request for the correctness of the problem-solving replacing the teacher with the test control system.

Numerous studies [1], [2], [6], pedagogical experiments [7], the results of the "Research of new forms of organization of the educational process using open online courses" project [4] showed that in the conditions of correspondence education, effective teacher control and permanent student self-control is only possible by maximizing the potential use of digital technologies. Digital technologies change drastically the content of the taught disciplines and the form of their presentation. Mass online education is developing rapidly. Students enrolled in traditional higher education institutions increasingly, if necessary or at their own will, supplement their education with online courses as the format is not only convenient in its opportunity to gain knowledge from the best specialists, but also in the opportunity to study in free time [10].

Today, among the most promising trends in the education development is the expansion of the educational system traditional model capabilities based on the creation of a digital educational space (Project "Modern Digital Educational Environment" [11]). One of the most important tasks which aims to create a single digital educational content is improving the quality of education, the implementation of academic mobility (getting access to online courses from leading scientists of the best universities in the country and the world); – reducing the gap between academic education and the actual conditions for the implementation of professional activities (involvement of practitioners who actually have the professional competences to implement educational programs, the formation of a mechanism for building and developing professional trajectories of graduates, including tools for adapting to the labor market) [8].

III.RESULTS OF THE RESEARCH

The development of distance learning based on electronic educational platforms made it possible to combine the benefits of various forms of education. The main advantage of distance technologies is the ability to organize learning control in an automated test form which implies fast "student-DLS-teacher" feedback. In addition, remote technologies allow to organize communication with the teacher in different modes: in the form of chat, forum, online lectures, etc.

In UFU, the Hypermethod DLS is used as a platform for organizing distance learning.

Using its capabilities, a model for organizing automated remote student intermediate control in mathematics was developed as a result of the study. The model implementation made it possible to improve such control indicators as regularity(frequency), systematic approach, the influence degree on the final indicators of teaching mathematics, the student independence degree in the examination process.

Let's consider the capabilities of this system to improve intermediate control in the process of learning mathematics.

The main element of the educational process in the Hypermethod DLS is a training course, divided into sections. They accommodate the groups of classes formed according to the desired principle (lectures, practical exercises, test control, project, etc.). Creating a theory lesson, the teacher can connect to its files or other e-learning resources with lectures, teaching manuals, electronic textbooks, etc. The system allows to connect individual students, change the group composition: to join in or out the students who will be able to access the course materials.

To prepare the students for the control activities the teacher places the subject educational and methodological complex in the "Information Resources", the "Course materials" tab. The added types of information resources are files, HTML pages, HTML sites, external resource links, etc.

In the "Statistics of studying materials" section, the course teacher can track the progress of students' work with the course materials (number of downloads, views).

In the "Lesson Plan" section there are classes that are either evaluated by the teacher or not. The test paper variants can be placed in the form of evaluation classes or as an element of information resources. Moreover, one of the Hypermethod DLS advantages is the ability to assign an individual version to each student. Entering the system the student will only see the option that he was assigned by the teacher, that is, he or she will not be able to solve someone else's test work by mistake.

From our research perspective, the most significant advantage of distance technologies is the ability to organize an automated learning control in the form of testing. At the same time, the Hypermethod allows you to set the desired test parameters and select the desired type of test tasks.

To create a test in the Hypermethod DLS, select in the course menu the "Lesson Plan" tab and go to the "Tests" tab. Here you can see a list of already created tests and create a new one (Fig. 1).

Тесты				
 Создать тест 				
Выводить в таблице: используем	курсе все, включая тесты из	все, включая тесты из Базы знаний		
Название: Ме	есто хранения:в	се 🗸 Дата последнего и	изменения:	
Метки:				
Показать Сбросить фильтр				
Сортировать по: Название -	Место хранения	Доступ для слушателей	Количество в	
Дата последнего изменения				

	Название 👻	Место хранения	Доступ для слушателей	Количество вопросов	Дата последнего изменения
	<u>Вариант 1</u>	Учебный курс	Доступ через план занятий	<u>30</u>	04.04.2017 15:13:54

Fig.1. Test creation

To create a test task, you need to register the text of the question, the topic and select one of the specified types. It is possible to create tasks for:

- 1) single choice;
- 2) multiple choice;
- 3) concordance;
- 4) ordering;
- 5) classification;
- 6) form filling;
- 7) the choice on the picture map;
- 8) choice from a set of pictures.

If the question contains mathematical formulas or images, it can be attached as a separate file.

Then, you need to fill in these response options in accordance with the question type.

For example, in a single-choice question it is necessary to register:

- 1) question-wording;
- 2) question theme;
- 3) order of succession (the question number in the test):
- 4) time to answer the question;
- 5) range of points for the answer;
- 6) answer options.

Answer table indicates the answer to the question, the "weight" of the answer (if necessary), as well as the correct answer. In the right column, the teacher selects the answers that will be reflected in the task. In the test task, a file with the accompanying illustration can be attached to work with the question.

With the help of another advantage of the Hypermethod system as the possibility of organizing communication between a student and a teacher, one can eliminate the problem of feedback lack during distance education.

For organizing the communication of the educational process participants, the system offers such tools as news; forum; blog; wiki; chat; contacts; messages; file storage.

With the help of the news, the teacher can convey any useful information to all students. To the piece of news, you can attach any image that will be displayed on the page along with text information.

It should be noted that Hypermethod DLS allows sending to students some personal messages. There are two types of messages in the Hypermethod: system messages and personal ones. System messages show the messages that were sent to the students, as well as messages that were received from the Hypermethod. In personal messages with any students exchanges are displayed.

Let's consider the model of intermediate control in mathematics, the central element of which is the self-evaluation of the test papers in the Hypermethod DLS (Fig. 2).



Fig. 2 Model of the intermediate control organization

Before solving the individual tasks, the student has the opportunity to study the methodological manuals by the course sections, as well as to complete workshops in order to eliminate gaps in the understanding of educational material.

As an improvement to the intermediate control, we offer the following scheme:

1) the student does an individual test work;

2) for self-testing, a student takes a test based on the test work variants, and by its results eliminates own errors, checks himself/herself for the course theoretical elements knowledge;

3) if the test is more than 80% done, the student sends the paper to the teacher, otherwise corrects errors in the work and performs the test again;

4) the student is allowed to take the exam after the teacher checks the test paper. If there are comments, the work is returned to the student.

Let's consider the concept of creating automated tests to check test papers.

In the development of automated tests for each task of the control work test tasks are compiled. Monitoring the correctness of the task can be direct or indirect.

Indirect control checks the solution logic, the chosen method relevance, the intermediate stages of the solution and, most importantly, the knowledge of the theoretical basis of the problem-solving. In contrast to indirect control, direct control evaluates the correctness of the problem solution according to its final result.

The test used for self-diagnosis may contain various components:

1. Theoretical. In this case, the test result evaluates the quality of mastering the course basic terms. Given that there are no separate theoretical questions in the remote student test papers, there is no full-fledged concept understanding in the learning process. The final testing is reduced to the solution of the typical tasks a sample of which is presented in the solution of the zero (example) version. Thus, the level of theoretical material assimilation is checked only by the final control: examination.

Inclusion of the theoretical questions into the test papers compensates for the shortcomings of the intermediate control through the solution of typical tasks. Theoretical questions (testing the knowledge of the conceptual and evidence-based apparatus of mathematics) are present in the test, exercising indirect control over the test task solution correctness.

As a theoretical test task you can select tasks for:

- the course key concepts identification,

- concept relationships establishing,

- the patterns, dependencies identification,

- knowledge of basic theoretical facts (theorems, properties, formulas, etc.) verification,

- typical tasks of the course recognition.

2. Practical. First of all, this component includes tests that directly verify the answer correctness. Such tasks, as a rule, require a definite answer to the problem question. The presence of a clear answer is typical for calculation tasks.

In addition to checking the answer correctness, practical tasks include:

- splitting tasks into subtasks,

- checking the correctness of intermediate results (results of the subtasks),

- testing the basic techniques for typical task solving,

- the task solving results interpretation,

- the solution relevance verification.

3. Meta-subject. Provides intermediate control functions enhancement. The purpose of the first two components is to test the subject learning outcomes. The purpose of the metasubject component is to check and improve the level of general educational skills acquirement (possession of research methods, heuristic methods for task solving). It contains tasks for:

- identification of reasoning errors,

- verification of information and analytical skills,

- checking the development of predictive skills, etc.

The combination of all these components provides complex monitoring of the test implementation.

To determine the content of the questions, it is necessary for a student to decompose the final test task into subtasks, determine the sufficient and necessary conditions for its implementation. For example, to perform typical tasks for the function representation in the form of a Fourier series, for a student, it is *enough* to know:

1) The definition of a periodic function,

2) periodic function properties,

3) properties of periodic function integrals,

4) The definition of even and odd functions,

5) properties of integrals of even and odd functions.

Let's formulate the necessary conditions. If the task of the control on the topic "Fourier series" is performed correctly, then the student knows:

1) Fourier series definition,

2) condition of decomposability of a function in a Fourier series;

student can:

1) decompose the periodic function in a Fourier series,

2) continue the function in an even and odd way and

decompose the resulting function in a Fourier series [7].

Based on the selected conditions we form test tasks. It is necessary to take into account a number of requirements and recommendations for test compilation and its implementation:

1. As the experience of automated tests approbation showed, unit testing is the best option for control organizing. Its essence is to check the control test paper on the topics included in it. The indicated duration of the test on the topic is of an advisory character. After the end of the deadline, the test conditions are restricted. Until the specified period, results of 70-80% are counted, after - above 90%.

2. The number of test tasks should not be too big. Three to five questions are recommended for each test assignment if the test checks all topics at once, and five to seven if the test is limited to checking the module.

3. Test assignments should combine direct and indirect control tasks representing a combination of theoretical and practical assignments and questions of a meta-subject orientation.

4. It should be remembered that the primary goal of the test tasks is the student self-control for the solution correctness, extended one is the diagnosis of understanding the



entire course topic. Therefore, it is unacceptable to include only the general topic questions not related to the test tasks.

Let's consider an example of some test assignments that provide the 2nd semester mathematics test work verification. It includes the following sections:

- indefinite integrals,

- definite integrals,
- differential equations,
- systems of differential equations.
 - Examples of the test tasks (TT)

Task number 1. (from control work) Calculate the indefinite integral

$$\int \frac{1-x}{\sqrt{12+4x-x^2}} dx \tag{1}$$

1. TT - Direct control (correct answer is 3).

Choose the correct answer for task 1 (Figure 3):

$$\frac{1}{2}\sqrt{12+4x-x^{2}} - \arcsin(x-2) + C,$$

$$\sqrt{12+4x-x^{2}} - 2\arcsin\left(\frac{x-2}{4}\right) + C,$$

$$\sqrt{12+4x-x^{2}} - \arcsin\left(\frac{x-2}{4}\right) + C,$$

$$\sqrt{12+4x-x^{2}} - \arcsin\left(\frac{x-2}{4}\right) + C,$$

$$\sqrt{12+4x-x^{2}} - \arcsin\left(\frac{x-2}{16}\right) + C.$$

Fig. 3 Answer Options

2. TT - Indirect control (correct answers are 1,2). In this case, the function of indirect control is the expansion of the control area. Check for: knowledge of the "differential function" definition, the ability to perform the action of "summing the function under the sign of the differential".

2

Mark the correct statements (Figure 4)

$$\frac{4 - 2xdx}{\sqrt{12 + 4x - x^2}} = \frac{d(12 + 4x - x^2)}{\sqrt{12 + 4x - x^2}},$$

$$\frac{4 - 2xdx}{\sqrt{12 + 4x - x^2}} = \frac{d(4x - x^2)}{\sqrt{12 + 4x - x^2}},$$

$$\frac{4 - 2xdx}{\sqrt{12 + 4x - x^2}} = \frac{d(\sqrt{4x - x^2})}{\sqrt{12 + 4x - x^2}},$$

$$\frac{4 - 2xdx}{\sqrt{12 + 4x - x^2}} = \frac{d(4 - 2x)}{\sqrt{12 + 4x - x^2}}.$$

Fig. 4. Answer options

1. TT - Indirect control (correct answer is 4). The ability to recognize the type of table integral is checked. At the same time, the control of the intermediate stage of problem-solving is carried out.

Which type of integrals should be used to calculate the

$$\int \frac{1}{\sqrt{12 + 4x - x^2}} dx?$$

$$\int \frac{du}{u^2 - a^2} = \frac{1}{2a} \ln \left| \frac{u - a}{u + a} \right| + C,$$

$$\int \frac{du}{\sqrt{u^2 \pm a^2}} = \ln \left| u + \sqrt{u^2 \pm a^2} \right| + C,$$

$$\int \frac{du}{\sqrt{u^2 \pm a^2}} = \frac{1}{a} \arctan \frac{u}{a} + C,$$

$$\int \frac{du}{\sqrt{a^2 - u^2}} = \arcsin \frac{u}{a} + C.$$
re 5) 4)

Fig. 5. Answer options

integral (Figu

4. TT - Indirect control (correct answer is 1,2). The ability to act analogically to identify the scope of application through the identification of the task object essential characteristics is checked.

Which of the proposed integrals are calculated using the "obtaining the derivative of the denominator in the numerator" technique (Figure 6)?

$$\int \frac{1-x}{\sqrt{12+4x-x^2}} dx$$

$$\int \frac{1-x}{12+4x-x^2} dx$$

$$\int \frac{1}{\sqrt{12+4x-x^2}} dx$$

$$\int \frac{1}{\sqrt{12+4x-x^2}} dx$$

$$\int \frac{12+4x-x^2}{\sqrt{1-x}} dx$$

Fig. 6. Answer options

Task number 2. (from control work) Solve the Cauchy problem:

$$y'' - \frac{y'}{x} = tg \frac{y'}{x}$$
, if $y(1) = \frac{\pi}{8}$, $y'(1) = \frac{\pi}{2}$. (2)

1. TT - Indirect control (correct answer is 1). In the control task No. 2, all the test tasks perform the function of the stepby-step control, therefore, they can be considered as student support. As a recommendation, the trainees should note the expediency of the simultaneous final work and testing.

With what replacement (Figure 7) you can downgrade the equation order

$$y'' - \frac{y'}{x} = tg \frac{y'}{x}?$$
 (3)

1) y' = p(x),2) y' = p(y),3) y' = x.

Fig. 7. Answer options

1. TT - Indirect control (correct answer is 1). What type of equation is



$$y'' - \frac{y'}{x} = tg \frac{y'}{x}?$$
 (4)

1. The second-order differential equation which reduces to a homogeneous first-order equation.

2. The second-order differential equation reduced to a linear equation.

3. The second-order differential equation reduced to an equation with separable variables.

4. The second-order differential equation which reduces to the Bernoulli equation.

3) TT - Indirect control (3142). Checks general educational skills to analyze information, build a logical chain of reasoning.

Arrange in the order of action when calculating the integral dt

 $\int \frac{dt}{\sin t}$ by applying the function under the differential sign

(Figure 8). For example, insert 1234 in the answer line.

$$\int \frac{-d \cos t}{1 - \cos^2 t},$$

$$\frac{1}{2} \ln \left| \frac{\cos t - 1}{\cos t + 1} \right| + C$$

$$\int \frac{\sin t \, dt}{\sin^2 t},$$

$$\int \frac{d \cos t}{\cos^2 t - 1}.$$

Fig. 8. Answer options

3) TT - Indirect control (312). The assignment is of educational nature: demonstrates the presence of different ways to solve the problem, allows choosing the most rational one.

Arrange in the order of action when calculating the integral

 $\int \frac{dt}{\sin t}$ by the replacement method through a universal

trigonometric substitution (Figure 9). For example, insert 1234 in the answer line.

$$\int \frac{dt}{t} = \ln t$$

$$\lim_{z \to -\infty} \left| \ln \left| tg \frac{x}{2} \right| + C \right|$$

$$\int \frac{dt}{dt} = tg \frac{x}{2}, \quad dx = \frac{2 dt}{1 + t^2}, \quad \sin t = \frac{2t}{1 + t^2}.$$

Fig. 9. Answer options

IV.DISCUSSION OF RESULTS

The model of remote student intermediate control organization developed within the study was introduced into the educational process. The results of the implementation were discussed at the methodological seminars of the Department of Information Technologies and Automation teachers at IRIT-RTF UrFU. The generalization of the research results in the case of teaching full-time students was tested at the IV International Scientific and Practical Conference in Penza, 2018 [7].

V.CONCLUSIONS

The use of the digital educational environment for the remote students training allows automating the organization of students intermediate control in mathematics. The Hypermethod Distance learning system enables students to control and test the semester examinations in the form of an automated test, compiled from control tasks. Before completing the test tasks, the student can study the methodological manuals for the sections of the course as well as attend workshops for mastering the course program.

Testing is individual in nature and provides the opportunity to eliminate the errors, to verify independently the knowledge of the course theoretical elements.

The self-test may contain various components: theoretical, practical, meta-subject. Questions of theoretical and metasubject orientation compensate for the shortcomings of the organization of intermediate control by the typical task solution.

The digital educational environment provides the teacher with effective tools for learning process management. DLS Hypermethod provides fast feedback. The teacher can place into the system the discipline educational complex, convey any useful information to all students, check how students cope with testing, see the dynamics of students' course material work and in general determine the degree of student readiness for the final control.

Thus, the use of DLS Hypermethod allows to improve the organization of intermediate control in mathematics. The testing automation stimulates students to a constant and systematic independent learning and cognitive activity, compensates for the existing shortcomings of the modern system of distance learning.

References

[1] V.A. Krasilnikova Comparative analysis of methods for controlling knowledge of USSPO students // Professional education. 2000. № 10. P. 22-24.

[2] N.V. Lokot Improving the quality of mathematical education of distance students with the help of pretests in modular training // Psychology and Pedagogy: methods and problems of practical application. 2009. - №9. P. 134-140.

[3] A.I. Melukov The system of textbooks as a means of organizing student independent work: The dissertation of the candidate of pedagogical sciences, - M., 1971, - 253 p.

[4] Scientific-based recommendations on the use of online courses in the implementation of educational programs of higher education [Electronic resource] Access mode: http://itoo.urfu.ru/ru/article/science.

[5] D.O. Perevezentseva, N.F. Stas Distance education: the main problem and its solution // Open Education. 2013. №4 (99). P.16-23. Access mode: https://doi.org/10.21686/1818-4243-2013-4(99)-16-23

[6] P.I. Pidkasisty, O.B. Tyshchenko Computer technologies in the system of distance education // Pedagogy. 2000. № 5. P.7 - 13.

[7] K.S. Potorochina, A.A. Kharitonova The organization of the remote support for an intramural course in mathematics in the Hypermethod system // Modern scientific research: Topical issues, achievements and innovations: collection of articles of the IV International Scientific-Practical Conference. In 2 p. P. 2. - Penza: ISTC "Science and Enlightenment". - 2018. - 254 p., P. 218-222.

 $[\bar{8}]$ A.G. Savina Digital transformation of the educational space: realities and prospects // Education and science without borders: fundamental and applied research. 2017. No 6. P. 208-211. Access mode: http://orelgiet.ru/userfiles/1517394673_part6.pdf [9] O.V. Skvortsova The technology of teaching mathematics for firstyear distance students of pedagogical universities (in the case of mathematical analysis): The dissertation of the candidate of pedagogical sciences, Novosibirsk, 2003 - 245 p.

[10] G.L. Tulchinsky Digital Transformation of Education: High School Challenges // Philosophical Sciences - 6/2017, p. 121-136. Access mode: http://www.phisci.ru/files/issues/2017/06/RJPS_2017-06_Tulchinskiy.pdf.

[11] Passport of the priority project "Modern Digital Educational Environment in the Russian Federation" (approved by the Presidium of the Presidential Council for Strategic Development and Priority Projects, Minutes No. 9 of October 25, 2016) [Electronic resource]. - Access mode: http://static.government.ru/media/files/8SiLmMBgjAN89vZbUUtmuF5lZYfT vOAG.pdf

[12] Handbook of Distance Education: Edited by Michael Grahame Moore, William C. Diehl/ Fourth edition, New York: Routledge, 2019, 580 pages.