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EXPERIENCE IN USING DISTANCE LEARNING TOOLS IN PROFESSIONAL DEVELOPMENT PEDAGOGICAL CORPS

Abstract: The article presents and describes a tool for the professional development of teachers. Special attention is paid to the subject-methodical section, the implementation of which since 2020 has been taking place in an online form with the use of distance educational technologies. The article describes and presents the concepts of «e-learning» and «distance learning technologies,» and briefly presents the history of the development of distance education in the world. The article contains a description of the advantages of distance learning, as well as an analysis of the difficulties experienced by students of training courses and seminars, and advanced training of distance courses. In the post-industrial world, one of the main qualification requirements is professional mobility, determined by readiness for continuous retraining and advanced training. The education system, designed to ensure the increase of human capital, and increase the efficiency and competitiveness of the economy, should, first of all, prepare people for life in rapidly changing conditions. Therefore, the system itself must keep up with the changes taking place. The main challenge of 2020 was the emergency transfer of the educational process to a remote form using e-learning technologies. The education system did not have time to «group up» and prepare. The implementation of educational programs in a remote format required careful coordination of pedagogical activities and thoughtful administration of the process. The crisis exposed serious substantive and organizational problems in the industry and identified professional-pedagogical difficulties in the field of ICT competence: both at the level of the general user and the level of the general pedagogical component. The pedagogical community has an objective need to master new competencies. We can assume that the current situation will inevitably entail changes in the standards of training and retraining, as well as the emergence of new training programs.

Keywords: professional education, professional development of teachers, distance learning technologies, distance learning, e-learning, instrumental and methodological support, instrument, methodological support

Introduction
The relevance of teaching teachers using distance learning tools is due to several factors. Firstly, vocational education should satisfy the students' need for quality professional development, including filling professional deficits. Secondly, one of the modern requirements for additional professional programs is mobility, which manifests itself in a prompt response to an educational request in terms of changing not only the content of educational topics

but also the flexibility of the training schedule. The third factor is determined by the list of necessary competencies that a teacher should possess by the professional standard. It is possible to solve this problem without special training within the framework of mastering the advanced training program, implemented through the developed training tool portal-channel "Digital Pedagogy" in an online format using distance learning technologies, where professional-pedagogical competencies occupy a central place in the fundamentally updated qualification requirements and qualification characteristics of teachers [1].

The scientific novelty in the development of the portal channel tool "Digital Pedagogy" lies in the fact that in this work, unlike the traditional system of interaction between a methodologist and a teacher in the process of work, an approach to the organization of training is proposed, taking into account the possibilities of an individual choice of content and methods, decision-making, introspection, self-assessment in the field of training. Courses and training seminars aimed at improving the quality of pedagogical activity are held on the portal channel "Digital Pedagogy."

The process of formation of distance education

Before proceeding to the consideration of the features of professional development of teachers through the training tool of the portal channel "Digital Pedagogy," we will briefly focus on the concept of methodological support and the historical aspect of distance learning, as well as the key concepts used in this article.

Today we are faced with the task of providing teachers with a practical training experience that contributes to their development of various areas of improving the professional competence of teachers [2], [3]. This is a complex task that requires deep knowledge of the pedagogical content [4], and therefore it is of particular importance to strengthening the continuous nature of teaching and professional improvement of the teacher. The diversity of connections of educational institutions in society is not an image factor today but a real condition for ensuring the quality of education [5]. Solving this problem, we approached the realization of the need for the implementation of educational projects and the organization of systematic innovation activities that ensure the growth of the quality of work of teaching teams [5]. Today our task is to respond to the challenges of educational institutions, and teachers, effectively introducing innovative practices and modern approaches to teaching methods [6].

So, let's find out the essence of the concept of "methodological support" one of the main forms of teacher training is methodical work, which includes all the substantive and organizational forms of providing methodological assistance to teachers. Methodical work is considered part of the system of continuous professional development of teachers. Research analysis on the support problem, allowed us to establish that support is an independent sphere of pedagogical activity generated by the humanization of education [7], [8].

According to the "Dictionary," to accompany means to follow alongside, together with someone as a companion or guide [9]. The concept of "support" is used for a person who needs help and support in overcoming emerging difficulties (problems) in the process of self-realization and achieving vital goals [10].

In pedagogical science, many scientists have addressed the problems of teacher support. Thus, V.G. Reshetnikov interprets support as a special sphere of activity of a teacher aimed at introducing a teenager to socio-cultural and moral values necessary for self-realization and self-development [11].

In [7], M.R. Bityanova believes that support is a system of professional activity of the pedagogical community aimed at creating socio-psychological conditions for successful learning and psychological development in situations of interaction.

Accompaniment in pedagogy is considered as the interaction of the accompanying and the accompanied, aimed at solving the life problems of the accompanied.

Accompaniment in pedagogy is understood as a special type of interaction to create favorable conditions for the development of interaction subjects, and its essential features are assistance in decision-making and interaction.

Methodological support of the teacher's activity will be considered as a holistic, systemically organized activity, in the process of which conditions are created for the professional growth of the teacher, and the development of his professional and pedagogical competence.

If we consider the process of formation of distance education in the world in close connection with the development of scientific and technological progress and the main stages of the information revolution, the starting point for it can be considered the last third of the XX century [12].

Meanwhile, the key idea of distance education – learning from a distance – is not so new. Researcher M. M. Pyannikov believes that the pioneer in this field can be considered Ya. A. Komensky (mid-XVII century), who first developed illustrative textbooks [13]. Thus, distance learning (with a broad consideration of the concept) originated simultaneously with the ability to transmit educational information using a certain medium (for example, books or letters).

Of course, the development of technology has had a significant impact on the development of distance education. So, D. R. Garrison developed a classification of distance learning tools, which is based on the main type of information carrier. Referring to the research of a foreign colleague, M. M. Pyannikov [14] cites three "generations" of distance learning tools.

The first is connected with the development of book printing in the world, including the mass production of textbooks.

The "second generation" of distance learning tools was marked by the creation in 1969 of the Open University of Great Britain (Open University), the first in the world to implement the idea of teaching adults in a convenient place and at a convenient time. In order to solve this difficult task, new textbooks have been developed, focused primarily on the independent work of students. The printed material was organically supplemented with audio materials and video lectures, which teachers sent to students by mail. Currently, the Open University of Great Britain is a high–tech opportunity to receive higher and additional professional education in absentia using distance learning technologies.

Distance education of the "third generation" was born simultaneously with the mass use of information and communication technologies in everyday life, followed by the so-called computer learning tools.

Currently, within the framework of distance education, synchronous learning (in real-time) and asynchronous (time-delayed learning) are distinguished. It is worth noting that each of the distance education formats has not only its unique features, conditions for effective implementation, and undoubted advantages but also certain difficulties in implementation.

In Kazakhstan, the idea of distance learning cannot be called new (for example, back in the USSR, a system of correspondence education was successfully functioning, in which the student independently mastered the content of educational issues, and the task of the teacher was to select educational material). However, the legal status of distance learning in the modern sense of the word boils down to the innovative nature of educational activities of universities and institutes for the development of education (advanced training) in terms of the use of information technologies, technical means, as well as information and telecommunication networks, has been fixed recently. Thus, two concepts are presented – "e-learning" and "distance learning technologies" [15]. E-learning is interpreted as a way of organizing educational activities through information and telecommunication networks that allow students to transmit educational information, thereby ensuring interaction between them and the teacher. As for distance learning technologies, the law characterizes them as one of the types of educational technologies implemented using the same information and telecommunication networks.

However, the main difference between e-learning and distance learning technologies is that the latter is used exclusively in the indirect (at a distance) interaction of students and teaching staff [16]. E-learning can be organized in person (for example, in a class in the format of a webinar under the guidance of a teacher). Distance learning (more simply, "distance learning, distance learning"), on the contrary, is determined by the exceptional independence of the student.

It is important to understand that distance learning technologies are, first of all, educational technologies. Therefore their content falls under several requirements, such as consistency, effectiveness, predictability, algorithmic, conceptuality, instrumentality, etc. [17].

Features of professional development of the pedagogical corps

Let's turn to the consideration of the features of professional development of the pedagogical corps, including through the presentation of the instrument.

The remote tool is the portal channel "Digital Pedagogy," which works to meet the needs of students to study in a convenient place and at a convenient time.

Figure 1 shows the current model of professional development of the pedagogical corps.
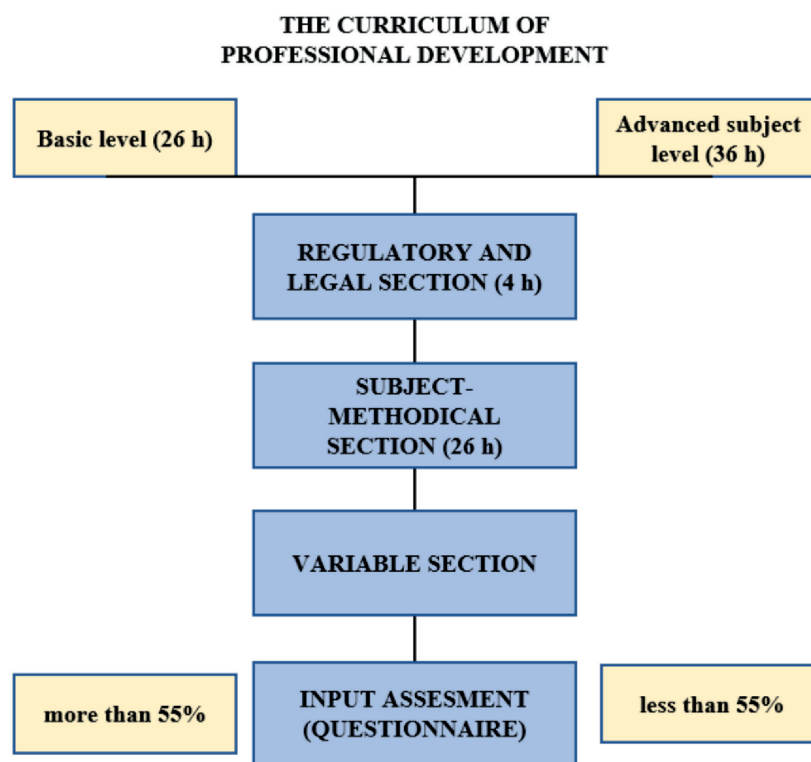

Figure 1. The model of professional development of the pedagogical corps

Currently, the teacher training model contains several consecutive and interrelated stages. At the beginning of the new calendar year, all teachers planning to improve their qualifications undergo a mandatory entrance assessment procedure (questionnaire), which solves two main tasks:

1) identification of professional deficits of teachers, the analysis of which allows you to quickly adjust the content of training sessions for advanced training programs;

2) individualization of the educational process through selecting those educational modules, the problems of which can satisfy the professional interest (request) of teaching staff.

Figure 2 shows an example of an input assessment (questionnaire).

Figure 2. Input assessment (questionnaire).

According to the results of the entrance assessment, the level of an additional professional training program is determined, according to which the teacher will improve his qualifications. So, after passing the questionnaire, teachers who have correctly solved more than 55% of tasks pass training seminars with a volume of 26 hours – the basic level. Teaching staff who have solved less than 55% of tasks are trained according to the curriculum of the extended subject level (36 hours), which includes a variable subject module of 6 hours. Thus, teachers who have shown below-average results have the opportunity for a more in-depth and serious study of the subject topics that caused them difficulty in the entrance assessment.

As soon as the teacher becomes aware of the results of the entrance assessment, he begins to form an individual educational route consisting of educational modules of regulatory, subject-methodical, and variable sections.

The most important in any additional professional training program is the educational module of the subject–the methodical section corresponding to the profile of the listener's activity. The invariant subject module is aimed at developing the subject competence of the teacher through the development of two basic topics – the methodology of teaching the subject and the actual topical issues of the subject area.

The subject-methodical section in any individual educational route is given 26 hours of distance learning. The changes concerning the form of advanced training courses – from online to offline with the use of distance learning technologies – have just identified the key features of the new model. Let's focus on this issue.

The following basic principles serve as the foundation for creating a model of methodological support for teachers of educational organizations:
1. The principle of priority of independent learning;
2. The principle of joint activity;
3. The principle of individualization;
4. The principle of focusing on problematic issues of practice;
5. The principle of creating conditions for the active activity of the teacher.

These principles formed the basis of the model of instrumental and methodological support.

The practical activity of teachers is multi-vector and often multidirectional, depending on the current pedagogical situation and practice. Therefore, it is advisable, without limiting oneself to the framework of a particular model of methodological support, to highlight the strongest elements of each of them and focus on the general features.

The quality criteria of the model of methodological support of teachers of educational organizations in the development of personal potential can be formulated as follows [18]:

- Purposefulness of the methodological support model in the development of teachers' potential.
- The effectiveness of the methodological support model in the development of teachers' potential.

These criteria are the basis for evaluating the model of methodological support of teachers.

A "Model of methodological support of teachers" was developed considering the selected criteria.

Let's consider the elements of this model in more detail.

I. Stage of planning and preparation. The objectives of this analytical and diagnostic stage are:

1. Analysis of teachers' difficulties and diagnostics of the teacher's professional position.

2. Theoretical preparation of the teacher for work.

3. Diagnosis and analysis of difficulties in the work of teachers, identification of the problem, and justification of its relevance.

4. Identification of contradictions that need to be eliminated as soon as possible.

The methods used at this stage should be personality-oriented, reflexive, and dialogical.

II. Stage of support. At this design stage, a program of methodological support is compiled, taking into account the previously identified requests, where an individual selection of forms and methods of support and improvement of professional skills take place.

III. The stage of using the survey results. The goal of the stage of the route implementation is to overcome the diagnosed difficulties in the professional activity of the teacher based on the selected forms and methods of methodological support. This goal is determined, on the one hand, by the educational priorities and features of the educational institution and, on the other – by the personal and professional tasks of the teacher's activity.

Individual routes of methodological support are implemented here, by which we understand the process of the teacher performing his professional functions, taking into account the selected forms, methods, and technologies, aimed at solving certain tasks.

The result of the implementation of the individual plan of methodological support is the teacher's understanding of his professional position and building his trajectory of professional development in the conditions of activity in an educational institution, as well as solving professional difficulties of the teacher, as a result – improving the quality of education.

IV. Support stage. This stage is characterized by: informal control and monitoring of changes in the activities of teachers, support and development of professional initiatives and experimental projects, organization of information exchange, and contacts between teachers.

V. Stage of the final analysis. The purpose of this control and evaluation stage is to monitor and evaluate the implementation of the escort route.

This is where the results are monitored, and reflection, efficiency assessment, and systematization of the accumulated material take place.

Organization and conduct of a pedagogical experiment

The purpose of the pedagogical experiment of this work was to test the effectiveness of the proposed system of methodological support of the pedagogical corps in the conditions of modernization of education.

The main characteristic that allows us to evaluate the effectiveness of the developed system was the quality of methodological support in the process of creating conditions for the professional growth of a teacher, and the development of his professional and pedagogical competence.

By the quality of professional growth of a teacher (in a broad sense), we will understand a systemic set of essential properties (characteristics, parameters) of professional development, according to which it should correspond in a balanced manner to diverse needs, goals, requirements, and norms that are currently quite strictly regulated by the state educational standard of education.

As the analysis of the work showed, the concept of professional growth of a teacher can be considered from three different positions since the term professional development itself can be interpreted from several points of view (as a process, as an educational system, and as a result). Within the framework of the purpose and objectives of the study, it was decided to focus on assessing the quality of professional growth of teachers as the most clearly and integratively reflecting the results of the application of methodological support.

The objects of assessing the quality of the results of training on the basics of research activities of teachers trained by the outlined system of methodological support were:

- the quality of teachers' training on practical tasks, reflection during advanced training courses;
- the quality of generalization of pedagogical experience at webinars, seminars, conferences, etc.

Also, important indicators of the effectiveness of the proposed system of methodological support can be considered the degree of initiative and independence of teachers during advanced training courses and the level of formation of their ability to analyze their activities.

In general, the pedagogical experiment included the following three main stages: searching, ascertaining, and forming. The purpose of the first two was to clarify the expediency and objective possibility of using the proposed system of methodological support for teachers to master IT technologies and to determine the state of the problem in work practice. During the formative stage of the experiment, the effectiveness of the developed system of methodological support for the professional growth of teachers was checked. By the nature of the problem raised in the work, a complete verification of the results of the study would require a fairly long period since, as already indicated earlier, it is advisable to use methodological support for teachers, starting from the first days of teaching experience. Table 1 shows the results of preferences in the field of organization of activities in PC courses.

Table 1. Preferences in the field of organization of activities in PC courses. The most preferred organizational form of conducting advanced training courses.

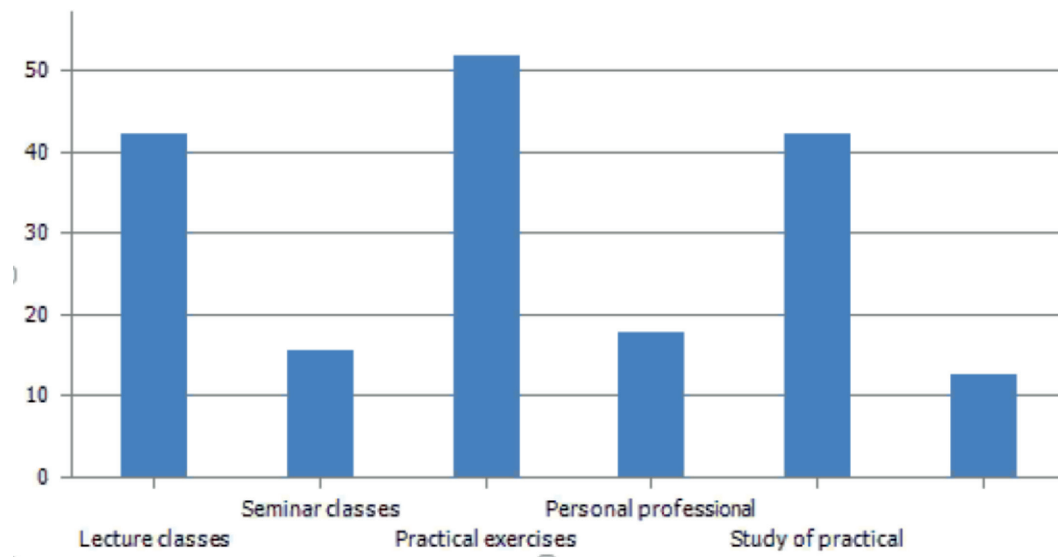| Lecture classes, in order to study modern theories of education and upbringing	Seminar classes with preliminary preparation according to the proposed plan	Practical exercises aimed at the following activities	Personal professional growth trainings	Study of practical experience in solving priority tasks of education development (round tables on the exchange of experience, networking, practical conferences)	Participation in the development of projects or programs aimed at solving priority tasks of education development
73	27	90	31	73	22

Figure 3. Preferred forms of education.

The most preferred organizational form of professional development courses is practical classes that organize ways of activity (52%). However, it should be noted that traditional forms of education are quite popular: lecture classes, in order to study modern theories of teaching and upbringing, as well as the study of practical experience in solving priority tasks of education development (round tables on the exchange of experience, networking, practical conferences) (42.6%). Development and holding seminars, ped. workshops, master classes, open classes for the purpose of mastering modern scientific theories and technologies (26%). It is worth noting that the smallest proportion of students (5.2%) chose "individual programs with tutor support" as the organizational form of the courses, but there is a significant increase compared to the previous study. Last time, none of the students chose this form of training.

Attention should be paid to the fact that students feel the need for practical classes in the direction being studied. A little more than a quarter of the students are ready to study remotely, although the sample includes students not only from the Kostroma region. Thus, it can be concluded that the majority of students require face-to-face practical training. These data are confirmed by comments in the outgoing diagnostics.

Table 2. Use of the Internet

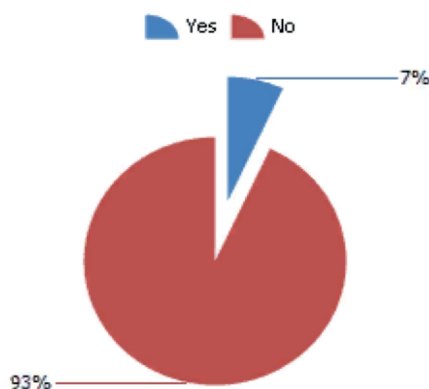| Yes | 161 | Analysis of the data obtained shows that 93.1% of listeners use Internet resources, while it is worth noting that 65.2% use Internet resources to search for information, browse Internet pages and e-mail, and 36% of listeners use Skype. It should be noted that about 15% of listeners use various messengers, as well as blogs and Internet radio and television. The data obtained indicate that the listeners are directed to independently search for information, as well as to receive information via e-mail. It can be noted that the willingness of students to work remotely is not great. |
| No | 12 | |

Fig. 4. Internet usage data analysis diagram

Table 3. Areas of training that students of the courses would like to improve

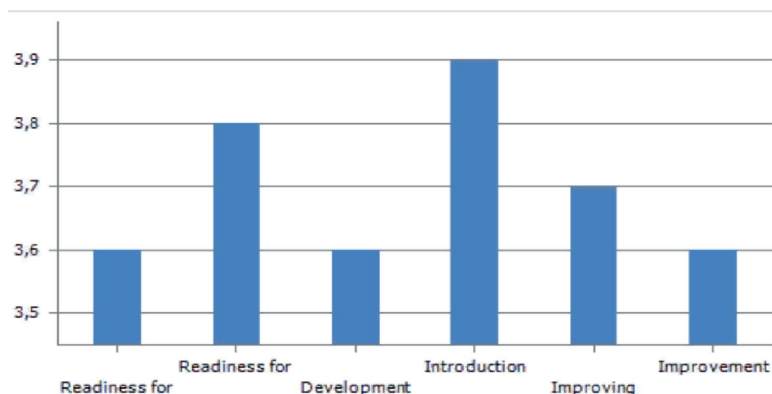| Readiness for a professional test at the base sit;	Readiness for developing, innovative activities;	Development of new methodological projects;	Introduction of learning technologies;	Improving the effectiveness of methodological solutions;	Improvement of individual aspects of the educational process;
3,6	3,6	3,6	3,6	3,6	3,6

Figure 5. Areas of training that students of the courses would like to improve

The analysis of the data obtained shows that quite relevant areas of professional development at the internship site are methodological competence in the field of methods of formation of knowledge, abilities, and orientation of trainees; special competence in the field of the academic discipline taught; psychological and pedagogical competence in the field of education; the introduction of learning technologies. These directions received an average of 4 points out of 5 possible. The least in demand are differential psychological competence in the field of motives, abilities, orientation of students; reflection of pedagogical activity; readiness for a professional test at the base site. Special competence in the field of the taught discipline; the ability to design and research; the introduction of learning technologies; the development of new methodological projects (3.5-3.8) points, respectively. However, it is worth noting that the level of demand for these areas remains above average. The data obtained indicate that the most important thing for students is training in the subject being studied.

The transition to the practical step-by-step implementation of the "model of methodological support of teachers in the development of personality" understanding the priority of the

following criteria for its implementation: maximum self-determination of each teacher in the choice of forms and methods of professional development. To achieve the goal of creating comfortable conditions for teachers in their professional activities, a remote tool, "Digital Pedagogy," has been created.

Remote tool "Digital Pedagogy"

So, the remote tool "Digital Pedagogy" implements training seminars and advanced training courses for teachers of geography and computer science subjects, as well as voiced presentations for the lesson. The content of training seminars and courses can be found at the link of the portal channel in the specialized section "Education" https://www.youtube.com/channel/UCQ1rO_7EUWc4ZBjjTZs2Zl

As part of the methodological support tool, distance learning courses and seminars have been developed on the Digital Pedagogy portal channel.
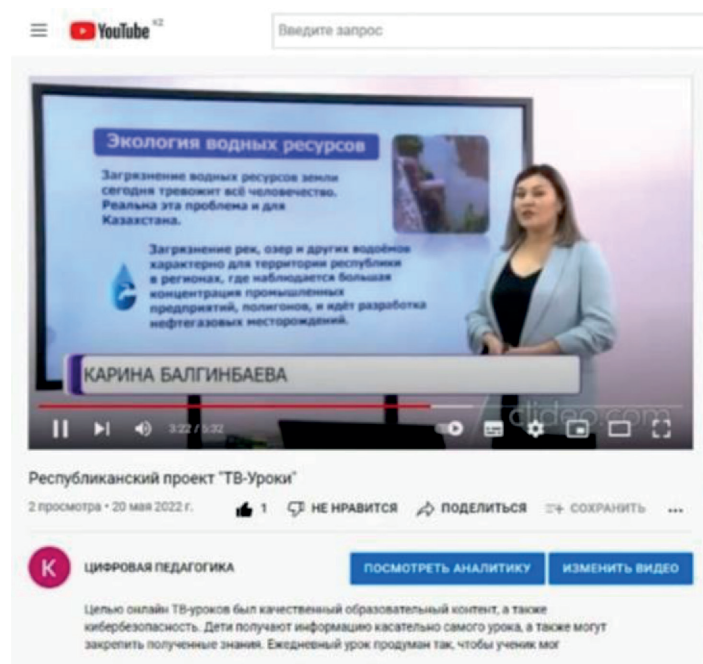

Figure 6. Page of the portal channel of the remote tool "Digital Pedagogy"

To log in, the listener must subscribe to the "Digital Pedagogy" channel. Distance learning is provided by the use of a set of educational technologies in which the interaction between listener and the teacher is carried out regardless of their location and the distribution of training over time.

Distance learning with instrumental and methodological support pursued several goals: firstly, the development of students' self-learning skills; secondly, increasing the level of ICT competence of the teaching staff; and thirdly, the formation of cognitive interest among teachers when working with various sources of information (including video materials) due to more conscious work on educational issues. In addition, distance learning is more flexible in terms of time frames than online, so it allows teachers to improve their skills at a convenient time for them.

Advanced training in distance learning allows you to identify the advantages as well as analyze the difficulties experienced by students during training [19].

Among the main advantages of distance learning identified by teachers of educational organizations, we note the following:

1) economy in time (no need to go to classes) and budget (no travel expenses);
2) availability of educational information at any time convenient for the listener;
3) the individual pace of mastering the e-course, as well as the opportunity to return to the issues that cause difficulties once again;
4) mobility, expressed in prompt feedback from the teacher in case of questions or difficulties from the listeners;
5) the technological nature of the educational process, which allows you to work with educational materials using a tablet or phone [20].

The main difficulty experienced by students, in addition to the low level of knowledge of ICT competencies of individual teachers, is the inability to organize self-study. Even though employees of the education system note time-saving among the advantages of e-learning, there is a tendency to postpone the course at the last moment.

Any distance course of training seminars, meanwhile, involves the following types of work:
1) independent study of educational material by students (text documents, presentations, video lectures, etc.);
2) performing practical tasks based on the results of mastering topics (sections), as well as self-checking;
3) the passage of relevant topics throughout the educational material of the educational and methodological section;
4) Fill out feedback questionnaires to improve the quality of training courses and seminars.

Thus, teachers of training seminars and courses, in addition to the main task – methodological support of students' training, face a new one: control over the timing of distance courses and seminars. The teacher plays the role of a tutor who not only develops and corrects the content of the electronic course but also coordinates the learning process of students, providing methodological, consulting, and organizational support in case of questions or difficulties.

The issue of specialized quality control of training seminars and courses deserves special attention. To solve this problem, the author of the portal channel "Digital Pedagogy" decided to conduct an internal examination of the quality of training courses by the criteria using a questionnaire presented in Table 4.

Table 4. Criteria for conducting an internal examination of the quality of distance courses

№	Criteria	Levels		
		Basic (1 point)	Advanced (2 points)	Exemplary (3 points)
1.	Compliance with tasks (training seminar/course) its content, and tasks.	The training tasks (the content of the training seminar/course) and the tasks are coordinated with each other.	The training tasks (the content of the training seminar/course) and the tasks are partially coordinated with each other.	The tasks of the training (the content of the training seminar/course) and the tasks are duly coordinated with each other
2.	The correctness of the use of professional terminology	There are significant contradictions in the use (use) of pedagogical terms and concepts	There are no substantive contradictions in the use of pedagogical terms and concepts. However, the content of the basic concepts of training seminars/courses is not disclosed	There are no meaningful contradictions in the use of pedagogical terms and concepts, and the basic concepts of the training seminar/course are fully disclosed

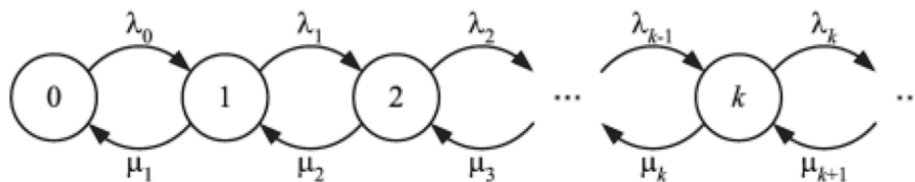| 3.	Opportunities to work with various sources of information	The training seminar/ course offers only one type of educational information that ensures the student's educational activity (either visual, textual, auditory, or kinesthetic activity)	The training seminar/ course offers several types of educational information that ensure the student's educational activity (visual, textual, auditory, kinesthetic activity)	The training seminar/ course offers a rich variety of educational information that ensures the student's learning activity (visual, textual, auditory, kinesthetic activity)
4.	The correspondence of the volume of information to the number of hours allocated for the development of the training seminar/course	The content of the Training seminar/ course is too voluminous insignificant; the listener is forced to master the distance course for a length shorter period provided by the educational program	Full compliance of the volume of information with the number of hours allocated for the development of the training seminar/course	The content of the distance learning course assumes a greater number of hours than is provided by the educational program. However, students are given a choice of topics, the study of which corresponds to the number of hours allocated for the development of the training seminar/course.
5.	The opportunity to get feedback and interact	The training seminar/ course provides limited opportunities for communication and interaction (listener-teacher, listener-listener); listeners have a one-time opportunity to receive feedback	The training seminar/ course provides optimal opportunities for communication and interaction (listener-teacher, listener-listener); students are allowed to receive feedback (including in the learning process)	The training seminar/ course provides rich opportunities for communication and interaction (listener-teacher, listener-listener); regular and timely feedback is provided to students throughout the distance learning process

Mathematical model of the use of remote technologies for professional development of the teaching staff

For users of distance learning technologies, the most obvious criterion characterizing the convenience and quality of work is the response time R, that is, the time elapsed from the moment the request was sent to the receipt of the HTML page from the server. Numerous studies show that to work comfortably with the remote technology server, the response time should not exceed 1 s, and for users not to be distracted by other tasks, the full page load time should remain within 10 s. Increasing the efficiency of remote technologies should be carried out through the prism of their main service functions, that is, searching and providing information of a certain nature at the request of the user.

Thus, mathematical modeling of distance learning technologies is relevant, aimed primarily at calculating the main performance characteristics of the system. Mathematical modeling of the performance of distance learning technologies can be carried out with varying degrees of detail: at the system level, when the system itself is considered a «black box» processing incoming requests, and at the component level, when models of processors, disks and networks are used. To analyze the characteristics of the system, we will construct its generalized model using the main provisions of the queuing theory.

Let's imagine the entire software and hardware complex automating the processes of distance learning technologies in the form of a «black box,» which receives user requests with an average frequency of λ requests/s, serviced by a system with an average performance of μ requests/s. Let's assume that the load is homogeneous, i.e. the requests are statistically indistinguishable, and only their number matters. Assume that the system is in operational equilibrium, i.e. the number of requests processed by the system at the beginning of the period under review is equal to the number of requests processed at the end of the period. We will describe the state of the system by a single parameter – the number of pending or service requests, while there is no aftereffect and the process of functioning of the system under consideration is Markov.

Let's construct a diagram of transitions of a generalized model of the system level, denoting its possible states by the numbers 0, 1, 2,..., k,..., considering that the intensity of receipt and processing of requests λ_k and μ_k may depend on the state.

Since the system is in a state of operational equilibrium, the flow of transitions to state k must be equal to the flow of transitions from this state, that is, the principle of equality of incoming and outgoing flows is fulfilled. Based on this, we have the following system of equations:

$$\bar{N} = \sum_{\kappa=1}^{W} \kappa \rho_k \qquad \begin{cases} \lambda_0 \rho_0 = \mu_1 \rho_1 \\ \lambda_1 \rho_1 = \mu_2 \rho_2 \\ \dots \\ \lambda_{k-1}\rho_{k-1} = \mu_k \rho_k \\ \dots \end{cases} \tag{1}$$

where p_k is the relative period during which the system is in state k. The law of conservation of flows is carried out taking into account the previously made assumption about the Markov process of the system functioning.

From (1) we get:

$$\rho_1 = \frac{\lambda_0}{\mu_1}\rho_0;$$

$$\rho_2 = \frac{\lambda_1}{\mu_2}\rho_1 = \frac{\lambda_1}{\mu_2}\frac{\lambda_0}{\mu_1}\rho_0; \tag{2}$$

$$\dots$$

$$\rho_k = \frac{\lambda_{k-1}}{\mu_k}\rho_{k-1} = \frac{\lambda_{k-1}}{\mu_k}\dots\frac{\lambda_1}{\mu_2}\frac{\lambda_0}{\mu_1}\rho_0;$$

Using a more compact representation, we write (2) as

$$\rho_k = \rho_0 \prod_{i-1}^{\kappa-1} \frac{\lambda_i}{\mu_{i+1}} \tag{3}$$

Since the sum of all pk must be equal to 1, we get

$$\sum_{\kappa=0}^{\infty} \rho_k = \rho_0 + \sum_{\kappa=1}^{\infty} \rho_\kappa = \rho_0 + \sum_{\kappa=1}^{\infty} \rho_0 \prod_{i=0}^{\kappa-1} \frac{\lambda_i}{\mu_{i+1}} = \rho_0 \left(1 + \sum_{\kappa=1}^{\infty} \prod_{i=0}^{\kappa-1} \frac{\lambda_i}{\mu_{i+1}} \right) = 1, \tag{4}$$

where from

$$\rho_0 = \left[1 + \sum_{\kappa=1}^{\infty} \prod_{i=0}^{\kappa-1} \frac{\lambda_i}{\mu_{i+1}} \right]^{-1} \tag{5}$$

The system utilization factor is found as a fraction of the time during which the system is not idle.

$$U = 1 - \rho_0 \tag{6}$$

The average performance of the system will be equal to the sum of the products of the productivities μ_k by the fractions of time pk during which the system functioned

$$X = \sum_{\kappa=1}^{\infty} \mu_k \rho_k \tag{7}$$

The average number of requests in the system is defined as

$$\bar{N} = \sum_{\kappa=1}^{\infty} \kappa \rho_k \tag{8}$$

By Little's law, the average number of requests processed by the system is equal to the product of the intensity of the input stream (system performance) by the average processing time of the application. Therefore, the average response time is calculated as [5]:

$$R = \frac{\bar{N}}{X} = \frac{\sum_{\kappa=1}^{\infty} \kappa p_\kappa}{\sum_{\kappa=1}^{\infty} \mu_k \rho_k} \tag{9}$$

Within the framework of the generalized model obtained, it is possible to distinguish many variants of the functioning of the system, differing in a constant or variable processing speed, a finite or infinite queue, as well as a finite or infinite set of incoming requests (i.e., an open or closed type of system).

To model the system, we will use a queuing system model with variable processing speed, a finite queue, and a finite set of incoming requests (the choice of a closed model is justified by the limited number of requests from the distance learning system).

The speed at which the server processes requests increases until a certain number of simultaneously processed requests J is reached, after which a saturation state occurs, which can be described by the following dependence:

$$\mu_k = \begin{cases} X(\kappa), \kappa = 1, \dots, J \\ X(J), \kappa > J \end{cases} \tag{10}$$

Based on (8), it is possible to determine the average number of requests on the server:

$$\bar{N} = \sum_{\kappa=1}^{W} \kappa \rho_k \tag{11}$$

The average productivity, according to (7), is calculated by the formula:

$$\bar{N} = \sum_{\kappa=1}^{W} X(\kappa)\rho_k = \sum_{\kappa=1}^{J} X(\kappa)\rho_k + X(J) \sum_{k=J+1}^{W} p_k \tag{12}$$

The response time, according to Little's law, is defined as

$$R = \frac{\bar{N}}{X} \tag{13}$$

Thus, to calculate the main performance characteristics of the distance learning system, such parameters of the system-level model as the decision-making time Z, the number of students simultaneously working with the system M, the maximum number of requests simultaneously processed by the system W, the system performance values depending on the number of requests $X(k)$ in it should be known.

To calculate the theoretical characteristics of the system, we use the proposed mathematical model with the following parameters: decision-making time $Z = 60$ s; the number of users simultaneously working with the system $M = 3600$; the maximum number of requests simultaneously processed by the system $W = 150$; system performance values depending on the requests in it $X(k)$; according to the results of the experiment, and also taking into account the server configuration (two processors can process four independent threads, i.e., $J = 4$, $X(1) = 24$, $X(2) = 48$, $X(3) = 57$, $X(4) = 64$. Then by (11) – (15), we get that the average number of requests on the server is 14.53, $= N$ by (6) the system utilization factor $U = 98.2\%$, average performance $X = 59.76$ requests/s, average response time $R = 0.243$ s, and the share of lost requests is zero.

The response time of the system increases almost linearly as the number of simultaneous requests increases, indicating that the operating system distributes the load evenly between all the threads of the web server and the database management system. The average response time of the system can range from 38 to 1105 ms, depending on the number of simultaneous requests. The experimental results confirm the reliability of the data obtained by monitoring the page execution time carried out during the development and testing of the system. The presented model can be successfully used to calculate and optimize the performance parameters of distance learning technologies depending on the number of users, which makes it possible to reasonably determine the requirements for the system's software and hardware resources.

Conclusion

Conducting an internal examination of the quality of distance learning seminars and courses will allow not only to adjust their content but also to assess the compliance of each training seminar and course. Among the promising directions of the Digital Pedagogy portal channel for the next two years are high-quality work of training courses and training seminars, including through the creation of unique educational video and audio materials; conducting not only internal expertise, but also external due to the involvement of an expert community represented by methodologists from other regions, etc.

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