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SUBJECT BEHAVIOR DETECTION AND ANALYSIS BASED ON COMPUTER VISION TECHNOLOGY

Abstract: This article discusses the current problem of identifying violations during distance learning during the final certification.

The coronavirus (COVID-19) pandemic has served as a stimulus for innovation in the field of education in all countries, including Kazakhstan. Innovative approaches are being taken to ensure the continuity of education and training. Thanks to the rapid response measures taken by governments and partners around the world to ensure the smooth learning process. The ongoing digital transformation of an educational institution requires appropriate information content, suitable methodological models, effective teaching methods and a supportive learning environment. The solution to one of the urgent tasks is to ensure the quality and reliability of assessing the knowledge of students by introducing an online proctoring system. The primary task of the online proctoring system is to recognize faces and identify abnormal behavior of students.

The basis for obtaining data is the unified information educational environment of the D. Serikbayev East Kazakhstan Technical University is represented by the SPORTAL hardware and software system, which is an integration of two powerful subsystems: a Web application - the Dales of Knowledges educational portal and the SPORTAL information and software complex.

The main theoretical results obtained are aimed at solving practical problems and are being introduced into the educational environment of D. Serikbayev East Kazakhstan Technical University to increase the degree of confidence in the results of students' knowledge in distance learning using an online proctoring system. The article presents the results of studies of one of the Viola-Jones face detection methods, commonly known as Haar cascades. During the study, a technology for identifying faces and detecting violations in real time was developed.

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Domestic and foreign scientists who have made a significant contribution to the development of methods for processing facial images are noted.

Keywords: distance learning, face detection, proctoring.

Introduction

In the modern world of information technology, face detection systems are one of the most commonly used artificial intelligences. Facial recognition is a form of artificial intelligence that mimics the human ability to recognize people's faces. Just as a person recognizes someone's face, facial recognition software captures facial features and creates an appropriate pattern to identify or group faces [1].

The study was carried out on the basis of developed methods of computer experiment and control of computer vision processes using various algorithms. The creation of computer vision systems can significantly improve the quality of work, provide control over the work performed, and provide qualitatively new services [2].

The aim of the study is to develop information technology for analyzing the video stream and fixing the deviant behavior of students during the exam using modern face recognition methods.

To achieve this goal, the following tasks are solved:

- selection of a known method and algorithm for face detection in a video stream;
- substantiation of the mathematical model, method of identification of persons;
- development of information technology providing the process of detecting violations using computer vision systems.

Face detection involves scanning the input image for human faces. The task of segmenting an image to identify faces is time consuming [3].

Machine learning algorithms have tasks called classifiers. Classifiers identify a face for thousands of smaller tasks, making it easier to do [4].

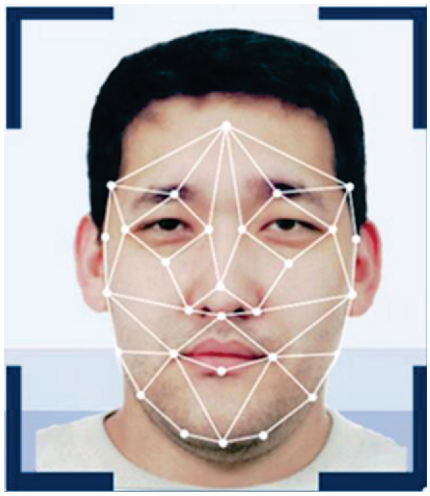

Figure 1. Visual display of key points of the face.

One of several key use cases that computer vision addresses is the task of face detection and recognition. Teaching the system to see the world the way we do is the goal of computer vision, and that is exactly what the face recognition module aims for. A face can be characterized by a set of key points that, when combined, form a "face" that the system can detect in a frame (Fig.1).

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Approximately for a face as a whole, more than 6000 classifiers are required to work. All of these classifiers must match a particular facial feature in order to be correctly detected [5].

With the gradual diversification of technology, face detection and recognition have become a technology closely related to our lives [6].

Research of the subject area.

Numerous studies in the field of educational technologies agree that the basis of online learning is a carefully designed and planned educational process, supported by a methodically sound and purposeful sequence of teaching and methodological and control materials that ensure the achievement of learning outcomes in the e-learning format.

D. Serikbayev East Kazakhstan Technical University has experience in remote attestation of students, starting from the summer session of the 2019-2020 academic year.

Forms of examinations during the period of intermediate certification:

1. Computer testing (online using the "Test Master" of the educational portal of D. Serikbayev East Kazakhstan Technical University);

2. Online oral exam using LMS and BigBlueButton (bbb) video conferencing system (on a fee basis);

3. Open book, essay/creative exam (with online work protection using LMS and BigBlueButton (bbb) video conferencing system, forum chat). An essay attached by a student to a course in the LMS 2 days before the exam must be checked for plagiarism in the TURNITIN system.

Since 2019, on the basis of the university, the Hesperus proctoring information system has been actively developed, designed to accompany and control the territorially remote process of passing exams, confirming the identity of the test person and confirming the results of his certification. Statistics show that since 2019, about 13 thousand students have been tested using the Hesperus proctoring system (Fig.2).

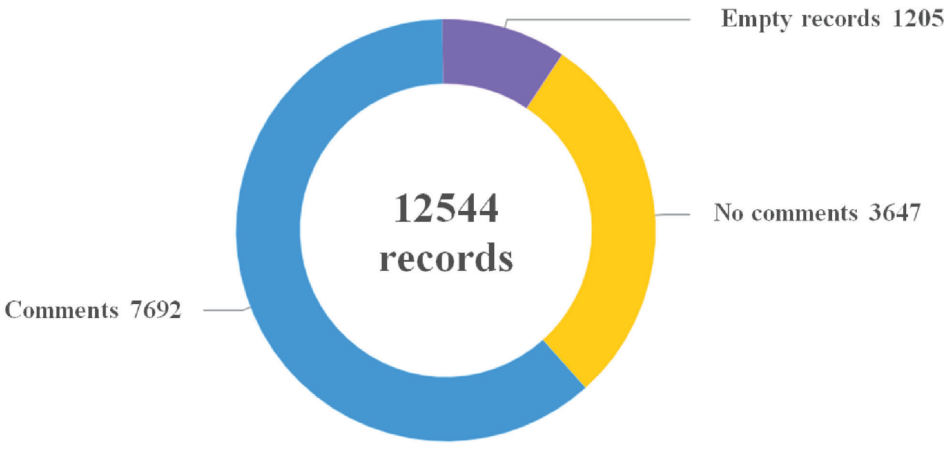

Figure 2. General statistics of detection of violations by the proctor.

All processes for conducting online exams are administered by a special unit. This unit also provides training and coordination of proctors from among the staff of the faculties.

Final certification with proctors allows one to follow the examinees in real time and make timely remarks or comments. The proctor identifies the student, monitors compliance with all procedures, and can comment on the student's actions in a special chat (Fig.3).

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Comments
lift your head
lift your head
lift your head higher
lift your head higher
do not lower your head and set the camera so that you can be seen
do not lower your head and set the camera so that you can be seen
raise your head and immediately answer questions
lift your head
lift your head
lift your head higher
lift your head

Figure 3. Proctors' comments during the exam.

Violation statistics: 311 (4.04%) cases were recorded when students resorted to the help of other people during testing. In 1524 cases (19.81%), students used the Internet during testing to find answers to a question. There were recorded 1034 cases (13%) of the use of gadgets, 1390 (18.07%) cases of remarking on non-verbal communication, 566 (7.36%) cases of voice detection and 2483 (32.28%) cases when the face of the examinee was poorly visible or was not discovered (Fig.4).

Figure 4. Statistics of violations identified by proctors.

According to the statistics of violations identified by the proctors, it can be said that the most common violation among examinees is the "Face is not detected" class (Fig.5).

Looking away from the screen for a long time: the violation will be noticed by the proctoring system or a human proctor. Of course, this does not mean that the examinee must constantly stare at the monitor. Sometimes examinees may think or get distracted and instinctively focus their attention on some object in the room. However, it should be remembered that even a brief but systematic look at the same object outside the camera's field of view can be regarded as an attempt at deception [7].

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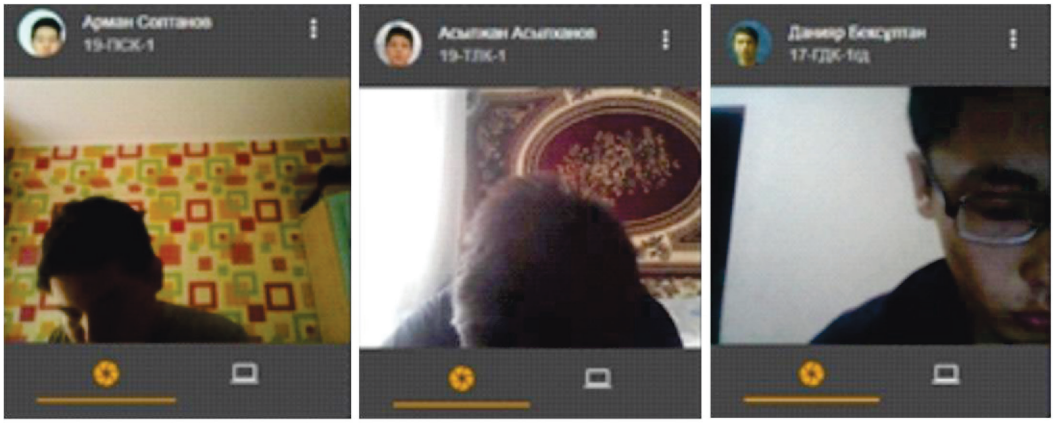

Figure 5. Partial absence of examinees in the frame of the video stream.

Academic honesty is a key value in the scientific and educational process. One of the main proctoring rules associated with face detection is the absence of strangers in the room. If the proctor suspects cheating, he may ask the subject to perform a partial or full scan of the room. Stopping a test subject lead to increased stress and anxiety, which is why the researchers recommend no more than one room scan per exam [8].

Methods and problems of face detection

The purpose of face recognition is to find out if there are faces in an image or video [9].

The detection results provide parameters for the location of the face and may be required in many views, such as a rectangle overlaying the central part of the face (Fig.6).

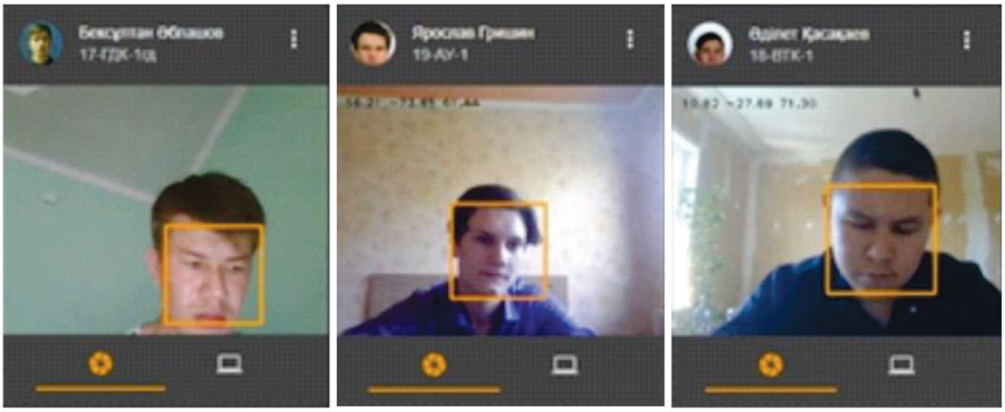

Figure 6. Results of detecting examinees in the video stream.

Typically, image-based strategies rely on statistical evaluation and machine learning strategies to find related features of the face and non-face images. Implemented features refer to the type of distribution methods or discriminant capabilities that are subsequently used to detect faces [10].

Techniques for detecting faces in an unrestricted environment are challenging. In recent years, the need for face detection methods has increased in many areas.

Automatic face detection algorithms perform face alignment, face tracking, face attributes, and other processes. Significant advances have been made in face detection research over the past decades, and many accurate and efficient algorithms have been proposed [11].

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However, in uncontrolled situations with complex backgrounds, occlusions, facial variations, and low resolution, detection and alignment remain a challenge. Despite these limitations, the rapid development of deep learning algorithms has contributed to the development of face detection techniques, thus contributing to computer vision.

Therefore, an ideal face detection and alignment algorithm should satisfy this requirement. In terms of image recognition tasks, deep learning-based algorithms provide better performance compared to traditional algorithms for detecting and aligning individuals [12].

There is an algorithm called Viola-Jones Object Detection Environment which includes all the steps needed to detect a face:

Selection of Haar objects, features derived from Haar wavelets;

Create a holistic image;

Adaboost Training;

Cascading classifiers (Fig.7).

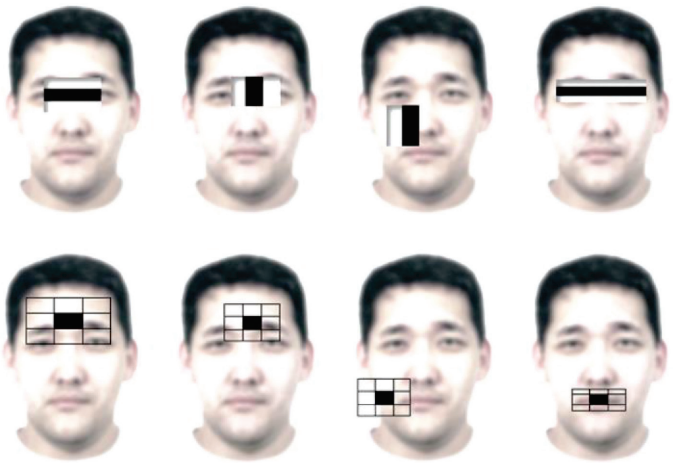

Figure 7. Haar Features extraction process.

The first feature measures the difference in intensity between the eye area and the area across the upper cheeks. The object value is simply calculated by adding the pixels in the black region and subtracting the pixels in the white region.

$$RectangleFeature = \sum(pixel_{blackarea}) - \sum(pixels_{whitearea}) \quad (1)$$

Next, the rectangle is applied as a convolution kernel throughout our image.

There are several types of rectangles that can be used to retrieve Haar objects.

Biangular feature is the difference between the sum of pixels in two rectangular areas, used mainly for edge detection (a, b).

The three rectangle function calculates the sum in the two outer rectangles subtracted from the sum in the center rectangle, used primarily for line detection (c, d).

The quad function calculates the difference between the diagonal pairs of a rectangle (e) (Fig.8).

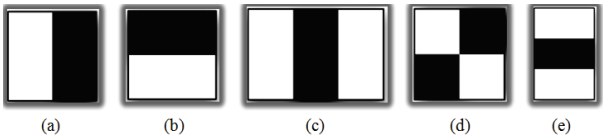

Figure 8. Types of Haar rectangles.

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The role of the integral image is to calculate any rectangular sum using only four values. Rectangle objects are defined at a specific pixel with coordinates (x, y). Then, an integral image of a pixel in the sum of pixels above and to the left of this pixel is performed. In the formula below: ii(x, y) is the integral image and i(x, y) is the original image.

$$ii(x,y) = \sum_{x' \le x, y' \le y} i(x', y'), \tag{2}$$

When computing the whole image, a shape recurrence occurs that requires only one pass of the original image (Fig.9). The system feeds a color image to the input of the face detector, where the detector performs a search operation to detect the presence of a face in the image [13].

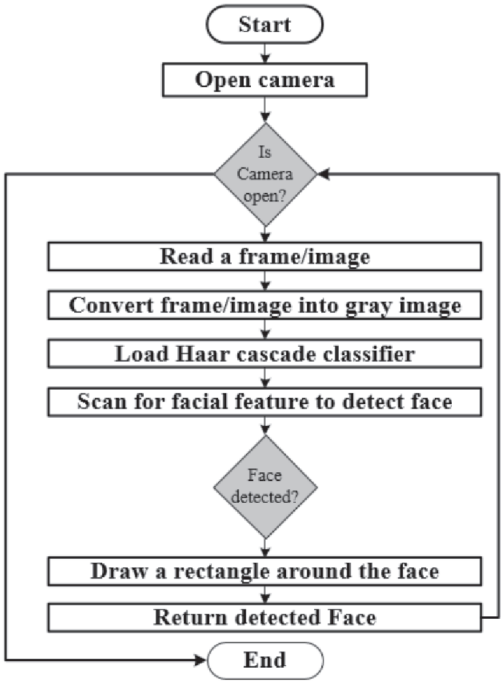

Figure 9. The flowchart for real-time face detection.

An example of working with an integrated image representation method, the main stages of face recognition in real time, as well as data comparison with the original database are presented by the authors in the article [14].

Practical implementation

The developed application for the proctoring system of D. Serikbayev East Kazakhstan Technical University is a solution for detecting the faces of examinees and supporting the detection of faces.

Absence of an exam or looking away in real time.

Head position estimates can provide information about which direction a person's head is facing. Although the problem of head position estimation may seem easy to solve, achieving acceptable quality on it has become possible only thanks to recent advances in the field of deep learning (Fig.10).

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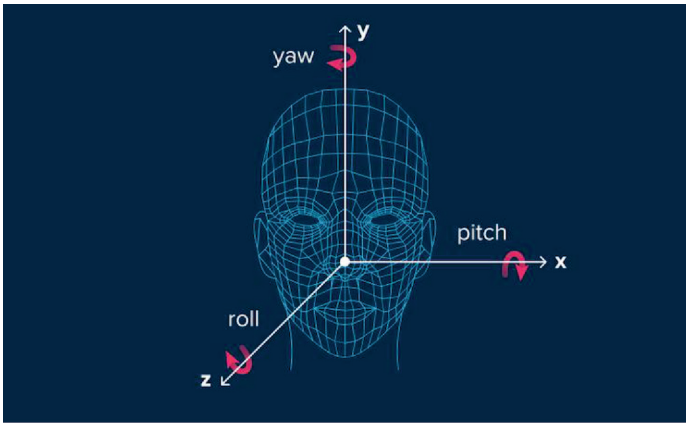

Figure 10. Head position in 3D space

Figure 11 shows the possibility of losing such a feature as the eyes when the head is tilted forward, since when the head is tilted forward, the eyes are obstructed by the superciliary arches. This situation fully applies to the rotation of the head in a horizontal plane, in which, for example, blocking of one eye by the bridge of the nose can occur.

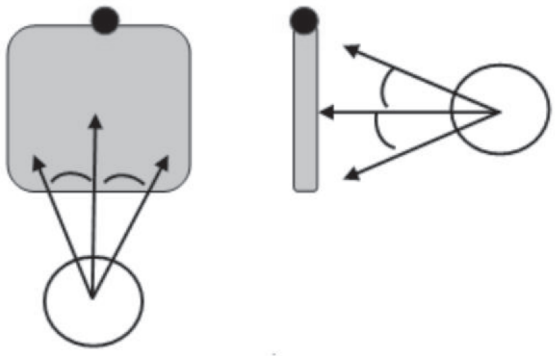

Figure 11. Measurement of human head movement (circumference) by a camera (black dot) located on the user's monitor for the case of: a – turns and b – head tilts.

Some facial landmarks are used to calculate Euclidean between two points or between points and intersection lines, other points. These scopes cover trigonometric functions that evaluate coverage.

$$Euclidean\_Distance = \sqrt{(X_2 - X_1)^2 + (Y_2 - Y_1)^2 \ldots} \tag{3}$$

The yaw angle is calculated as follows:

$$\theta = \begin{cases} 0 & if\ A = B \\ \sin^{-1}(1 - \frac{A}{B}) & if\ A < B \\ \sin^{-1}(1 - \frac{B}{A}) & if\ A > B \end{cases} \tag{4}$$

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θ: yaw angle.
A: is the Euclidean distance between points (17 и 21).
B: Euclidean distance between points (22 и 26)
(a) $A = B >> Yaw = 0$ head direction is straight.
(b) $A < B >> Yaw = A / B$ head direction to the right.
(c) $A > B >> Yaw = B / A$ head direction to the left (Fig.12).

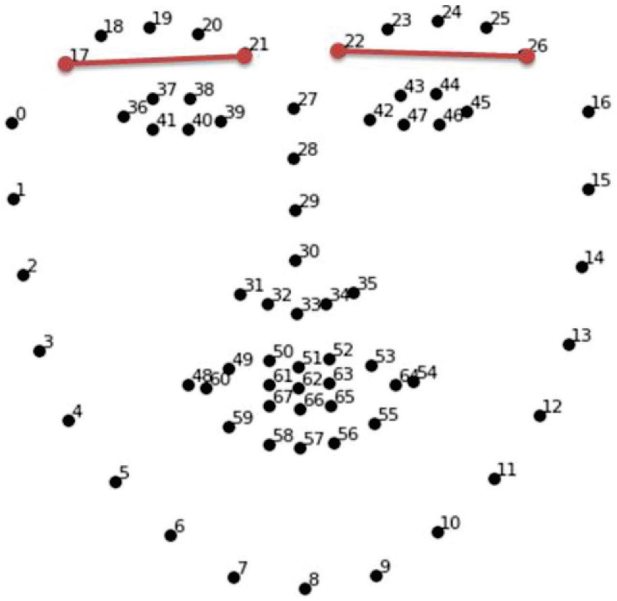

Figure 12. Selected points for angle calculation

Figure 13. Head position at different angles

In addition to the loss of key points of the face when turning and tilting, there is a change in the geometric figure of a person's face from an ellipse with one size (a straight line between the points of the temples) to a smaller size, as well as a change in the size of the axes of the ellipse. When turning, the ellipse will narrow, and when tilted, the compression of the formed image will be the greater, the greater the tilt up or down (Fig.13).

Of course, the system can make a mistake (the examinee can, for example, simply mechanically cover part of the face with his hand), so such incidents are always considered by the proctors.

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Figure 14. Detection of the examinee's face.

If the user is not completely in the field of view of the camera, the head is turned or his face is covered by something, the artificial intelligence will automatically fix the violation. The proctoring system will notify you of a possible violation. Short-term, but systematic looking away at the same object outside the camera's field of view can be regarded as an attempt to cheat (Fig.15).

Figure 15. Looking away in real time.

This, of course, is not about the fact that you must always look at the monitor. Realizing that sometimes a person can think or get distracted and instinctively focus their attention on some object in the room, the system will only notify the proctor of a possible violation [16].

The peculiarity of this system is to provide information about the violation from a large flow of information in real time. Control over the student's actions, in this case, is carried out by the proctor.

Research results

The COVID-19 pandemic has had a significant direct and indirect impact on global education. Educational challenges in the current crisis include the need for a rapid transition to digital learning and teaching, providing support for students and teachers who are learning or teaching at home.

It is believed that cheating during an online exam is mainly associated with an uncontrolled process when examinees have the opportunity to use additional resources during the exam.

The primary objective of this study was to investigate the deterrent effect of webcam proctoring on misconduct during online exams. The algorithm for detecting faces in a video stream has been studied, a mathematical model has been substantiated, and a system has been developed that provides the process of detecting the faces of examinees using computer vision.

The face contains traits such as identity, gender, race, mood, attention, and emotions. Facial recognition is critical for some services [17].

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Discussion

The proposed approach contributes to the solution of the "Face detection" module of the proctoring system in educational institutions during the remote form of passing the examination session. The developed system was tested in real time. The face detection algorithm locates and extracts the number of faces ("face images") present in that frame. The low failure rate was expected, because to be 100% accurate, it must overlap its own face, given the window size and central location. Sometimes poor lighting also affects the result. The rest of the system worked perfectly, detecting almost 85-90% of the faces in the video stream.

Conclusion

How to maintain academic integrity is still an open question, but this study demonstrates that online proctoring does influence the educational experience in ways that need to be considered when balancing the risks and benefits of proctored versus non-proctored assessment.

This article proposes a face detection method that can quite successfully implement the basic functions of a proctoring system based on a stereotypical set of visual features common to different faces.

This research has implications for computer education, especially in areas related to online exams and e-learning systems. This is also important, since the Ministry of Education of the Republic of Kazakhstan requires the introduction of appropriate procedures or technologies for distance learning for students of schools, colleges and universities who pass final certification online in real time.

The results of the study also apply to other industries, including those that offer online professional certification exams and exams for potential employees, as well as employee training and testing.

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