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Abstract *- This article is devoted to the issues associated with the organization and implementation of a reliable monitoring of students' knowledge in a higher education institution in the context of a challenging epidemiological situation in the world and a forced full-scale educational process transfer to an electronic implementation format. In early 2020, higher education institutions were not ready to switch over to a distance work format. Educational organizations encountered a huge list of problems affecting literally every single element of the educational process. The most strongly this transition affected the students' knowledge monitoring process. At that time, universities had neither regulatory, nor methodological information base that could become a basis for developing individual approaches to solving the problem of knowledge monitoring process organization, using information technologies; the experience in arranging training sessions, accumulated by institutions over the past six months, gives the advantage. However, it's important to understand that it's impossible to control students' knowledge en-masse in approximately the same time interval without appropriate software and an established performance algorithm & implementation procedure.*

Key words *- distance learning, higher education institutions, knowledge monitoring, algorithm.*

I. INTRODUCTION

In 2020, the world faced an unprecedented challenge. The pandemic caused by the new Covid-19 virus put national education systems in a highly unstable position. In the context of a global implementation of protective and quarantine measures, several critical problems have emerged both for the society as a whole and for the education system in particular.

The quarantine measures and restrictions, implemented with the aim to prevent a wide spread of the virus, revealed that the IT infrastructure and IT services were not ready for a large-scale transfer of all educational and administrative processes to a digital platform as well as for a momentary transition of students of all forms of education to distance learning. Furthermore, another challenge has emerged, the answer to which has yet to be found and which is discussed in this article, i.e. the students' knowledge monitoring as one of critical elements of the educational process. The task is set to develop an algorithm for monitoring the knowledge of a group of students, based on which specialized monitoring software modules may be developed and/or updated. The author also wants to bring out the issue of a required and sufficient level of proctoring rigidity as a necessary element of the students' knowledge monitoring process, for a general public discussion.

Nowadays, a lot of studies is targeted at a distance educational process organization by using IT technologies. E.g., according to an in-depth overview study of the application of digital and, in particular, cloud information technologies (Yousef a. M. Kassem at al, 2020) in the education system, represented by commercial companies and higher education institutions, the transition to a widespread implementation of information and cloud technologies is a fresh trend that covers ever growing areas of life. Business processes, associated with education and staff training in commercial organizations, including those operating in the field of education, are actively using information technologies to expand their presence in the market and to overcome national and territorial boundaries; it's natural for them to apply advanced technological solutions, in particular, cloud technologies. However, according to the study, the implementation of information technologies for arranging a distance learning process in higher education institutions proceeds with a time lag. There is no wide practice of using integrated technical solutions. Often, only individual elements, optimizing part of processes accompanying the educational activities, are used.

In 2020, the situation has changed dramatically. The restrictions imposed by quarantine measures with the aim to hamper the spread of the new viral infection became a key impetus for universities to switch over all standard educational and support processes

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to a distance format in a short run. At the same time, the judgment stating that technical solutions are not implemented because university employees are not ready to apply them, is not true. For example, according to a study conducted on the basis of the Udmurt State University (Neborskiy E.V. at al., 2020), only 16% of the respondents selected out of the teaching staff were completely unready to implement the distance work format in the first month after the enforcement of the restrictions. Similar studies were also conducted for other national universities and showed that employees are highly prepared to implement advanced technologies. However, it's worth mentioning that the transition to a distance learning format has significantly increased the workload on each individual teacher. This fact forces the author to adjust the task that he set for himself: it's necessary to create a simple and intuitive algorithm, rather than to develop it.

II. METHOD

To solve the educational process support problem and to conduct a reliable knowledge monitoring, the national market was screened to identify whether appropriate solutions tailored to distance learning organization at the University scale are available, and advantages and critical shortcomings thereof were reviewed.

More than 10 solutions available on the market, including specialized software and messengers supporting VoIP, video conferencing, etc., i.e. iSpring, Google classroom, Coursera, Webex Stepik, Discord, NetAcad, Oracle Web Academy, WebEx, Webinar.ru, TrueConf, were examined. Taking into account the restrictions imposed by specific activity of a university as a large organization that needs to support a great number of parallel educational streams with a great number of participants, iSpring, Webex, Google classroom, Zoom, Webinar.ru , Moodle were selected for a more detailed study.

iSpring and Moodle have been recognized to provide the best software solutions. At the same time, it should be noted that both services have significant drawbacks, preventing their use in the educational process in the "as is" format, namely:

- *iSpring* is a platform for corporate education, training and coaching. The platform's functionality includes placing and storing various educational courses, creating educational paths, planning events, establishing direct liaisons and feedback with the course developers as well as with the department responsible for employee development. The platform is also capable to track progress in learning courses selected by a student. This platform can be used by organizations of any size, from small and medium-sized companies to multinational corporations. The platform is user-friendly and allows structuring and monitoring both student groups and other divisions included in the system. It's also important that this system has a detailed monitoring and reporting system that can track student attendance of lectures and seminars, as well as provide detailed statistics for each individual person and educational programs in general. The ISpring Learn company also enables the educational platform integration with existing corporate systems and databases. Provided that a competent management and administration through this system are ensured, the educational process of a higher education institution may be built. However, the platform has a number of disadvantages, in particular, video communication and webinars, being the most demanded functionality for an educational institution, is implemented through the Zoom service; lack of a knowledge monitoring system in the scope sufficient enough for a university level, since training on this platform is built on a student self-motivation principle, taking into account operating features of commercial companies; security concerns. Also, a high cost of this solution as well as a mandatory requirement to deploy the system on an educational organization server, whose capacity may be insufficient, will be another important disadvantage for an educational institution.
- *Moodle* is an open source code software; this means that the software may be freely updated and integrated with any possible system. The latest versions of this software have a broad functionality, enabling building and implementing educational programs for secondary and higher education. Moodle has an unlimited functionality, but each add-on, e.g., a video conferencing module, design tools or controls, must be developed and installed as plugins. This is not a cloud solution; it requires hosting either on a third-party server, or on an educational institution server. It's important to note that this solution imposes high requirements for a server and consumes many resources of the systems it is connected to.

The most important disadvantage of the both services is the lack of sufficient capacities for a simultaneous proctoring of the knowledge monitoring process for a group (about 30 people) of students. Meanwhile, the *iSpring* platform does not allow you to modify its functionality on its own; instead, you can request the developer to make required modifications. The *Moodle* platform is an open source software allowing you to modify it on your own. However, an appropriate algorithm is required to make the update, and this article is devoted to the development of such an algorithm.

Then, let's discuss the main functional capabilities of the algorithm to be developed, taking into account requirements that may be imposed by a higher education institution. The algorithm is designed to be implemented as a subprogram module for a two-tier "client-server" architecture system/ software of one the following two types: "Remote data presentation" or "Distributed application" (Gartner Group classification).

The module should have the following functionality:

1. Video conference room should allow connecting 0 to 40 persons;

2. To get connected to the room, a person must pass an authorization process in the client application by entering an individual username and password;

3. Transition to the "virtual room" should be implemented through an interface or by following a direct link received from the server through a notification or a personal invitation message. Access to the room should be granted to students in accordance with their belonging to a group that has to pass a specific exam. Access to a teacher room must be provided according to the information specified in the timetable. Access of people who do not have the specified attributes, except for the administrators, should be limited;

4. The "virtual room" functionality should include general and personal text chats;

5. The "virtual room" should be connected to a dedicated temporary shared storage (created for the room's existence duration) for file exchange; also, the storage must contain additional information obtained from the server database for a specific exam;

6. Availability of a function of a random issuance of examination papers, preliminary downloaded into the server database, to each student on a specific subject. The examination paper issue process should be initiated by the teacher. "Closed" examination papers should be handed out to all students at once; students should receive access to viewing the examination paper on-by-one, with the "permission" of the teacher. If the number of students exceeds the number of downloaded examination papers, the system should select all students, who did not get examination papers after the first pass, and repeat the examination paper issue procedure for them once again. Once the examination papers are handed out, the system should inform the teacher about the examination paper received by each student as well about available examination papers.

7. For a written answer to the questions posed in the examination paper according to the form established in the educational organization, a separate window for text entry should open. Once the student entered the answer to the examination paper, the information should be sent to the teacher for review, saving and print-out. The information should also be sent to a database to be stored and linked to the student's personal account;

8. For an oral answer to the exam questions, the student's image should be displayed to the teacher's screen in full size from a miniature. Also, the teacher should see the written answer to the question in the examination paper in the window, next to the student's image. Once the answer to the oral question is finished, the student's image should be minimized, and the teacher can select a student, who will be the next to answer, from the list of remaining students.

9. As soon as all students passed the written part of the exam and answered orally, the instructor finishes the exam. Upon completion of the exam, the "virtual room" should be closed, all connected users should be automatically disconnected, the "virtual room" transmits a video record of the passed exam to a database for temporary storage and final summaries to appropriate modules;

10. The system in the teacher's personal account generates an examination sheet for the students who have passed the exam.

11. Proctoring:

    a. Automatic tracking of each user connected to the "virtual room", the time of user connection, status and transfer of this information to the server for attendance monitoring.

    b. Intelligent analysis of audio and video streams for static, looping or other deliberate distortion.

    c. For proctoring purposes during knowledge monitoring, the client software should have access to the student's personal computer to track running applications, access to desktops, input-output devices (including mouse-tracker, key-logger, control over audio devices, as well as the ability to disable hot-key buttons controlling these devices). The application should track the above mentioned information and send it to the server for on-line analysis. During the exam, only the exam window should be open in the application in the student's PC. The student is prohibited to use notes, textbooks and additional third-party materials as well as use the Internet, mobile devices and other third-party help. Also, the student should not be allowed to switch over the PC windows.

The requirements developed and proposed in this paper are designed to ensure an extremely high knowledge monitoring level as well as a high degree of student observation during the entire process. Despite the enhanced monitoring ensures a high quality knowledge testing, it also creates a very stressful situation for both students and the teacher, which can cause errors called as the "human factors", affecting the knowledge monitoring results. A lot of studies are devoted to social aspects of the distance educational process. With this in mind, the author sets the question of a "required and sufficient" proctoring level, which would ensure the knowledge test quality and neutralize possible deliberate violation of the knowledge monitoring procedure by students.

III. RESULTS (ALGORITHM)

Let's discuss the students' knowledge monitoring using for example an exam divided into several stages:

1.Creation of a room, connection of students and teachers;

2.Examination task issue and student's preparation to answer;

3.Student's answer;

4.Completion of the exam, disconnection of students and teachers from the room.

5.Checking of automatic proctoring results and completion of the examination sheet.

Input limiting conditions: the highest possible quality monitoring over each individual student is required, allowing minimization of a number of students' tricky methods during the, while ensuring a complete security of students' personal data and server as well as complying with the time limits established by the Federal State Educational Standard.

Let's start with the first stage. The "virtual room" should be created either by the administrator manually, or by the system automatically.

A short list of advantages and disadvantages of a manual room creation includes the following:

1.Administrator is available in the room lobby and is able to promptly provide support in case is something goes wrong;

2.Likelihood of automatic errors is reduced;

3.Burden on teachers, associated with the system's performance checking before an exam, checking students' presence at the exam, etc., is reduced;

4.Workload on each individual administrator increases dramatically due to the necessity to simultaneously create several rooms and provide full technical support to them;

5.Likelihood of a "human error" at the exam preparation stage grows and may disrupt the exam.

It's important to understand that in practice, while developing and creating a students' knowledge monitoring module, the above mentioned list will be expanded, taking into account many additional factors, which could potentially cause problems. An automatic room creation has mirrored advantages and disadvantages as compared to the "manual" one.

The algorithm for connecting users to a virtual room created for students' knowledge monitoring through an exam is described below:

1.Administrator/ Server create a "virtual room". The following values are recorded in the "virtual room" identification data: discipline title, training area, number of the lesson in the list of lessons associated with this discipline, teacher's full name, study group number, date of the exam, time of the exam, and time of the room creation. Information on the first 7 specified values is downloaded from the "Schedule" module either automatically, or at the System Administrator's request.

2.Administrator should be able to modify the "virtual room" identification data after its creation.

3.While creating a new room, the system should record its identifiers in a separate register of active "virtual rooms" and verify the identifiers of the newly created room against the already recorded data to ensure mismatches. If a match is found, a warning to the Administrator, containing information about the rooms having matched identification data, should be issued. The existence of two rooms with the same identification data must be excluded. If the Administrator manually updates the "virtual room" identification data, the system should execute another check.

4.Next, the "virtual room" transmits the request to the "Teaching" module and sends its identification data and a link for direct connection. Then, the information is sent to the educational process monitoring system which, possessing information about the study group number and the teacher's full name, directly connects concerned users to the "virtual room" or, via private messages, sends them a link for connection to the room. In response to a request, information about a list of students belonging to this study group, their identification data and, what's important, information about the main devices stored in the memory, used by each student of this group to connect to the distance learning system, is transmitted to the "Knowledge Monitoring" module. Further, the teacher's full name and identification data are also transmitted there.

5.In parallel, the "virtual room" sends a request to the "Educational programs and individual training courses" Database, informing of the discipline title, training area, number of the lesson in the list of lessons associated with this discipline. In response to the request, the Database should send documents to the "virtual room" file storage: academic discipline curriculum, additional materials for the exam, examination papers.

6.Upon connection of each user, the "virtual room" verifies the user data with those received from the system and records the time of connection. If the data of the connected user does not match the data received by the "virtual room" from the system, the connection is reset and the teacher is notified of an attempt to connect a third-party user not related to this exam. Also, a notice thereof is sent to the Administrator, in particular, about attempts to connect a teacher other than the person recorded in the "virtual room" data. If a student is connected from a "non-standard place", a notice thereof is sent to the teacher and to the Administrator.

7.Thereafter, the identity of the connected students must be confirmed. Typically, presenting an identity document to the video camera is used for this purpose. Each student, being in the focus of his own video camera, must show his open identity document, holding it with his hand next to him. To protect students' personal data, the system must turn off all incoming video streams for all students, except for a signal from the teacher, for the duration of identity verification period. During the identity verification, the system should record a separate video file to be used later (after the exam) for the person identity verification.

Stage 2. "Examination Task Issue"

Exam tasks should be issued and assigned to specific students on the server. The examination task issue procedure should be started by the teacher and, based on the results of its operation, provide the teacher with a list of students with a list of the tasks assigned to the student. Having received the list of students with the list of tasks assigned, the teacher should be able to randomly send tasks to students for preparation to the answer; at this point, it's necessary to provide for the possibility of issuing tasks "one-by-one" or "by list". A task re-assignment procedure should be envisaged. The possibility of an arbitrary replacement of the examination task assigned to the student by the teacher should be excluded.

Examination task issue algorithm is as follows:

1.The examination paper issue procedure starts upon the teacher's click the "Issue exam tasks" button.

2.The system generates a list of students connected to the "virtual room" to pass the exam.

3.From the storage connected to the "virtual room", the system uploads the preliminary prepared exam tasks and randomly assigns them to the students. The possibility of a multiple issue of the same assignment should be provided for. Once the assignment procedure is finished, the teacher receives an alphabetical list of students with numbers/ codifiers assigned to the tasks. This information is not imparted to the students.

4.In addition to the necessary information, the list received by the teacher should have the "Issue a Task" button opposite to each student. When the teacher pushes this button opposite a certain student, the system should send an examination task, assigned to this student, to the said student for answer preparation as well as start a countdown timer set for a time limit in accordance with the local regulatory documents applicable in the university. Given the limited time available for the students' knowledge monitoring, the possibility of a simultaneous examination of 1 to 39 students with individual timers should be provided.

5.Upon receipt of the examination task from the server, the client software should automatically open it for viewing and entering a written answer. As soon as a written answer is entered (by student's pressing the "Send" button) or if the time allotted to the student for answer preparation is expired, all the entered information is to be sent to the server. In this case, the information that the student's answer to the task has been received and is available for review as well as the "Invite for Oral Answer" button should appear in the list of students with the assigned exam tasks.

The examination paper issue stage starts with the issue of the first examination paper and ends when the last student submitted the last answer (upon completion, or in case of time expiration). It's important to note that the "Exam Tasks Issue" and "Student's Answer" processes run in parallel most of their time.

The next stage is the "Student's Answer".

After the first answer to the examination paper is submitted, the "Student's Answer" stage starts at the teacher's decision. In developing this algorithm, the author understands that a distance knowledge monitoring process, using proctoring tools, produces a significant stress in any student, event in a stress-resistant one. And this stress will make the strongest impact on the oral part of the examination process. For students, knowledge monitoring creates stress itself; furthermore, a distance examination against the traditional one as well as the use of proctoring tools also aggravate the situation. In the knowledge monitoring period, universities receive extended rights for access to the personal computer and information about the student's environment, which creates severe discomfort. It should be understood that at current conditions, creating the most comfortable and calm atmosphere for an oral answer is not less important task than the knowledge monitoring itself.

For this purpose, the author proposes the following algorithm:

1.As soon as one of the students received the "Invitation for Oral Answer", the System sends a signal to the called student's Client to inform the latter that he has been called to answer, then the Client re-displays the examination paper questions to the student’s screen; at the same time, the teacher's video communication window enlarges. The server stops transmitting video and audio streams from other students, participating in the exam, towards the responding student.

2.An examination paper assigned to the examining student as well as the text of the answer, entered by the student, is displayed in front of the teacher. The window of the student, who is taking the exam, is enlarged. Audio streams from other students, participating in the exam, are muted. The distance knowledge monitoring procedure for universities should include the provision that during the examining student's answer, other students can ask questions to the teacher only through a text chat.

3.During the student's oral answer, the system lowers volume/ mutes the teacher's sound for all students. Before starting with the first student's answer, the teacher should be allowed to choose one of the two options.

4.Dependent on the knowledge monitoring system implemented in the educational organization, the student after his answer can either disconnect from the "virtual room", or wait until the knowledge monitoring is finished. In both cases, the supervision of the examining student, his environment and his personal computer should be stopped.

As soon as the last student has answered, that part of the knowledge monitoring process that assumes a direct participation of students is finished. Next, the following actions are performed:

1.The system displays a request to the teacher to complete the exam.

2.After the completion request is confirmed, the system sequentially disconnects the remaining students and, after that, disconnects the teacher and closes the "virtual room".

3.Video record, text chat log, recorded text answers of students and the results of automatic proctoring of the intelligent audio/video stream analysis system are sent, in accordance with the established practice, to the university database for storage. A temporary data storage, created for the knowledge monitoring period, is closed down and the information, duplicated to it from the Database, is deleted.

Verification of automatic proctoring results (including student's identity confirmation) and completion of the examination sheet by the teacher are the final activities, after which the knowledge monitoring process deems complete in full. Automatic proctoring results can be verified by technical specialists without the involvement of the teacher who took up the exams. The verification includes the analysis of errors, warnings and notes made by the automatic system during the knowledge monitoring process, as well as watching the video record, if necessary. If the violations revealed by the automation system during the knowledge monitoring are confirmed, a sanction, established in accordance with the university documents regulating the knowledge monitoring procedure, is applied.

The knowledge monitoring sheet is filled in by the teacher independently and in parallel with the automatic proctoring verification.

IV. CONCLUSIONS

By suggesting the above mentioned algorithm, the author understands that this algorithm is difficult to implement. However, after creating a clear understanding of the knowledge monitoring process, the issue of finding a balance between the below mentioned three factors will arise:

1.Complexity of the development;

2.Scope of resources required (for the module development and support, server requirements, software client requirements for technical specifications of students' personal computers, PC speed, the Internet connection stability, etc.)

3.Level and rigidity of the examination process monitoring.

To find the above-mentioned balance, statistical data related to technical capabilities and server capacities of various universities (small-, medium-, large-sized and international higher educational institutions) should be gathered to determine modal values of technical capabilities and to develop constraints imposed on their basis on the module being developed.

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