Digitalization of educational and methodological support for the training of aviation dispatchers

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The process of training personnel for civil aviation structures, in particular air traffic controllers, carries a load of great responsibility in terms of knowledge by future specialists of the rules and regulations for servicing aircraft on the ground and in flight. The rules and regulations of service are the result of a long accumulation of statistical data, their processing, systematization, and rationalization, which in some cases were introduced as a result of serious accidents. Compliance with the rules and regulations ensures the guaranteed safety of flight and technical operation of aircraft, which is most important when transporting passengers and valuable cargo.

Legislative and regulatory documents (hereinafter aviation documents) of civil aviation are developed by a special aviation structure, endowed with the rights to do so. These documents have a different focus and purpose, have domestic and international application. The number of their types and purposes corresponds or even exceeds the number of types of processes.

Probably it will be appropriate if we note: - The professional knowledge of aviation specialists engaged in flight maintenance and the technical condition of aircraft consists entirely of the rules and regulations set forth in the relevant aviation documents. In terms of this, let us pay attention to the place given to the study of aviation documents in universities that train specialists for air traffic services.

In a scientific article (Shamsiev et al., 2020) on the example of aviation educational institutions of the USA, Russian Federation (RF), Czech Republic and the Republic of Belarus, an analysis of training programs for air traffic controllers is given. As an example, let us dwell on the analysis of the working curricula of the Moscow State Technical University of Civil Aviation (MSTU GA) of the Russian Federation. The training of air traffic controllers at MSTU GA on the air traffic control profile is carried out within the framework of specialty 161000 - Air navigation according to the Federal State Educational Standard of Higher Professional Education (Federal State Educational Standard of Higher Professional Education) of the Russian Federation.

Federal State Educational Standard of Higher Professional Education of the Russian Federation established requirements for the level of preparedness of a graduate. The preparedness of a graduate is assessed within the framework of two categories of competencies - these are general cultural competences (OC) OCi (i = 1,61) and professional competencies (PC) PCj (j = 1,72). The semantic content of the types of categories of competencies is given in the FGOS VPO RF (FGOS VPO RF, 2009) and work curricula.

Since 2017, MSTU GA has been issuing air traffic controllers in the direction of undergraduate education under the code 25.03.03 - Air Traffic Control. A repeated study of the composition and content of working curricula for this direction of education (MSTU GA RF, 2019) showed that, in general, the requirements for the professional competence of graduates remained unchanged. Based on this, it was concluded that the data given in (Shamsiev et al., 2020) can be used as an argument for the particular importance of studying aviation documents.

Let us briefly dwell only on the composition of professional competencies that are promoted to graduates according to the Federal State Educational Standard of Higher Professional Education of the Russian Federation. Based on the analysis of working curricula for 41 academic disciplines, it was revealed that there is a certain range of PCj. Certain types of professional competence are often mentioned. These PCj include the professional competence of PC-1. A sample of the most frequently mentioned types of PCj was made. The statistics for the most frequently mentioned PCj are summarized in the table 1 (the code designation of the type of professional competence in the table corresponds to the code given in the curriculum).

Table 1

The Types of PCs Most Often Mentioned in Training Programs for Air Traffic Controllers at MSTU GA

Code	Content of competence	κ
PC-1	Be able to use regulatory legal documents in their professional activities.	8
PC-3	Have a readiness for independent, individual work, making responsible decisions within the framework of their professional competence.	8
PC-29	Be willing to provide and service aircraft flights.	1
PC-30	Have a willingness to provide air traffic services.	2
PC-37	Possess the methods and procedures for ensuring the safety of aircraft flights and the use of airspace.	1

To ensure the convenience of comparative assessment, the concept of "weight coefficient" *Nk* was introduced, which is determined by the ratio of the number of references to the type of professional competence in the working curricula of disciplines to the total number of disciplines, namely:

$$K_v = \frac{Nk}{Nud},$$

where: *Nk* - the number of references to the type of professional competence in the curricula of academic disciplines; *Nud* is the number of academic disciplines.

Based on the statistical data, a diagram is built (Figure 1), which shows that more weighty attention is paid to the knowledge of future air traffic controllers on aviation documents. This is one aspect of the importance of a thorough study of aviation documents. The given data apply only to classroom lessons - lectures and practical ones.

Figure 1

Diagram of the Distribution of the Weight Coefficients of the Types of PC Most Often Mentioned in the Curriculum of the Disciplines of the Specialty 161000 "Air Navigation" (MSTU GA, 2021)
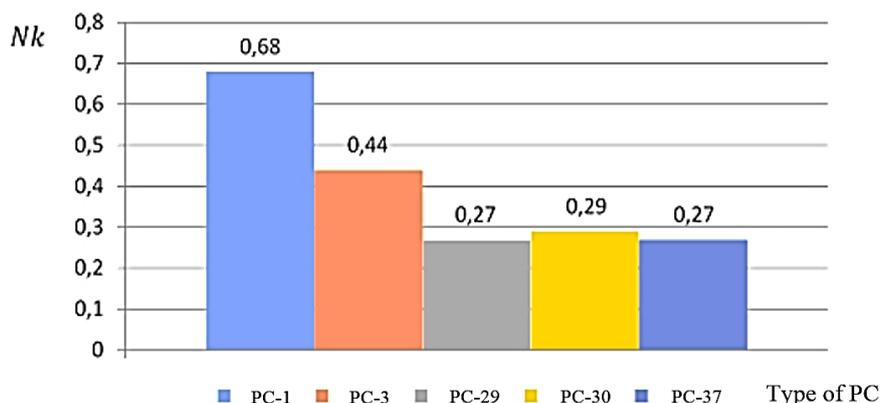

According to the context of the curriculum, it can be concluded that the study of aviation documents is carried out in lectures and practical exercises. In these classes, the materials most necessary from the point of view of the teacher are provided. Students can evaluate the practical value of these materials during the passage of simulator training in an educational institution or in air traffic services, as well as in the conditions of their future professional activities.

Modern educational institutions that train specialists for air traffic services, as a rule, are equipped with a computer simulator, on which students practice the functions of an air traffic controller in the "Conditional air traffic controller - Conditional pilot" mode (Figure 2). Modern simulators differ in the range of simulations, functionality, provision of data on aircraft movement in the air and on the ground, and other indicators.

Figure 2

A Schematic Diagram of a Computer Simulator for the Formation of Practical Skills for Air Traffic Control
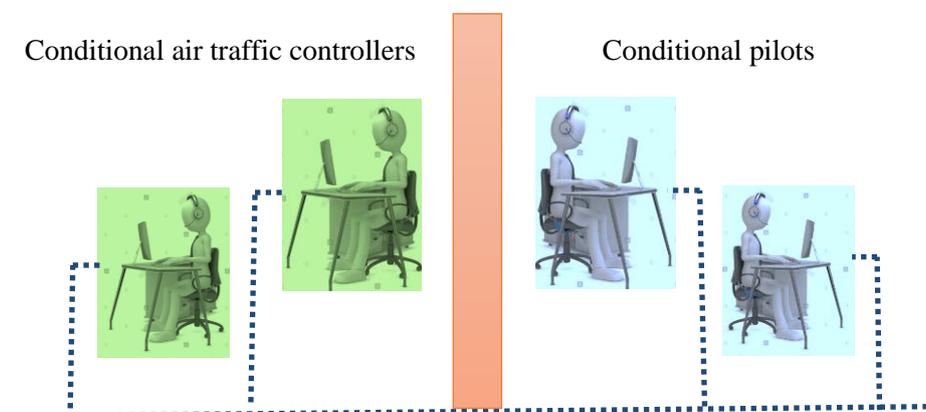
The process is conducted with variations in events and conditions. Such an educational process requires from the participant the amount of knowledge on aviation documents, which has both domestic and international application. Due to the fact that the process is educational in nature, the participant (student) does not always have the full amount of knowledge in the field of norms and rules, he finds it difficult in situations and violations of action. For relevant knowledge, it is necessary to have access to sources that, as a rule, are not available in training rooms.

In the context of the topic of the material, let us turn to publications devoted to modern training systems used in aviation educational institutions.

In the article (Eliseev et al., 2010), based on an analysis of the use of a simulator at the University of North Dakota training center in the USA, it is noted that the development of effective air traffic control (ATC) systems for airport tower dispatchers faced a safety barrier, since there is no the ability to train dispatchers on the airfields of modern large airports without the risk of an accident. Therefore, the solution to this issue was the development and use of computer simulators with imitation of a 360-degree view from the airport tower using computer graphics. Evaluating such simulators, the authors identified three serious drawbacks:

1) training is carried out on the virtual airfield of the airport, while effective training can take place only on the real field of a real airport;

2) permanent placement of ATC in special premises of training centers, which requires the termination of the work of dispatchers during training;

3) high costs for simulators and training.

To eliminate these shortcomings, attention is focused on the development of new information technologies of combined reality (CR, other definitions used - mixed reality, augmented reality, English terms - mixed reality, augmented reality). CR technology combines real-world objects and virtual, computer-generated artifacts. At the same time, it is noted that mixed reality in aviation is by no means new; an example is the helmet-mounted systems of combat aircraft for indicating the target, in which the real object seen by the pilot is a target combined with iconic graphic information generated by a computer. Thus, it becomes relevant to develop a simulator for air traffic controllers for launch, landing and taxiing based on CR technology, which allows creating emergency training situations on a real airfield, as well as mastering combinations of existing and new aviation dispatch equipment presented in the form of virtual objects in training classes. In support of this direction, the necessary review of foreign developments is given. Further, the authors provide typical scenarios of training and test situations for such simulators. Interesting from the standpoint of the relevance of the digitalization of the methodological support of trainings in the above scenarios are the general requirements for controlling the actions of the dispatcher at the taxiing, landing and launch points. The requirements are given in the edition: - Accuracy of following the instructions of regulatory documents ("Typical Technologies of Operations of Dispatchers") for air traffic services. One of the main conclusions

of this work is that theoretical knowledge of aviation documents should be an integral part of the simulator training system for aviation dispatchers.

Noteworthy are the materials presented in the article (Kolotusha, 2013). Despite the fact that this article is eight years old, it contains materials that are relevant today. The article is entirely devoted to the tasks of improving the educational process of training aviation dispatchers. At the very beginning, the author draws attention to the problem associated with the increase in the complexity of automated ATC systems and, consequently, the expansion of the spectrum and complexity of issues within the sphere of professional interests of the aviation dispatcher. This situation, as stated in the article, primarily concerns the stage of initial training, the quality of which significantly affects the future professional activities of an air traffic controller. In part of this problem, it is mentioned that modern multimedia technologies, modular and complex dispatch simulators for practicing practical skills, standardized curricula, and targeted provision of students with teaching materials are widely used in the educational process. Monitoring the progress of learning is also important. The author, guided by the issues of adaptation of the provisions set forth in a number of ICAO and EUROCONTROL documents and trends in the training of aviation specialists, voiced in the materials of the regional symposium of the ICAO and TRAINAIR PLUS regarding the training of the next generation of aviation specialists (June 17-19, 2013, Istanbul), makes the following main directions for improving the initial training of aviation dispatchers:

a) individualization of the training process;

b) seamless training: combining the types of training activities related to theoretical knowledge with the types of training activities related to the practical training of air traffic controllers;

c) exchange of information resources between training organizations;

d) improvement of the air traffic control simulator exercise preparation process;

e) reducing the level of subjectivity in assessing the competence of the listener group / team (ATC shifts);

f) optimization of training volumes through increased use of multimedia technologies.

Further, the question of the development of the educational process by moving away from the rigid division of training into theoretical and practical parts is argued. It is noted that modern educational activities include:

– Case Study - the study of situations, Computer Web-Based Training training using electronic training materials and Web-technologies (a set of technical, communication and software methods for information support of training tasks based on the use of the Internet and / or Intranet, Hands on - training, when which the student uses real equipment (not involved in the production process) to practice certain technological operations, skill acquisition (SA), the acquisition of skills.

– Pre-exercise preparation, which allows the trainee to practice individual practical actions necessary to complete operational tasks. At the same

time, training can be carried out in an artificial working environment (for example, on a 2D model of an airfield), part-task practice (PTP) - the practice of partially performing production functions.

— Pre-exercise training, which allows you to work out fragments of operational tasks in limited or in real time, for example, on the PTT - Part-Task Trainer - a simulator for performing partial tasks.

The result of the article is the statement that the outlined approach to organizing training will create a link between theoretical training and practical training on an integrated dispatch simulator and implement a "seamless" training scheme for air traffic controllers.

In the above text, from the standpoint of the goal and objectives of this work, the preparation and use of electronic training materials is of interest. This begs the question: - What is the current volume of electronic educational aids used in educational institutions, how effective is their application and what conceptual pedagogical model do they rely on?

An important aspect of the educational process is the assessment of the level of specialist training. This issue is relevant from the standpoint of guaranteeing employment and the prestige of the educational institution in which the specialist studied. This does not go unnoticed by scientists. The article (Borisov et al., 2019) provides information on the analysis of the quality of work of a dispatcher performing direct air traffic control. It is noted that monitoring with the help of objective control means reveals deficiencies in air traffic services during each operation, and also allows developing a set of measures to prevent aviation events in the future. The research methodology is based on establishing the dependence of the level of air traffic safety on the class qualifications, experience and age of the controller performing air traffic control. The work of dispatchers of classes 1, 2, and 3 was analyzed. The record of experience was carried out in gradations of less than 3 years, from 3 to 5 years and from 6 to 10 years. In terms of age, a gradation of less than 30 years, from 30 to 40 years, from 40 to 50 years and more than 50 years is accepted. Ultimately, the authors of the work, relying on the results of processing statistical data, conclude that, according to the class level, the largest share of violations falls on class 2 dispatchers, according to the experience, the largest number of violations is committed by specialists with less than 3 years of experience and more than 10 years old: by age - from 40 to 50 years old and more than 50 years old. These statistics appear to be interesting and should be carefully studied and the compelling reasons for this picture identified. Based on the study of these data, the authors draw generalized conclusions:

— after receiving the 2nd class, dispatchers have self-confidence, and also control from the elders in the shift decreases, which contributes to the appearance of errors;

— air traffic controllers over the age of 40 have vast experience in resolving a particular conflict situation, but due to their age they have excessive confidence, there is a loss of qualities necessary for air traffic control, such as attentiveness, susceptibility to changes in the structure of the airspace,

documents regulating the work of the dispatcher, console operations; it is easier for young professionals to adapt to such changes; the ATC controller, who is accustomed to working according to a certain algorithm, is less adapted to changes in the air navigation system; changes in equipment, separation standards, radio traffic rules and the like, which in turn may affect flight safety.

Valuable in the materials of the article (Borisov et al., 2019) from the standpoint of the study is the conclusion about the loss of qualities by dispatchers associated with updating knowledge on aviation documents regulating their work.

Based on the above review of the state of the art in the field of digitalization of the educational process of training air traffic controllers, the following fundamental conclusions can be drawn:

1) in the available open information, there is no clarity in the presence of targeted works devoted to the development and improvement of the educational and methodological base of the process of training air traffic controllers based on the creation and implementation of an electronic training system for aviation documents, although all their activities in the future are related to them;

2) the available methods and means of theoretical and practical training of air traffic controllers must be strengthened by creating and introducing a special electronic educational complex (EEC), which allows you to remotely receive the necessary information, conduct theoretical and practical classes on the basis of effective pedagogical technologies and monitor knowledge.

However, we must not forget the not fully studied aspects of digitalization. One-sided approaches to solving digitalization problems can lead to some negative results. An example is research on the effectiveness of virtual learning using various simulation tools (Fussell et al., 2020). In this publication, the authors note the progressiveness of this direction in achieving a solid mastery of the skills of the aviation profession. At the same time, they draw attention to the insufficient knowledge of the impact of virtual funds on users. In this regard, the study set out the goal of a comprehensive assessment of the benefits of using such systems in the educational environment. The authors' research, based on a survey of students using a questionnaire developed using Google Forms, was aimed at identifying factors and elements of virtual tools that need to be revised before mass distribution. The results provided a preliminary insight into how students perceive the use of virtual reality and the factors that can negatively influence the adoption and ultimately the use of virtual technology to train aviation professionals. In terms of this, the results of the studies presented in the article (Coyne et al., 2017) deserve attention. The authors analyze students' perception of the use of simulators with high fidelity from the standpoint of satisfying the skills of future aviation dispatchers at the workplace. Based on the analysis, it is concluded that researchers and administrators should consider the use of modeling as an integral part of teaching methods. Students prefer modeling when integrated with traditional teaching methods. Students find that there are more benefits to using air traffic

control simulators. Ultimately, an important conclusion is made that when drawing up training programs in the context of the development of new learning technologies by universities using modeling, it is necessary to take into account the opinions of students. Currently, the emergence of the coronavirus pandemic has also led to a revision of certain aspects of distance learning, the need for which is already appearing in scientific publications (Sorensen, 2021).

Materials and Methods

In this work, on the basis of well-grounded conclusions, solutions of a certain set of problems are considered in terms of the development of an educational and methodological platform for the educational process of training air traffic controllers. As a methodological platform, it is proposed to create and implement special electronic educational complexes (EEC) for aviation documents in order to increase the efficiency of the educational process, simplify and accelerate the search for the necessary information and create a convenient pedagogical space for future aviation specialists to acquire knowledge on aviation documents that would have clarity, unambiguity and firmness. In aviation, even seemingly insignificant causes, as a rule, can lead to undesirable results, up to serious accidents.

In the educational structure of the Tashkent State Transport University there is an aviation simulator (Figure 3), on which students improve their knowledge and practice their air traffic control skills. The lack of conditions in

Figure 3

A Training Room for the Formation of Practical Skills in Aircraft Traffic Control on the Ground and in the Air

the room for obtaining the necessary theoretical knowledge, which were forgotten or simply were not provided to them, significantly reduces the

effectiveness of simulator training. This circumstance served as the beginning of a revision of the existing platform for educational, methodological and technical support of the educational process, i.e. the question of replacing the traditional educational and methodological support with electronic one, digitalization of aviation documents in a form convenient for obtaining the necessary aviation information was raised.

It was decided to develop an EEC "Legislative and Regulatory Documents" (L&RD) and equip the training room with this complex in order to create convenience for students to obtain the necessary information from aviation documents. To increase the scale of the use of the EEC "L&RD", the methodology provides for the implementation of the following set of pedagogical functions (in the future, the functions will be expanded):

a) theoretical studies with knowledge control;

b) practical exercises with knowledge control;

c) obtaining forgotten information in simulator training;

d) remote receipt of information by working specialists to improve the level of knowledge;

e) *distance learning for distance education.*

Currently, within the framework of the first version, a limited set of programs has been developed, which allows using keywords to find a particular aviation document, the information required from it, as well as to test knowledge based on a special pedagogical technology, which will be discussed below.

In general, the creation of the first version of the EEC of aviation documents provides for solving problems that are advisable to consider based on the conceptual functional structure shown in Figure 4.

According to the conceptual functional structure of the EEC "L&RD," the first version provided for the formation of a database based on the relational model. The creation of the database provides for the inclusion of a fairly large number of documents that have domestic and international application. International documents include ICAO documents. However, this issue also includes the task of including aviation documents of foreign countries with which there are air connections, so that students can compare certain rules and regulations in areas of interest to them.

The Air Code of Uzbekistan and other countries, as well as government decrees regulating the legal aspects of civil aviation are considered as legislative documents. Further, the database contains a place for the documents of the Civil Aviation Agency of Uzbekistan, which mainly represent the Aviation Rules approved by the Cabinet of Ministers of Uzbekistan. The database also includes various production and working documents according to the services of aviation structures. The search for a document can be carried out by the exact name of the document, by keywords, the approximate name and purpose of the document. In the first case, the search is carried out with one command, with other types of query, the search is performed step by step. For example, a student entered the words "aviation regulations." The system prompts you to assign

Figure 4
Conceptual Functional Structure of EEC "L&RD"
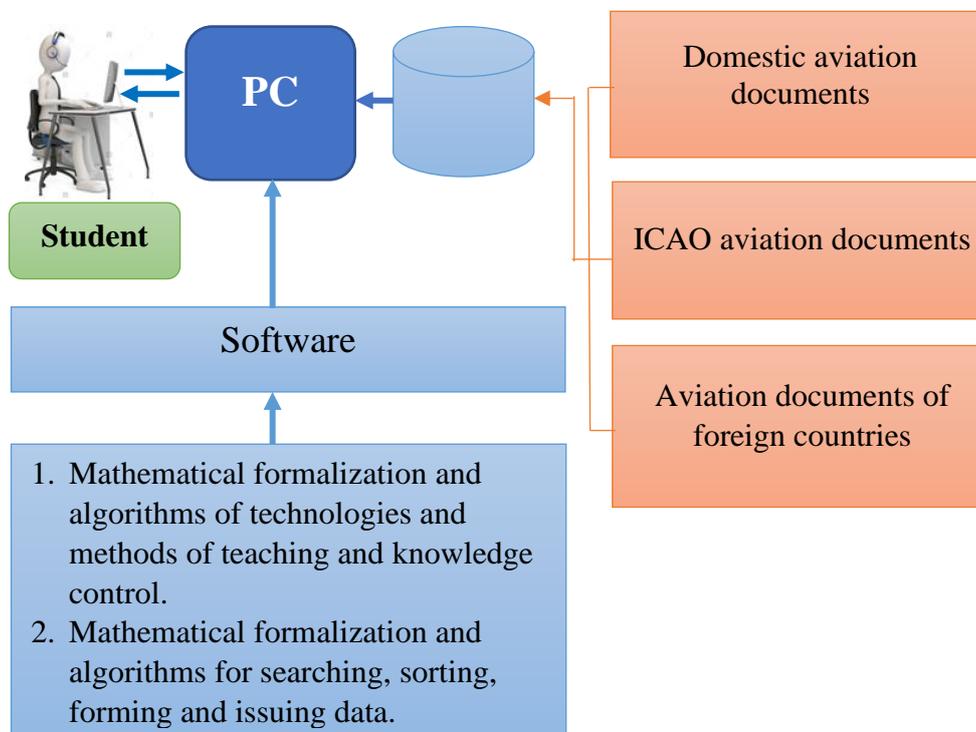
these rules. The cycle repeats until - until the request is satisfied. To facilitate the search for documents, a composition of various keywords in various variations (as a guide) has been developed to create convenience for the student. The system allows you to make a selection of individual fragments from the content of the document.

Another functionality of the EEC "L&RD" is the ability to conduct practical exercises on the assimilation of aviation documents based on a logical explanation of their content. For this, the appropriate technology for the construction and conduct of classes has been developed. With the help of the complex, variants of tasks are formed, the number of which is not limited and depends on the need.

Within the framework of this article, it is appropriate to give some results on the technology of using the EEC "L&RD" for a practical lesson.

Options for tasks on concepts and definitions using the EEC "L&RD" in a previously known form, which is available in the database under a certain code, can be compiled in the form of a list consisting of 3, 4, 5, and more concepts, taking into account that the student could meet the allotted time. Below, using an example of a simple nature, the process of completing a practical lesson on aviation concepts and definitions related to altitude types is reflected.

An example of a practical lesson on the definitions of types of heights.

To conduct a practical lesson with the help of the EEC "L&RD," the following task is formed and given to the student:

1. A drawing depicting elevation views (Figure 5) with questions, the drawing is contained in the database, as a typical graphic information, which, upon a key request, is displayed on the screen, the teacher prints it on a printer.

2. Table with a list of concepts by types of heights (Table 2).

Figure 5
Types of Aircraft Flight Heights
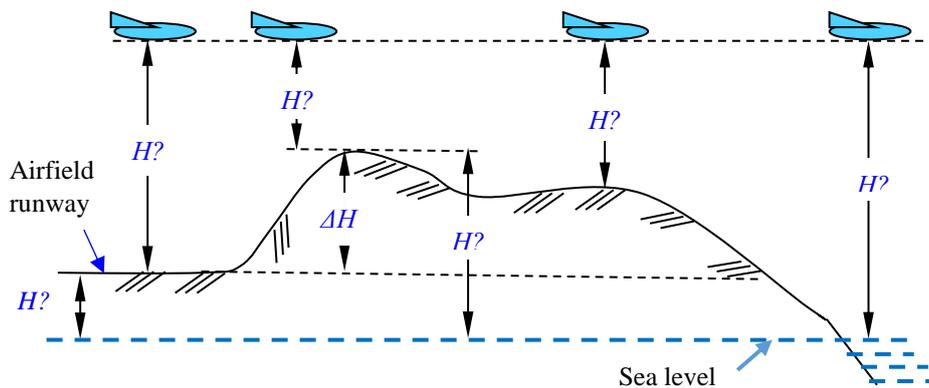
The student is given the following instruction:

− *put down the names of heights in the picture instead of a question mark;*

− *write down the definition of each type of heights in the table;*

− *explain how the types of heights can be calculated, give an example;*

− *draw up a report in the prescribed form.*

Table 2
Questions on the Definitions of the Types of Flight Altitudes of the Aircraft

Questions about height determinations	Write a definition and explain
1. What is the barometric altitude of the flight?	
2. What is the absolute altitude of flight?	
3. What is the relative altitude of the flight?	
4. What is the true flight altitude?	

The teacher does the following:

− evaluates the correctness of entering the names of heights in the drawing;

− draws attention to the completeness and correctness of definitions by types of heights;

− evaluates the correctness of the answer of calculating the types of heights;

− gives an overall score for the work performed.

The teacher can give the student some time to search for information in the EEC "L&RD", but with the condition not to copy or rewrite the necessary information, but simply to read and remember. This allows you to develop the student's memory and ability, to express thoughts concisely and as accurately as possible. Provides advice if necessary.

Main Results

− The expediency of digitalization of educational and methodological support for the training of aviation dispatchers by creating a special EEC "L&RD" according to civil aviation documents has been substantiated.

− An initial version of the EEC "L&RD" has been developed, which, when tested, showed good results, confirming the importance of continuing work on the development and improvement of the complex, expanding its educational and functional capabilities.

− The complex made it possible to expand the pedagogical capabilities of the teacher.

− EEC "L&RD" is not only effective for classroom studies, but also necessary for remote knowledge acquisition and education. It is of value to students, teachers and professionals.

Conclusions

The issue of creating a full-fledged version of the EEC is associated with a fairly large amount of work. Based on the adopted approach to digitalization of the educational process of training air traffic controllers, the following conclusions can be drawn:

1. Analysis of the state of the art in the training of air traffic controllers gave reason to believe that the most relevant part of the educational process is the study of aviation documents, which are the basis of the foundations in the profession of air traffic controllers.

2. Digitalization of the process of studying aviation documents is the imperative of the times, as it increases the speed of searching for the necessary information at the right time, expands the pedagogical possibilities of training due to the computer development of tasks, their implementation and assessment.

3. Digitalization expands the audience due to the remote receipt of the necessary information, which is also important when receiving distance education. However, within the framework of distance learning processes, developers recognize the controversial aspects of the widespread use of digital technologies in education, including distance learning, which are actively discussed in scientific circles (Song, 2010).

4. Pilot testing of the initial version of the EEC "L&RD" showed its effectiveness in various aspects of the educational process, such as demonstrating fragments of aviation documents during lectures, conducting practical exercises based on the computer compilation of options for individual or collective tasks, promptly obtaining the necessary information in the training room on the rules of air traffic services, etc. Efficiency is expressed in reducing the time for searching for information, reducing unproductive academic time, creating conditions for the student to complete tasks in an electronic environment, etc.

5. The development and widespread use of EEC will make it possible to significantly increase the efficiency of training air traffic controllers due to unlimited targeted access to aviation documents and create convenient educational conditions based on the development of various options for theoretical and practical lessons on the topic according to the curricula of academic disciplines.

6. When developing and expanding the composite components of the structural and functional concept of the EEC "L&RD," it is envisaged to solve problems in accordance with the ICAO recommendations regarding the training of an air traffic controller and the assessment of his knowledge based on competencies (Doc 10056 ICAO, 2017). Along with this, the methodology of convergence of the training program with the professional activities of aviation specialists (Shamsiev, 2021) will be taken into account, which is based on the requirements of the aviation document (APRUz-61, 2004), designed to certify the theoretical knowledge of an air traffic controller.

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