Integrating Digital Technologies Into The Distance Learning Process

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ABSTRACT

The article indicates the number of technologies used for teaching in the field of education.

Keywords: Distance learning, distance learning laboratory, interactive dialogue distance learning tizimi, aurdino laboratory.

Introduction

The emergence of digital technologies has transformed practices that had remained unchanged for centuries. This transformation is reflected in the replacement of traditional letter correspondence with electronic mail and conventional libraries with web-based platforms. In recent years, the education system has also experienced a significant shift, as elements of distance education have been introduced in place of, or alongside, traditional forms of learning. The integration of modern information and communication technologies into the educational process has contributed to the development of a new mode of instruction—distance learning—which complements conventional teaching methods.

In distance education, students and instructors are geographically separated yet remain in continuous interaction through specially designed instructional courses, assessment formats, electronic communication tools, and other internet-based technologies. Distance learning founded on the application of digital technologies enables access to the global information and educational network and performs a range of essential new functions based on the principles of integration and interconnectivity. This form of education provides all individuals seeking learning opportunities with the possibility of continuous professional development. Within this instructional process, students independently master educational and methodological materials in an interactive mode, undergo assessment, complete supervised evaluation tasks under the direct guidance of instructors, and engage in communication with other members of a so-called “vertical learning group.”

For individuals who, due to certain circumstances, are unable to pursue full-time studies at educational institutions—such as those with health-related limitations, individuals seeking to change their professional specialization, or adult learners aiming to enhance their qualifications—distance learning is considered a convenient and effective mode of education.

Distance learning employs a wide range of information and communication technologies, with each technology selected according to the specific objectives and instructional tasks involved. For instance, traditional print-based instructional tools (such as textbooks and study guides) are primarily used to introduce learners to new content, whereas interactive audio and video conferencing technologies facilitate synchronous communication within defined time frames. Electronic mail is designed to establish both direct and feedback-oriented communication through the transmission and reception of messages. Pre-recorded video lectures enable students to listen to and view lectures at their convenience, while facsimile communication, messaging systems, and the rapid exchange of information and assignments through network-based technologies support instructional processes by enabling continuous feedback and interactive learning.

Theoretical and Empirical Review of the Literature

A number of domestic scholars, including, U.N.Nishonaliev, A.R.Khodjabaev, N.Sh.Shodiev, N.A.Muslimov, Kh.I.Ibragimov, E.I.Roziev, U.Q.Tolipov, N.Sayidakhmedov, D.Ergashyev, Sh.S.Sharipov, O.Abduquddusov, E.T.Choriev, O.Turaqulov, J.Hamidov, A.Juraev, U.Jumanazarov, O.Kuysinov, and many others, have conducted extensive scientific research on issues such as improving the training of technology teachers, fostering their professional development within a digitalized educational environment, and examining the role of digital technologies in enhancing the quality of education.

Research Design and Methodology

The methodology of the article is based on the analysis of scientific and increasingly influential sources and focuses on examining the professional activities and technological competencies of prospective technology teachers, as well as the significance and role of digital technologies—particularly distance education—in the process of teacher preparation. The study analyzes the contribution of digital technologies to improving the quality of technology education and highlights their pedagogical potential within contemporary teacher training systems.

In addition, methods for analyzing the structure of digital technologies aimed at enhancing the quality of technology lessons were employed, along with the examination of curricula, instructional programs, and methodological guidelines designed to improve educational quality. The research also involved the scientific generalization of best practices in the use of modern web-based tools and the application of interview methods conducted with prospective technology teachers to explore issues related to the research problem.

Results and Discussion

The implementation of remote tasks in a distance mode is ensured by a remote control system for pedagogical experiments through general telecommunication networks, including the Internet and the university's local area network.

To provide access to laboratory activities, specialized software has been developed, through which users connect to a server via the Internet or a local area network. Using this software, users configure the experimental setup based on the studied scheme, install measurement instruments within a designated workspace, adjust signal parameters, generate queries, perform measurements, process the collected data, and present the results. [1]

Remote laboratories should be designed and operated in accordance with specific requirements, including the following:

1. Remote laboratory activities should support a multi-user mode, meaning that the same experimental setup can be used by multiple students according to a predefined schedule;
2. Remote equipment and laboratory benches should possess technological compatibility that allows integration with other laboratories, such that identical locally installed devices can be utilized across different remote experiments and laboratory activities;
3. Remote laboratory benches should operate in a 24/7 mode, enabling students to complete learning tasks at a time that is most convenient for them.

The Interactive Dialogue Remote System (INDUS) was developed at the university to enable the remote control of distant objects via the Internet. The system is oriented toward locally developed solutions for interfacing experimental setups with computers through digital-to-analog and analog-to-digital converter (DAC–ADC) boards, as well as through devices based on previously widely used international standards (e.g., CAMAC). Unlike many conventional systems, INDUS does not require expensive licensed software environments such as LabVIEW for its operation and employs the HTTP protocol to facilitate communication between the client and the remote control console.

At the same time, the system incorporates the separation of data transmission functions, the configuration of multiple operational modes between the web server and the client computer, and mechanisms for result processing. These features minimize the volume of data transmitted over the network and enable faster task execution. Owing to the formulated design principles, the development of software and hardware complexes connected to the Internet is considerably more cost-effective than purchasing expensive imported equipment that relies on proprietary application software environments.

Within the INDUS system, software tools used to integrate computers and various system components operating under DOS and Windows environments are developed using programming languages such as Pascal, Delphi, Java, and HTML. These tools can be easily adapted to existing local hardware in order to enhance usability and minimize the costs associated with automating experimental setups over a network. For converting files into various graphical formats and visualizing measurement results, both specially developed software libraries and standard tools available in existing software environments can be utilized [2]. The application software comprises a set of subsystems that provide functional support to different structural components of the laboratory.

Remote laboratory workshops are widely used in the educational process at foreign technical universities. For example, National University of Singapore operates a remote laboratory through which students study various measurement instruments—such as function generators, oscilloscopes, multimeters, and others—as well as the time-domain and frequency characteristics of radio circuits and devices. The remote system is developed based on GRIB elements connected to a personal computer equipped with a data acquisition controller.

Access to the functionalities of the remote laboratory is provided by a server machine operating as a web server. Visual monitoring of the studied processes is carried out by a video camera integrated into the system. During the learning experiment, data transmission between the remote user and the system server is performed using the TCP protocol in conjunction with a CGI application. Students' interaction with laboratory equipment is implemented through a web-based interface via an Internet browser using the HTTP protocol. On the server side, the execution of the CGI program was implemented within the LabVIEW software environment.

The Automatic Control Engineering Laboratory operates at the Faculty of Electronic Engineering of the University of Niš in the city of Niš, Serbia. The automated learning system is based on a client–server architecture. The TCP/IP protocol ensures data transmission between remote users and the system server and is essential for implementing remote control of laboratory equipment. Within the laboratory, two research complexes have been developed, focusing on the study of magnetic fields and high-speed servomechanisms.

Remote laboratory activities are also conducted in the field of radio electronics. At Mysore Engineering College (India), a laboratory setup has been developed for the remote control of bioreactor processes. The program interface, implemented using the LabVIEW software environment, enables the visualization of process characteristics, the configuration of control signals, and the analysis of measurement results. Interaction between the web server and the bioreactor elements is achieved through the ELVIS measurement station developed by National Instruments, along with the PCI-6251 input/output data acquisition module. The user interface based on virtual instruments allows monitoring of process parameters, while a web camera enables real-time observation of the ongoing processes.

The task addressed using the laboratory bench involves the remote study of ATmega328 microcontrollers, including the following components: remote learning of the fundamentals of microcontroller programming; remote control of input–output devices installed on the laboratory bench; and remote visual monitoring of the outcomes of microcontroller programming.

For this purpose, the laboratory bench is equipped with indicator LEDs integrated into control switches, as well as an electronic board incorporating digital and analog data input/output elements; a variable resistor actuated by a servo motor; a web camera for remote monitoring of the laboratory bench; and two Arduino UNO controllers connected to a personal computer, which provide a remote control console and enable remote operation of the laboratory bench.

Using the laboratory bench operating in a remote mode, students are able to perform the following laboratory activities related to microcontroller programming and control [3]:

- digital data output (control of LEDs and a micro electric motor);
- digital data input (detection of switch states);
- analog data output and digital-to-analog conversion (adjustment of LED brightness and micro electric motor rotation speed);
- analog data input and analog-to-digital conversion (determination of the potentiometer shaft position);
- control of a seven-segment display.

The algorithm and procedure for working in a remote laboratory possess specific characteristics. Access to the Arduino LAB remote laboratory requires visiting the remote laboratory website (https://sites.google.com/site/arduinolaboratoria/). The access procedure includes the following steps:

1. Create a Google account via https://accounts.google.com.
2. Install the Google Chrome browser on your personal computer (https://www.google.ru/chrome/browser/desktop/index.html).
3. Install the Chrome Remote Desktop application. To do so, use the Google Chrome browser to locate and install the application via the Chrome Web Store (https://chrome.google.com/webstore/category/apps), namely Chrome Remote Desktop (https://support.google.com/chrome/answer/1649523?hl=ru).
4. To obtain access credentials and operating instructions for the remote Arduino LAB, users are required to subscribe and subsequently send a message to the group page of the remote Arduino laboratory at https://vk.com/DArLab, providing their full name, the name of the educational institution, field of study, group number, and Google account (Gmail email address).

Over time, the algorithm and operating procedures of the Arduino LAB remote laboratory may be modified and further improved. All updates and changes related to the operation of the remote laboratory are published on the laboratory's official website (URL):
https://sites.google.com/site/arduinolaboratoria/

The block diagram of the remote laboratory workshop is presented in Figure 1.

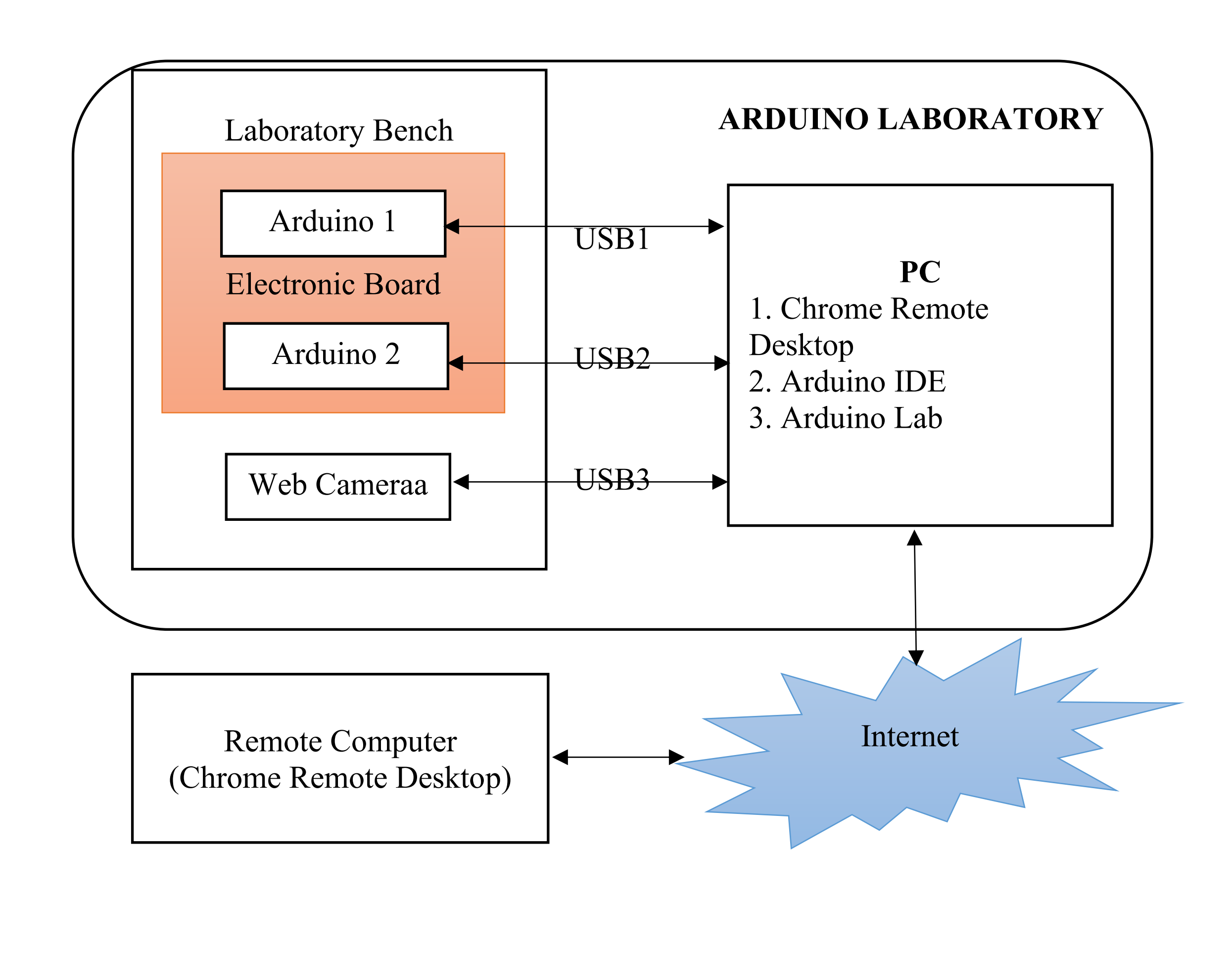

Figure 1. Functional Block Diagram of the Remote Laboratory Workshop

Thus, the laboratory bench designed for the remote study of microcontrollers enables learners to acquire microcontroller programming technologies remotely and to analyze the operation of control devices and indicators. This form of organizing students' independent work enhances the effectiveness of the educational process and significantly reduces the time required to master the fundamentals of microcontroller programming.

When studying digital technologies, students demonstrate a high level of interest in working with digitally controlled machines. Such machines can be used particularly effectively in project-based learning activities. Technologies of remote interactive laboratory work also enable the remote control of machines equipped with digital control systems.

The remote laboratory setup consists of a milling machine, a server to which the machine is connected (a specialized computer), software installed on the server for machine control, and a web camera connected to the server for monitoring machine operation (Figure 2). To operate the machine remotely, it is sufficient for a student to have a personal computer with Internet access. In addition, remote computer control software must be installed on both the laboratory server and the student's personal computer.

As the equipment for the remote laboratory, a milling machine developed by a student during the course project was used. A rotary engraving tool serves as the primary drive of the cutting instrument. The machine control system enables software-based switching of the machine on and off, as well as movement of the cutting tool along three axes.

Figure 2. Schematic View of the Remote Laboratory Installation

The Kcam software is used to control the machine. A distinctive feature of this software is its flexibility, as it can be configured for virtually any control unit connected to a computer via the LPT interface. Using this software, the machine can be operated in various modes, including:

- manual control via the keyboard or on-screen buttons;
- manual entry of G-code commands in the program's control window;
- execution of command files in formats compatible with the commands supported by the software;
- utilization of files generated by computer-aided design (CAD) systems.

This wide range of options enables the execution of functions typically associated with more expensive software packages. The standard applications of Kcam include 2D and 3D milling, engraving, contour milling, drilling, and plasma cutting.

To monitor machine operation, a web camera is connected to the computer. When a fully computer-controlled machine is equipped with a camera that transmits its operation, it becomes possible to organize remote laboratory activities. In this case, only remote access to the control computer is required.

Several technologies can be employed to remotely control the equipment. The first method is the use of a "remote desktop." With this technology, everything displayed on the remote computer screen is replicated on the student's personal computer monitor, allowing the student to control the laboratory computer in real time. Through this approach, keyboard and mouse commands are transmitted from the student's computer via the network, while the visual output is streamed from the remote computer. At sufficiently high connection speeds, it becomes almost imperceptible whether the user is operating a local or a remote computer.

The second method involves file exchange between multiple computers. In this case, when connecting to the remote computer, the user gains access to a list of files and folders that can be edited and copied. Remote control of the laboratory computer is then carried out through file-based operations.

The third method entails controlling peripheral devices of the remote laboratory that have the status of network devices. Typically, such devices include printers, scanners, and web cameras, although other devices and configurations may also be involved. Access to these devices is usually provided via a web-based interface.

In the present study, the first method—remote control of the computer—was identified as the most suitable for organizing remote laboratory activities. To implement this approach, appropriate software must be installed on both the laboratory server and the student's personal computer. A wide variety of software products are available for remote control purposes, some of which are presented in Table 1.

Table 1.
Software Tools for Remote Computer Management

Product Name	Developer	Distribution Size	Distribution Model
Radmin (Remote Administrator)	**Famatech**, www.radmin.ru	9.1 MB	Shareware (free version available)
UltraVNC	**UltraVNC Team**, www.uvnc.com	2.0 MB	Freeware
TeamViewer	**TeamViewer GmbH**, www.teamviewer.com	4.7 MB	Shareware (free version available)
Remote Manipulator System	**TektonIT**, www.rmansys.ru	11.5 MB	Shareware (free version available)
Anyplace Control	**Anyplace Control Software**, www.anyplacecontrol.com/ru/	4.8 MB	Shareware (free version available)
Ammyy Admin	**Ammyy**, www.ammyy.com	0.7 MB	Shareware (free version available)

Several software products were tested, each of which exhibited both advantages and limitations. For the purposes of this study, the most convenient and user-friendly solution was **Ammyy Admin**. This lightweight and compact application enables secure and fast remote access to a personal computer via the Internet. It allows real-time control of a remote server, file and folder exchange, and voice communication through an integrated chat function. Notably, Ammyy Admin does not require installation; it is sufficient to copy the application to the personal computers and launch it.

To establish a connection, a special identification code transmitted via email must be entered on the student's computer, while access authorization for controlling the laboratory setup must be confirmed on the laboratory computer. Access permissions can be configured individually for each student, enabling the personalization of connections and assigned tasks.

Prior to students performing remote laboratory activities, a preparatory phase is conducted in the laboratory, which includes configuring and connecting the equipment. The responsibilities of the laboratory technician include the following:

- visual inspection of the electronic and mechanical components of the machine to identify potential defects and prevent malfunctions;
- selection and secure installation of the cutting tool and workpiece;
- powering on the control computer and the machine;

- launching the Ammyy Admin software package on the control computer to obtain the identification number and password required for remote access;
- transmitting the access credentials to the student via email or Skype authorization parameters.

Before initiating the laboratory work, the student must contact the instructor or laboratory technician in advance to receive methodological guidance on connection and task execution. To work with the laboratory, the student must have:

- a personal computer with Internet access (minimum bandwidth of 512 kb/s);
- remote access software installed on the computer to connect to the server desktop (Ammyy Admin);
- upon receiving access credentials, the ability to connect and launch video streaming and machine control software;
- a pre-prepared control program uploaded to the Kcam software module;
- the capability to remotely power on the machine and initiate execution of the control program.

Once a connection to the laboratory server is established, the display of the student's personal computer appears as shown in Figure 3.

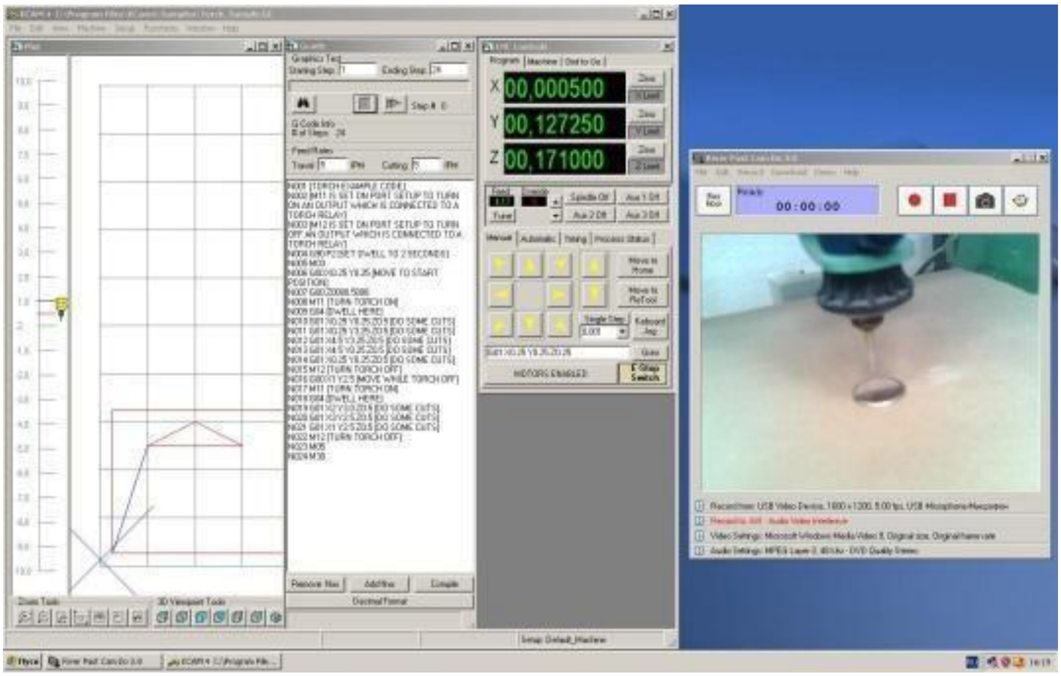

Figure 3. Screenshot of the Student's Computer Interface

Naturally, the student must possess confident skills in operating a personal computer, navigating the Internet, be familiar with the specialized **Ammyy Admin** application, and be able to use the **Kcam** control program.

Conclusion

The use of such virtual technologies and distance learning tools in the educational process provides qualitatively new opportunities for students' independent learning. This approach enables not only the demonstration of advanced interactive technologies but also the real-world remote control of modern technological equipment, thereby significantly enhancing the effectiveness and practical orientation of the learning process.

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