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Organising the Process of Physics Students' Cognitive Activity

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Abstract The mass application and development of information and communication technologies in all spheres of life inevitably puts forward the need for informatization of the educational process through the widespread introduction into the system of education of methods and means of information and communication technologies, creation on this basis of computer-oriented information and communication environment with appropriate electronic content and electronic filling opportunities for the use of scientific, educational and management resources in solving various problems. An important part of the work of every modern specialized enterprise, scientific laboratory or university scientific complex is the use of automated data collection and processing systems and automated control of experimental research. The purpose of the work is to develop a method for connecting real measurement and computing complexes to the Internet and provide access to information about the measurement results and the actual management of the experiment. Changes in research methods associated with the transition to the process of experimental data processing and virtual labs are forcing modern software and measurement systems to be managed in a single, continuous cycle to manage the experiment and process its results. The description of the created hardware and software complex of data acquisition and processing using a thermocouple, microcontroller, a digital camera connected to a personal computer, and based on the LabVIEW environment implements remote access mode. This complex is characterized by flexibility and mobility and is capable of filling laboratories under conditions of insufficient funding, which is relevant for the current financial state of Ukrainian science and the educational process.

Keywords Research Work, Supervising Scientific Projects, Information Technologies, Laboratory Experiment, LabVIEW

1. Introduction

One of the equal components of the vocational training system along with its other constituents – goals, content, forms, methods, activities of the teacher and students is a means of training. Applying teaching aids greatly optimizes the teaching and learning process and is one of the factors contributing to saving time, transferring a large amount of information in a relatively short time, effectively organizing students' scientific activities.

By means of the pedagogical activity, according to I. Zymnaya (2003) scientific (theoretical and empirical) knowledge is meant, with the help and on the basis of which the thesaurus of the intending specialist is formed. Means of teaching in the studies of numerous scholars are considered to be the source of obtaining knowledge, developing skills.

Issues effective development of practices of the introduction of modern technologies of training in the educational process with the subsequent application of the formed skills and consequences of such practice was investigated in works L. Darling-Hammond's at al. (2020).

Applying the systematic approach requires solving didactic problems by managing the learning process with the precisely defined purpose achieving which must be clearly described and defined that is why the definition and classification of teaching aids according to many authors are based on considering learning as a process of managing students' cognitive activity. Such an approach is based on the theory of systematic forming mental actions and defining the management of the learning process as the system of realizing educational purposes. From the point of view of the educational management theory, the learning process is perceived as one of the types of management processes, namely managing the process of obtaining knowledge.

In the system of scientific training a university teacher performs the following functions: develops the program of students' activity and the program of managing their activities, directs the process of research activities, controls it, and makes corrections. While organizing research activities the purposeful managing students' cognitive activity is carried out with the help of available aids and didactic possibilities of intending specialists.

The process of managing cognitive activity requires the presence of feedback between teacher and students to properly correct organizing the research process. Learning aids can have a controlling influence on the learning process, create a problem situation, and involve students in the active cognitive search (Lutsenko, G.V., 2018).

Using S. Smirnov's (1999) classification as the basis we will present two variants of educational aids in Physics researchers' professional training:

- specialized software, artificial environment for acquiring the professional competencies;
- sutomated workplaces for scientific and educational activities; scientific literature; didactic materials; technical training aids; equipment for laboratory and demonstration experiment.

In the educational process, educational aids perform the following functions: compensatory, adaptive, informational, integrative and instrumental. Experts in the field of creating educational information environments suggest that one of the teacher's tasks is selecting, structuring the training content, searching the appropriate visual images for adequate transferring the educational content.

After all, mass applying and developing information and communication technologies in all the spheres of life inevitably necessitates the informatization of the educational process through wide introducing methods and means of information and communication technologies into the education system, creating on this basis computer-oriented information and communication environment with the corresponding electronic content and opportunities of using scientific, educational and managerial resources in solving various tasks.

Applying automated systems for collecting and processing data and automated control systems for experimental research is an important part of the work of every modern specialized enterprise, a scientific laboratory, or a university scientific complex. All the modern research centers regularly implement and periodically update automated systems for control and optimization of managing the experiment. To successfully use such automation systems it is necessary to begin their practical applying while studying at the university still.

On the other hand, the experiment in Physics plays an extremely important role (Lucenko G., 1998). Since ancient times people watched some kind of natural phenomenon and tried to repeat it in "artificial" conditions. On the basis of the obtained data, a certain theory was created that could describe this phenomenon both physically and mathematically. Absolutely new theories should have experimental confirmation, without it they are worthless. Even Albert Einstein once published a scholarly paper on the great role played by experiments and experimenters in Physics. Conducting physical experiments at school or university allows a better understanding of the phenomenon, touching it with one's own hands. But it is not always possible to conduct an experiment: for example, there are no specific devices or there is no opportunity to be present in the laboratory.

These issues became especially relevant during the COVID-19 pandemic, which forced most countries to switch the education system to distance learning. Although we agree with the views of scientists on the problem of providing full-fledged skills to work with experimental installations and further objective assessment of students' practical competencies in such conditions (Russell M Viner, et al. 2020).

2. Activity and Contextual Approaches

Studies conducted since the turn of the century have used different types of virtual labs, using different methods and techniques. Researchers offer an extremely wide range of virtual physics laboratory programs, offer very different designs, areas and means of application (Özden Karagöz Mirçik, 2018; Yevgeniya Daineko, at al., 2017)

The work in such a workshop is carried out in the same way as the usual laboratory practice, replacing the real experiment with a computer one (virtual or in the mode of remote access using the graphical programming environment LabVIEW (Peich, L.Y., Tochylyn, D.A., Pollak, B.P., 2004; Ronald W. Larsen, 2011). The LabVIEW concept differs significantly from the consistent nature of the traditional programming languages, giving the developer easy in using graphic shell containing the entire set of tools necessary for collecting analyzing and presenting data.

A user who wants to do laboratory work enters a specific address via a web browser. In the window of his/her web browser, he/she will see a page where the virtual devices created in LabVIEW are located.

The process of creating software for such a virtual course is performed in advance. In particular, all virtual devices are described below and the software shell for working with them was created by students in classes on computer simulation of physical processes in LabVIEW (Lucenko G. V., Popovichenko A.A., 2012).

In order to have access to ADC one needs to authorize. This is done first of all for the user not to have full control over the laboratory work (full access exists only for the operator), and secondly, because the number of requests to the ADC should be minimal so that its work would be stable. On authorizing the user can use ADC, which is to get real numbers measured by ADC (for example, temperature values) and use them in further calculations in his/her own laboratory work. Thus, we do not need to enter a table of results obtained by another performer in the course of experiments for counting some quantities, but already enter the true data that we would get when conducting an experiment in life.

The connection between the user and the main server can be implemented in two ways (LabVIEW lessons, 2003; LabVIEW, 2017):

1. **The user's computer does not need any additional LabVIEW software**. In this approach, the Web server as well as the program implementing the interface of the laboratory work is running on the main server. By means of LabVIEW, you can create an HTML-page with the interface of the laboratory work based on the Active-X module. In order to see the interface of the laboratory work, the user needs a web browser with the installed Active-X module. All the requests coming from the user are processed by the Web server
2. **Applying the Data Socket Transport Protocol (DTSP) special protocol**. The main difference from the first method is that LabVIEW software must be installed on the user's computer. This method is easier to implement and allows creating a functionally "heavier" that is a more filled user interface.

We will consider the first method is more detail since it facilitates communication with the remote laboratory work as only a web browser is required to complete the work.

Before starting the Web server you need to set it up.

To realize it is necessary to enter the menu Tools=>Options=>Web-Server (Fig. 1). We can also see that there is another server, VI-server. VI-server is not connected to the Web-server and controls the operation of the virtual device. In the settings of, we see different settings for the Web server. For example, we can configure the root folder which will contain VI files, select visible VI files, enable recording server logs, change HTTP port (default port is 80), etc. In the configuration of the VI-server, we can enable the Active-X module, configure our TCP/IP protocol, and enter the IP addresses for which we access VI-server. Setting up a web server is the first step in our work. Further, we need to place the page with the interface of our laboratory work on the Internet. To do this we will use the standard tools for publishing VI-files on the Internet. We open the Tools menu, then find the Web Publishing Tool and launch it (Fig. 2).

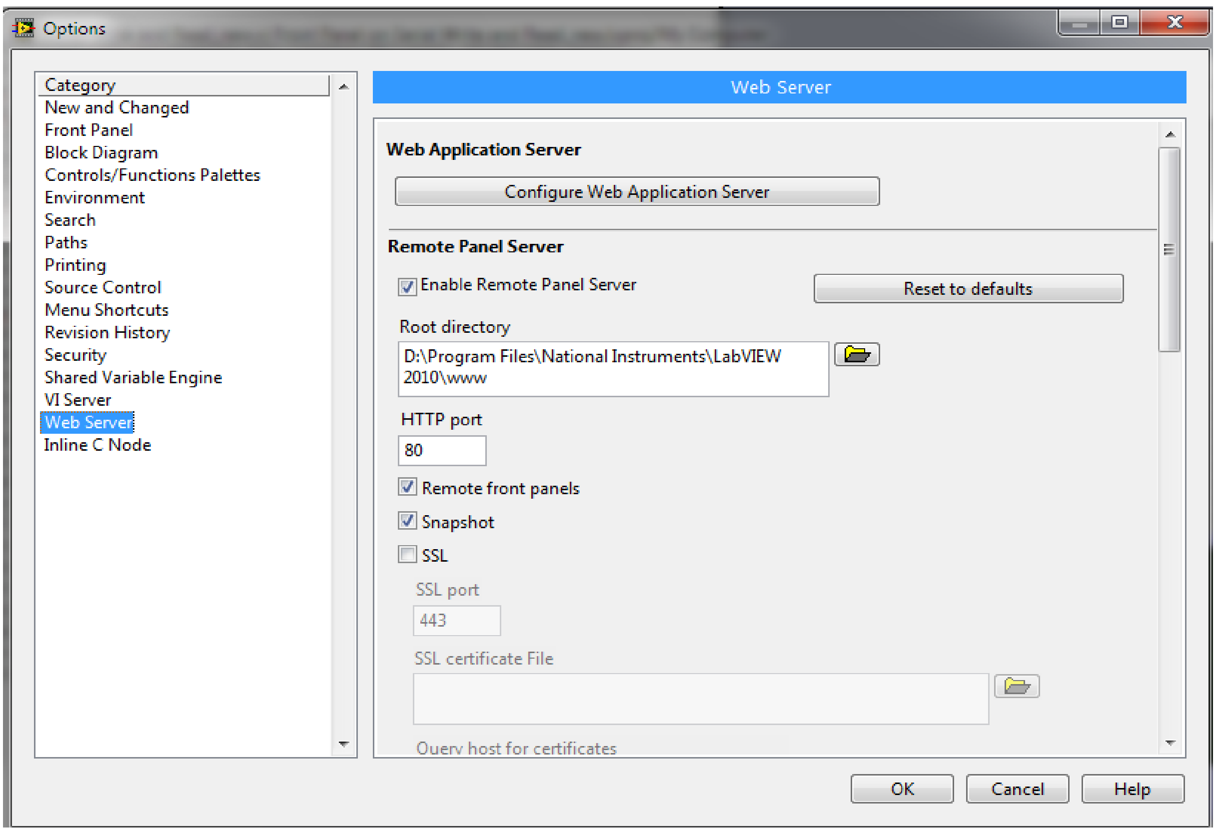

Figure 1. Setting Web-server

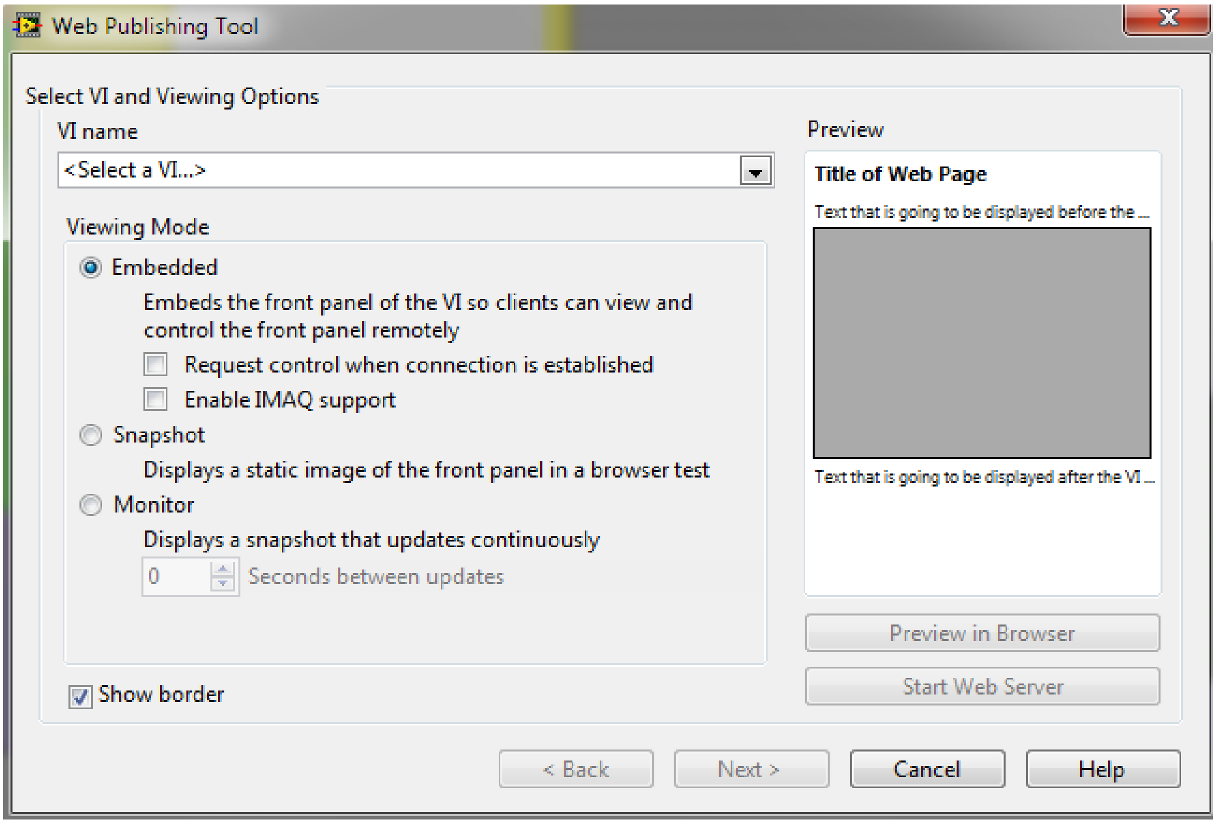

Figure 2. Initial setting up Web Publishing Tool

In the open dialogue window, we are offered to choose the VI-file that we want to place into the Internet and the modes of displaying its interface. Let's dwell in more detail on these modes:

1. **Embedded Viewing Mode** By choosing this interface display mode, the user can fully interact with the interface of the lab work, for example, to set the regulators in certain positions by setting the set parameters. This mode is the best one since it provides virtually unlimited access to the software managing functions that provide the work of the laboratory stand (full access to the settings of the laboratory stand exists only for the operator of the web server).
2. **Snapshot Viewing Mode** In this mode the user will only see a static image of the interface in his/her web browser. This image will not be updated.
3. **Monitor Viewing Mode** This display mode of the interface differs from the previous only by updating the static image with a certain periodicity that can be specified. This is convenient if we want to display a schedule that changes over time.

Clicking the button next we go to the next page of the menu (Fig. 3). In this menu, we can configure the final characteristics of the HTML page. That is, change the caption on the page, change the header and footer. On completing these steps go to the next page (Fig. 4).

In this menu, we can select the directory where we want to save the HTML file, its title and we will get an URL-link (URL allows determining where the document is in the network, it specifies its address on the Internet and the route). URL can always be seen when you enter an address in a Web browser on our newly created page.

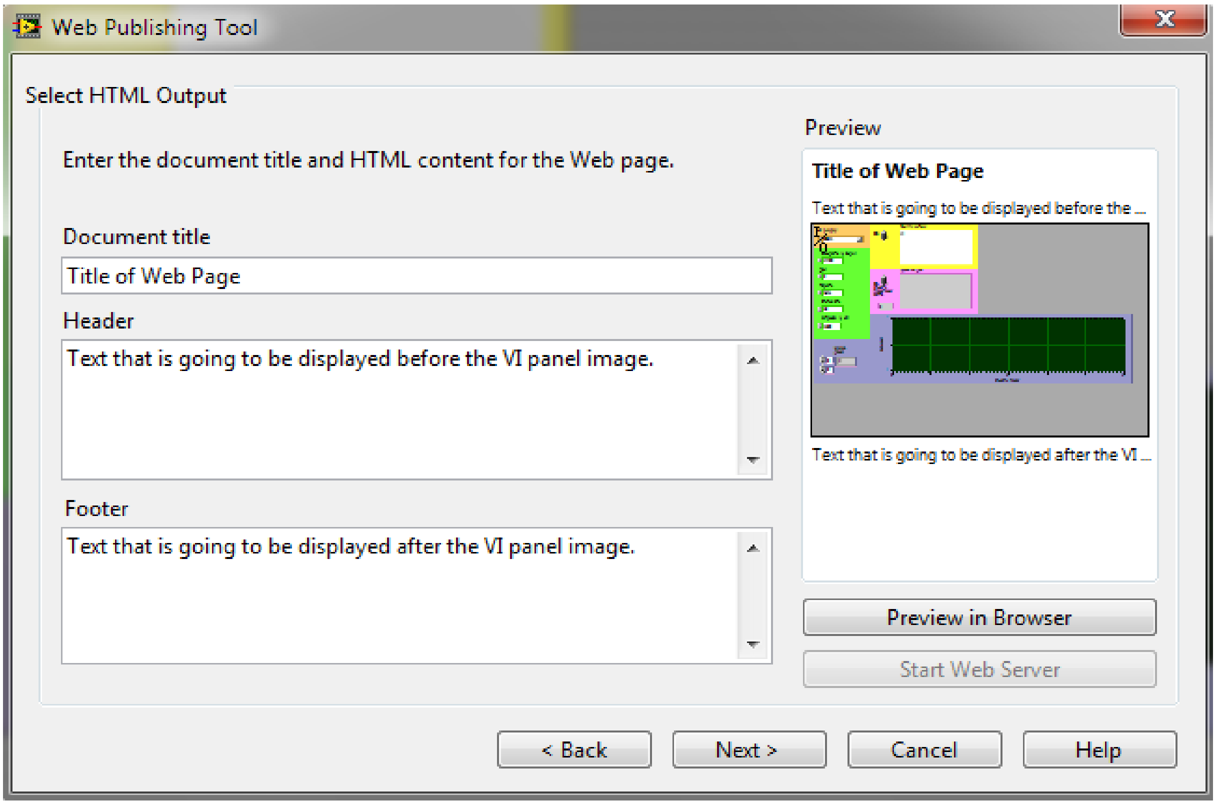

Figure 3. Setting up HTML-content menu of Web Publishing Tool

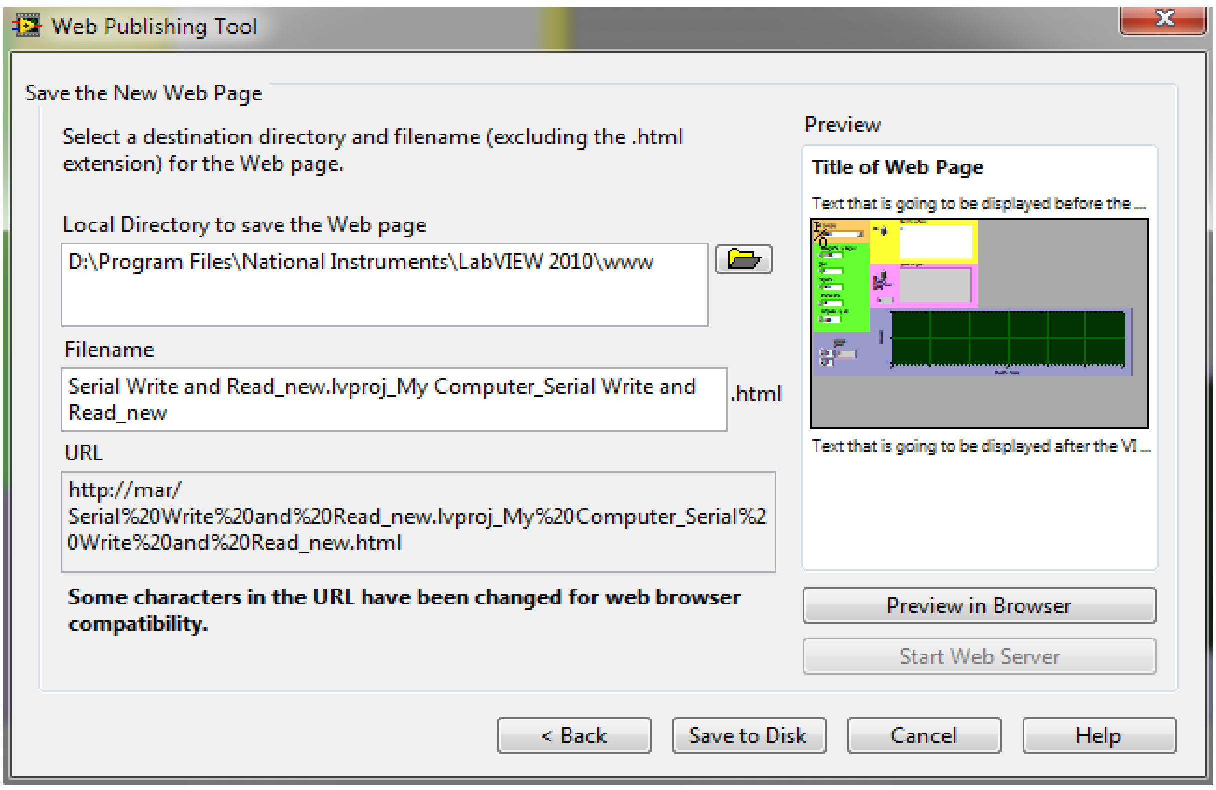

Figure 4. Final setting up the menu of Web Publishing Tool

The remaining action is launching the web server. To do this we should go to the Tools menu, where we see two submenus - Start G web-server and G web-server configuration. By clicking on the first submenu we will immediately launch the web server. In the web server settings we can choose the mode of operation of the web server:

1. The Web server may work separately from LabVIEW. In this mode, the web server works as a separate server through its port which should be different from the HTTP port asked in the previous web server settings.
2. The web server can work as a common server with LabVIEW. All the users' requests are processed by the CGI program. In this case, the web server will be launched using the HTTP port we chose in the web server setup.

After we launch the web server a dialogue box appears in which we can see the IP-address of the computer on which the server is running (Fig. 5).

Our program is working; the web server is also working. Let's look at the interface of the program on another computer over the Internet through a web browser. The web browser must be Microsoft Internet Explorer since the other web browsers do not support the ActiveX module based on the display of the front panel of the program. In the Internet address entry field, you must enter the IP address of the computer running the web server and the full name of the created and published HTML-page. On entering the address it is necessary to wait a bit because in case the ActiveX component is not installed a dialogue window will appear prompting you to download and install the item. Once installed, we will be able to see our front panel (Fig. 5).

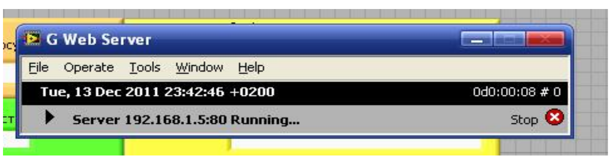

Figure 5. Launched web-server

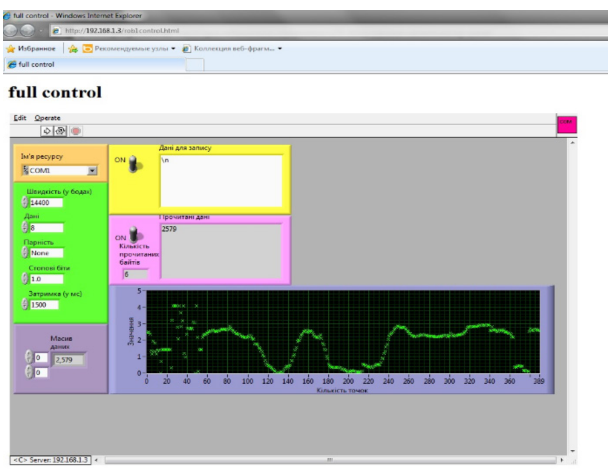

Figure 6. The front panel of the program in Internet Explorer

A fully assembled laboratory stand has the following form (Fig. 7).

Figure 7. Laboratory stand

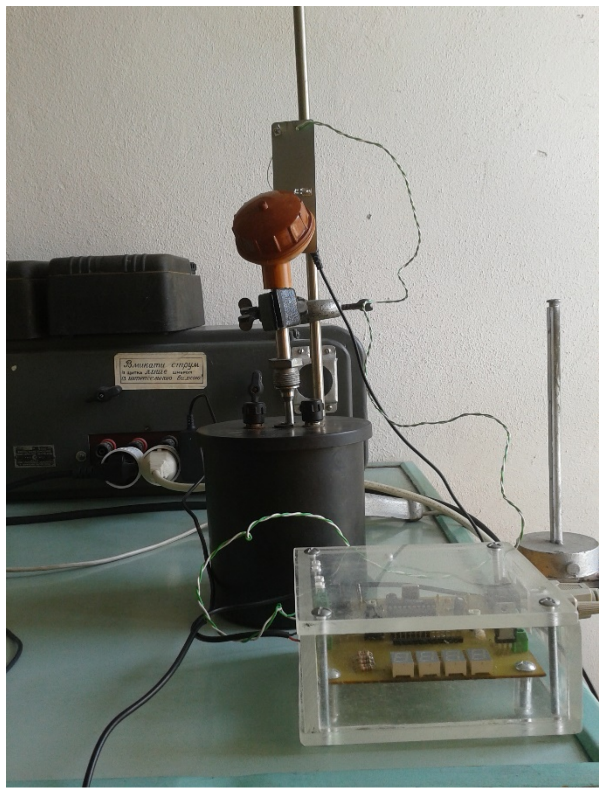

Figure 8. Thermocouple (Type L) and a microcontroller with ADC

On the laboratory table, there are the following devices: a computer with a periphery, thermocouple (Type L) fixed on a tripod and connected to a calorimeter (Fig. 7), a microcontroller with ADC (Fig. 8). After running LabVIEW on the workstation (Fig. 7) we can immediately log into the browser at the address on which our web server is fixed since the web server runs automatically with the launch of LabVIEW. The web browser must support ActiveX technology because the front panel uses this technology. In the status bar of the web browser, you need to type the web server address and the page name of the front panel produced in Web Publishing Tools. After that, the front panel of the virtual laboratory work will open. All the buttons on the panel will not be available for pressing. That is, the server controls the front panel and all the settings. If the work is started then in this experiment we will see a graph of the temperature dependence on the time which will gradually change in real-time (Fig. 9). In order to gain control over the front panel, you need to click on Request Control for User from the bottom of the front panel, which is to request control of the front panel. After that, all the buttons on the front panel will become active and the user will be able to control the front panel (Fig. 10).

Figure 9. Front panel in web-browser under server control

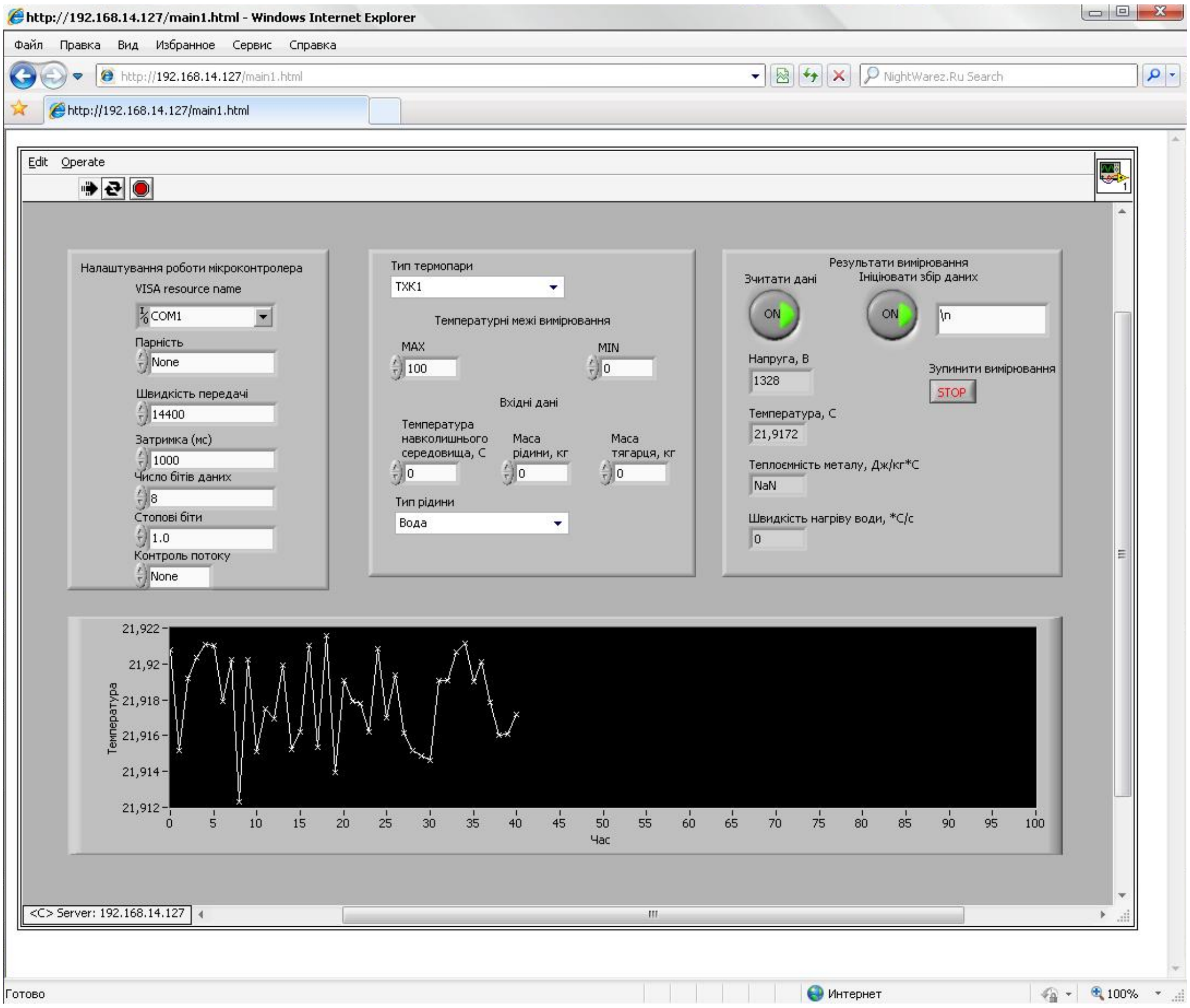

Figure 10. Front panel in web-browser under user's control

It should be stressed that the presented options for the front panels (and, accordingly, the program codes) are the simplest ones. If necessary, this software is easily modified by supplementing it with blocks of signal filtering, statistical processing, etc.

The analysis of the effectiveness of the use of the created complex of virtual laboratory works was carried out in a group of bachelor students majoring in "Physics". 23 students of 2-3 courses were involved. Part of the laboratory work was performed by the experimental group using a virtual laboratory during the semester. After conducting a survey in the control (CG) and experimental groups (EG), the following results were obtained.

The level of teamwork remained low at 36.4% of respondents in the experimental group, which is the worst indicator relative to the control. In turn, the level of creativity of the experimental group was much higher than in the control - 45.5% and 25%, respectively. According to the level of acquired applied competencies, the group that studied according to the traditional system showed a stable advantage (Fig. 11).

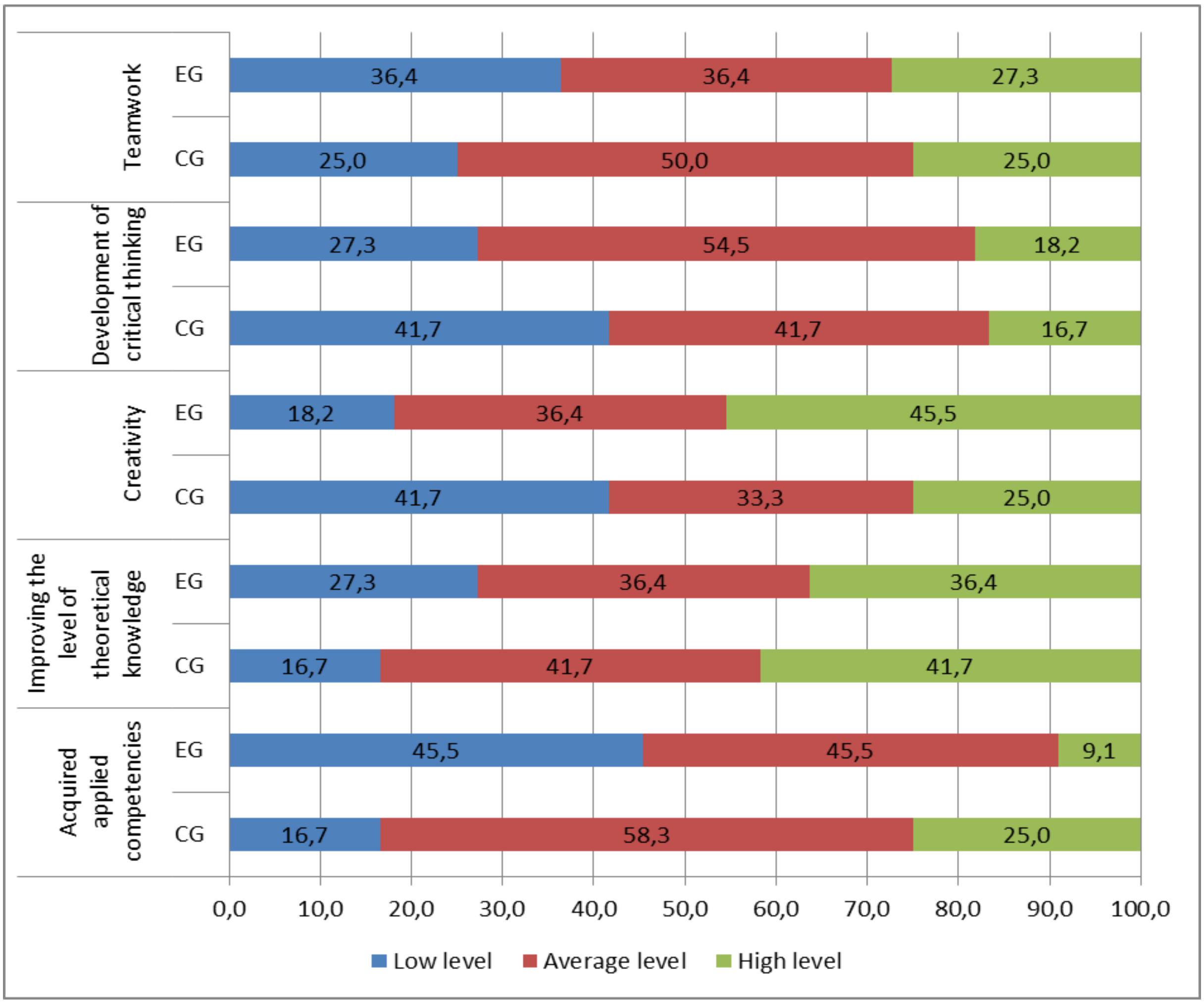

Figure 11. Evaluation of the effectiveness of the introduction of virtual laboratory workshops in the educational process

3. Conclusions

Taking into account the above mentioned educational aids we can conclude that the changes in research methods associated with transiting the process of machine processing of experimental data and the work on creating virtual laboratories make educators use modern software and create measurement devices allowing a single continuous cycle of managing the experiment and processing its results. The created hardware and software complex for collecting and processing data using a thermocouple, a microcontroller, a digital camera connected to a personal computer, and on the basis of the environment LabVIEW, implements the remote access mode. Such complex is characterized by flexibility and mobility and is able to provide complete laboratories in the conditions of insufficient financing, which is relevant to the current financial state of the Ukrainian science and the educational process. However, we emphasize that it is not able to completely replace the work with a real experimental setup.

The systematic approach to forming intending scientific researchers' competence aims at integrating theoretical and practical training of researchers in Physics. To do this it is necessary to fill training with as many as possible tasks of heuristic and research types.

Thus, developing the system of professional training of the intending researcher in Physics set the task of developing the model of managing the educational process in the context of the research activities of the intending specialist. Educational aids and creative tasks in such a model have a managerial influence on the cognition process, produce educational situations of creative and reproductive type, and involve students in the active cognitive search.

Conflict of Interests

Authors declare no conflict of interest.

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