ABSTRACTS OF THE WORKS
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of Assoc. Prof. Dr. Eng. Nadezhda Miteva Kafadarova,
Head of the Department of EKIT, Plovdiv University "Paisii Hilendarski"

1h. A REVIEW OF STATE OF HEALTH BATTERY DIAGNOSTICS METHODS: CURRENT STATUS AND FUTURE CHALLENGES

Nadezhda M. Kafadarova, Silvia V. Stoyanova-Petrova, Sotir I. Sotirov, Diana V. Stoyanova and Nikolay V. Vakrilov

Lithium-ion batteries are widely used energy sources in modern systems such as renewable and sustainable energy storage devices. Problems with their safe operation caused by an inaccurate assessment of their health status (SOH) can lead to significant losses in terms of facilities, the environment and people.

This study was conducted within the framework of research project No. KP-06-H57/2 15.11.2021 "Hybrid and fusion forecasting of the functionality of energy conversion elements". The project has been developed in line with European priorities, the European Green Deal and the European Union's commitment to make Europe the first climate-neutral continent by 2050. In recent years, considerable interest has been focused on the development, management and monitoring of new sources of energy conversion as an important step towards improving people's quality of life. The most commonly used elements for energy conversion are batteries and battery systems.

In this article, a comparative analysis of the capabilities of modern methods for predictive management of battery performance and SOH is made. These methods are classified into three categories: model-based methods (electrochemical model and equivalent circuit modeling), data-driven methods, and fusion methods. A summary of the advantages and disadvantages of assessment and forecasting methods is presented.

Although model-based methods can accurately reflect the causes of battery degradation and aging, most models are complex, with many parameters and low predictive ability. Data-driven methods are based on a large amount of data. Although they have high accuracy, they require a large amount of data and perform a large number of calculations.

Prospects are outlined for future fast and accurate monitoring of SOH by applying innovative methods for non-contact determination of the internal resistance of batteries, for example indirectly through temperature-free non-destructive measurement of the battery surface.

2h. A REVIEW OF SUPERCAPACITORS STATE OF HEALTH ESTIMATION METHODS

Nikolay Vakrilov and Nadezhda M. Kafadarova

Supercapacitors are massively entering as an important supporting energy storage technology in various application areas such as electric vehicles, power distribution network,

renewable energy sources and household needs. The reliable operation of these systems requires accurate health prediction (SOH) of supercapacitors. This requires the development and application of various methods for evaluating the life of the supercapacitor during the design and optimization of the system. This article summarizes the main methods for evaluating the SOH of supercapacitors, as well as outlines some future research directions.

The presented research is carried out within the framework of research project No. KP-06-N57/2 15.11.2021 "Hybrid and fusion forecasting of the functionality of energy conversion elements". The idea of launching the project stems from European priorities, the European Green Deal and the European Union's commitment to become the first climate-neutral continent by 2050.

One of the most promising devices for building hybrid energy storage systems is supercapacitors. Their high energy density and their ability to accumulate and release energy very quickly make them particularly suitable for compensating for high energy loads.

This article provides an overview of SOH estimation methods. These methods can be classified into three categories: direct, model-based, and data-based. The current trends in determining the SOH of supercapacitors are outlined. Despite numerous studies and reliable results in the determination of SOH, there are still unresolved problems and challenges for the scientific community, which outline serious prospects for future research.

3h. STATE OF HEALTH DETERMINATION OF BATTERIES BY ANALYZING THE RATE OF INCREASE OF THEIR TEMPERATURE
Nadezhda Kafadarova, Sotir Sotirov, Anna Stoynova, Silvia Stoyanova-Petrova, Diana Stoyanova, Iliya Petrov

Lithium-ion batteries have been the main technology on which the global green energy initiative has been based in recent years.As an energy source, they have a high energy density and a long lifespan.They are relatively safe to use, and the production costs are relatively low.They are currently used in various types of electric vehicles, aerospace applications, and a large part of consumer wearable electronics. Predicting residual battery life and managing their proper operation depend on health monitoring (SOH). SOH is the main indicator of the safety and reliable operation of batteries. In most cases, this parameter is determined by measuring the impedance of the battery, which is associated with some limitations.

In this article, we present a model for determining the SOH of a battery that uses the rate of increase in battery temperature during the discharge cycle. The proposed model is based on an in-depth analysis of the physical laws describing the processes of increasing the temperature of the battery during its operation. Attention is paid to the relationship between these processes and battery degradation. For the purposes of the study, a set of NASA batteries was used. Based on these data, the relationship between the rate of increase in the temperature of the battery during its discharge and the number of discharge cycles, which is associated with changes in its capacity and degradation, is deduced. To determine the rate of increase in battery temperature over time, the first derivatives of the temperature function are calculated at the same discharge current, but after a different number of cycles. To illustrate the process in detail, these dependencies are represented graphically. Since the rate of increase in battery temperature depends on the size of the discharge current and the ambient temperature, the dependencies for two operating modes have been deduced: discharge current of magnitude 2A and 4A at an ambient temperature of 24 degrees Celsius. The proposed model for determining the SOH of the battery is an accurate tool through which improvements in operating safety, quality and reliability of the battery can be achieved.

The resulting dependencies will be used in future research. It is planned to conduct studies of the surface temperature of batteries through an infrared chamber. Based on the results

obtained, a neural network will be developed to determine SOH. Measurements will be made during the discharge cycles, and the resulting images will be used to analyze the homogeneity of the temperature distribution on the battery surface. The experimental results will be used as part of the neural network training input to predict the degree of efficiency of the batteries studied.

4h. BATTERY THERMAL IMAGE SEQUENCE PROCESSING
Sotir Sotirov, Nadezhda Kafadarova, Anna Stoynova, Silvia Stoyanova-Petrova, Diana Stoyanova, Nevena Mileva, Stefan Rizanov

The operating temperature of a lithium-ion battery is one of the key factors that significantly affect its performance. Heat is generated in the battery during the charging and discharging processes. the occurrence of permanent thermal damage. As a result of the significant change in temperature, surface mechanical deformation is possible, as well as changes in the chemical composition of the battery. In the worst case, this can lead to mechanical damage to the integrity of the case, explosion or electrolyte leakage. The article presents specialized software developed for the analysis of thermographic images of batteries, through which it is possible to extract and visualize the necessary information about the resulting temperature changes on the entire surface of the battery or certain parts of it. Python version 3.9 was used for the development of the software. to be successfully implemented in systems aimed at monitoring and controlling the temperature of batteries and assessing their health status and residual useful life (RUL).

The results obtained give a detailed idea of the amount of heat emitted by the battery case over time, representing well the exothermic nature of the processes taking place during discharge. The study conducted shows that the heat dissipation of the battery is highest in the first 1000 seconds. Between 2000 and 3000 seconds, the rate of temperature change begins to decrease. At the end of the discharge cycle, a new increase in temperature can be observed as the amount of heat, after 3000 seconds, increases faster due to a significant increase in the internal resistance of the battery when it is near the end of its capacity. The pronounced exothermic nature of the processes taking place at the end of the dilution cycle can cause a serious increase in temperature.

Future work will focus on integrating the developed software into embedded SoH prediction systems. These systems have the prospect of being widely applicable as stand-alone monitoring tools for the ever-expanding use of batteries as power sources in portable electronic devices, as well as for hybrid and pure electric vehicles.

5h. A SYSTEM FOR DETERMINING THE SURFACE TEMPERATURE OF CYLIN-DRICAL LITHIUM-ION BATTERIES USING A THERMAL IMAGING CAMERA
Nadezhda Kafadarova, Sotir Sotirov, Franz Herbst, Anna Stoynova and Stefan Rizanov

The topic of monitoring the condition of the battery by electrical and non-electrical test methods has aroused increased interest due to the imposed goal of extended industrial resistance. Within the framework of this study, we propose a new method for monitoring the temperature of batteries using infrared thermography. In order to improve the accuracy of the measurements carried out and overcome the limitations, imposed by the cylindrical battery housing, a new method has been developed to monitor and determine the temperature of the entire battery housing. An experimental system has been created through which the battery performs a rotational movement relative to its axis, and this rotational movement is

synchronized with the frame rate of the thermal imaging camera. The resulting thermographic images are processed using specially developed software. This software allows the segmentation of certain areas of the battery surface into a specific spatial perspective. The selected segments are subsequently used to generate a three-dimensional representation of the surface temperature distribution of the battery. In this way, errors in the results obtained caused by the viewing angle are avoided. In addition, a method for increasing the resolution of captured thermograms has been developed and presented.

The system presented in this article can be used to automate quantitative and qualitative thermographic studies of the thermal behavior of batteries during development, diagnostics, quality control in the manufacturing process and testing.

Future research guidelines may focus on testing batteries under a variety of environmental conditions, such as temperature, pressure, and vacuum.

6h. UTILIZATION OF INFRARED THERMOGRAPHY FOR BATTERY PERFORMANCE INSPECTION
Anna Stoynova, Borislav Bonev, Stefan Rizanov, Nadezhda Kafadarova, Sotir Sotirov

The article analyzes the approach and main considerations in using infrared thermography to remotely identify basic internal characteristics of batteries. The experimental results of the study, which affects two different types of batteries - lead-acid and lithium-ion (designated as "good" and "bad", according to certain criteria), make it possible to implement automated remote diagnostics in real operating conditions, allowing to assess the battery performance and preventively determine the type of potential defect that has occurred.

Thermal imaging from infrared thermographic monitoring can provide valuable information about the electrochemical behavior of the battery. It should be noted that quantitative examination of hot, and in some cases, colder atypical zones can become a powerful tool for refining the location of an existing defect. The amplitude of the thermal footprint on a given surface of the battery, as well as its diffusion distribution, can indicate the likely location of a defect. In the conducted study, it is proposed to use the correlation relationships between the electrochemical processes of the battery and infrared thermography as a basis for predicting malfunctions. This methodology not only offers easy and early fault detection, but also provides information on areas of interest (allowing rational selection of these areas so as to facilitate rapid diagnosis, evaluation and subsequent analysis of faults). Experimental validation of the relationship between thermal imaging imaging and battery internal reactions was successfully performed by a combination of passive infrared thermography and further characterization of defective batteries. The research is key to the implementation of automated remote diagnostics in real operating conditions, which relate to the evaluation of battery performance and the determination of the potential failure mode.

7h. DEEP NEURAL NETWORK ESTIMATION OF BATTERY CELL AGE
Nadezhda Kafadarova, Sotir Sotirov, Anna Stoynova, Stefan Rizanov, Borislav Bonev

The SOH assessment of batteries is a topic in many modern scientific papers due to the industrial push towards more resilient electronic systems. In order for the processing of SOH assessment to be carried out in an automated way - algorithmic methods of artificial intelligence and machine learning have become the dominant models used for regression and classification tasks. This research has developed and presented a classifier of battery age through a deep neural network, analyzing a set of parameters that represent the approximation

coefficients of the curve describing the processes occurring during the charging and discharging of lithium-ion cells.

Within the framework of the study, a method for estimating the SOH of the battery using a neural network was developed. A set of data was presented for 18650 aged battery cells subjected to 100 accelerated aging cycles. used to train a developed neural network classifier. The correlation of these parameters with the predictor of class affiliation and their statistical properties is presented. We developed and introduced the MLP DNN classifier to estimate the age of a given lithium-ion battery.

8h. METHOD FOR NON-RADIOMETRIC THERMAL VIDEO INTO RADIOMETRIC THERMAL IMAGES CONVERSION
Sotir Sotirov, Nadezhda Kafadarova, Anna Stoynova, Stefan Rizanov, Silvia Stoyanova-Petrova and Diana Stoyanova, Franz Herbst

This article presents an author's method for overcoming significant limitations in the processing of thermographic images and videos, which are related to the limitations of some budget infrared cameras and software to record and process a non-radiometric format. With the help of the presented method, the possibilities for the use of videos and images are expandedcaptured by affordable, user-oriented infrared cameras, making them functionally applicable in research.

For this purpose, software with the Python programming language has been developed.

The algorithm on which the method is based includes the following steps:

1. To determine the accuracy and prove the effectiveness of the developed method, after entering the correction coefficients of the camera, a radiometric photograph is taken, which is used as a reference. This is done initially for the respective camera by selecting the appropriate zoom mode.

2. An image or clip is shot in a non-radiometric format.

3. The developed software divides the clip into frames (thermograms), which are recorded in a standard digital format and are subject to processing.

4. To determine the temperature of each pixel of the thermogram that is recorded in jpeg format, it is necessary to know the exact relationship between the color space of the image and the distribution of the temperature field. For this reason, the image area should contain a temperature scale. This scale shows the color distribution in the interval between the highest and lowest temperature values in the image.

Through the developed software, its image is represented as a matrix of pixels, consisting of N rows and M columns. Each of the pixels represents a vector with three color coordinates (R,G,B). This vector array is used to create a k-d binary tree structure in which each node is a k-dimensional point. Determining the temperature of a specific pixel from the thermogram image is achieved by extracting its color coordinates (R,G,B). To determine the color position of this pixel in the temperature scale, the nearest neighbor method is used.

The results obtained show that the developed method can be successfully applied to extract temperature information from non-radiometric digital images. The results are in line with those obtained from the licensed software of one of the most widely used brands of thermal imaging cameras.

9h. A HYBRID PORTABLE BATTERY PACK SCREENING SYSTEM Stefan Rizanov, Anna Stoynova, Nadezhda Kafadarova, Sotir Sotirov, Borislav Bonev

With the growing industrial interest in the design and implementation of computationally powerful and portable networked devices, there is a need to test and evaluate

single-cell batteries and battery packs. The aim of the development is to design and manufacture a portable and easy-to-use battery screening system capable of performing aging, electrical and thermographic monitoring of batteries , through which the measured transient data is converted into two-dimensional spiral images.

The developed system performs accelerated aging and monitors the voltage of the battery cell, as well as the current temperature using an infrared camera. The main physical mechanism responsible for battery failure is presented. With the help of the developed system, experimental results were obtained, reflecting the influence of aging on battery performance. A new method has been proposed to convert the voltage, current and temperature measurement data of the cell into a 2D image. This data can be used as input to a machine learning model for classification or regression.

10h. MACHINE LEARNING ASSESSMENT OF BATTERY STATE-OF-HEALTH
Stefan Rizanov, Anna Stoynova, Nadezhda Kafadarova, Sotir Sotirov and Borislav Bonev

The topic of assessing the state of lithium-ion batteries has become extremely relevant in scientific research over the past 15 years due to the desire for a more sustainable green industry. In this paper, a machine learning method for estimating the state of batteries based on the approximation coefficients of the curves is presented. A method has been proposed to convert the resulting battery charge and discharge data into spectrograms that can be used as training data for a convolutional neural network image classifier.

Training has been carried out and various models for classification by machine learning have been presented, capable of determining with sufficiently high accuracy the class affiliation of a new and aged lithium-ion battery. In addition, a method has been proposed to convert the learned transient data into spectrograms that can be used as unique digital identifiers for each battery, and also as data records for a convolutional neural network image classifier. Future work will be aimed at expanding the currently available datasets and using deep neural network classifiers to infer battery status.

1. CONDUCTING A PEDAGOGICAL EXPERIMENT ON THE EFFECTIVENESS OF THE INTRODUCTION OF THE "AUGMENTED REALITY" TECHNOLOGY IN TRAINING WITH MOBILE DEVICES
D. Stoyanova, S. Stoyanova-Petrova, N. Kafadarova, D. Tokmakov

This article presents our experience of using mobile technologies and augmented reality technology to stimulate and support the learning of the subject "Man and Nature" for 4th grade. Students from two Plovdiv schools took part in the pilot experiment.

The analysis of the results obtained clearly shows that the use of the "augmented reality" technology during a lesson does not create anxiety or anxiety in students, but makes the learning process exciting and enjoyable. Moreover, it provokes students' cognitive activity and creates an attitude for independent work at home. The collected data gives us reason to conclude that AR technology has great potential to provide visibility in learning. It helps to develop the imagination of students and in an undeniable way facilitates the study of the learning material. The pedagogical research and the analysis of the results obtained have categorically proved that the technologies used are successfully applicable in primary education in Bulgarian schools and have didactic value.

2. EVALUATION OF THE PAC SYSTEM
N. Kafadarova, S. Stoyanova-Petrova, N. Mileva

The purpose of the article is to describe the PAC project and the strategy for evaluating the results of the project. PAC is a project to develop a curriculum adaptable to the needs of business and employment at the master's level, applying the concept and principles of learning through productivity support systems in productivity-focused learning content management systems. In this article, we describe our work on the development of comprehensive programs at the master's level, meeting the needs of the business for more qualified personnel who have graduated from higher education. The requirements for graduates of higher education are changing - for skills to work in many jobs, not only in terms of formal qualifications, but also in terms of detailed skills and competencies. The identification of new qualification requirements and the development of a qualification profile will support business and employment in the development of curricula and the development of courses in order to meet the need for practice-oriented/professionally specific and business-specific training materials through which participants can acquire the practical skills and know-how necessary to work in a particular profession, the successful completion of which usually provides participants with a qualification corresponding to the labour market.

Initial results:

- Identified skills needs and new requirements for competences in the field of optical technologies, control systems, electronic and software engineering.
- Job creation, skills.
- Developed qualification profiles – knowledge, skills and competencies in the learning outcomes, curriculum framework.
- Developed an Adaptive Performance-Oriented Curriculum (PAC) for qualification PAC Test Report.
- Assessment of skills, knowledge and competences – answer to the question: "The right skills for the right job?

Impact: As we continue to work to raise and develop national standards to meet the specific needs of local industry and businesses, as part of a broader effort to build new qualifications to meet emerging competence needs in the sector, we support progress towards pan-European certification of qualifications. This document briefly outlines the overall evaluation methodology, research designs, and methods for data collection and analysis to initiate discussion and decision-making on future evaluation activities within the PAC project. The report is closely linked to the document describing the measuring instruments. In the article, we present the questionnaire that we have prepared to obtain clear information about students' attitudes towards the PAC approach. This questionnaire may require some revision as some of the elements need to be reformulated and new scales need to be added (e.g. expectation of effort, motivation, likelihood of acceptance and facilitative conditions).

3. STUDY OF THE INFLUENCE OF VARIOUS THERMALLY CONDUCTIVE PASTES ON THE THERMAL CHARACTERISTICS OF HIGH-POWER LED SYSTEMS
Nikolay Vakrylov, Nadezhda Kafadarova

The article investigates the influence of various thermally conductive pastes on the tholin characteristics of LED systems. 8 heat-conducting pastes were studied, which are

characterized by different thermal conductivity and thermal resistance. For the assessment of thermal characteristics, a thermally modeled LED system is used, consisting of an LED with a power of 1W mounted on an MCPCB board with an aluminum heatsink.

From the studies carried out, it is clear that with the increase in the thermal conductivity of the studied pastes, the temperature of the LED system decreases, which leads to a significant improvement in its thermal characteristics. The improvement in the thermal performance of the LED system is directly related to the higher thermal conductivity of the pastes and the low thermal resistance that occurs between the MCPCB board and the heat sink. The low thermal resistance ensures more efficient heat removal from the source to the surrounding space.

4. ENHANCING ELEMENTARY STUDENT LEARNING IN NATURAL SCIENCES THROUGH MOBILE AUGMENTED REALITY TECHNOLOGY
D. Stoyanova, N. Kafadarova, S. Stoyanova-Petrova

The article describes the use of mobile augmented reality (MAR) applications in teaching practice as an innovative way to transfer knowledge in education. It is envisaged to modernize the way information is accessible and presented to students and thus improve their perceptions. The potential of MAR technology in education is relatively unexplored. The aim is to design, develop, implement and evaluate innovative mobility services using augmented reality technology in primary school science education. It was launched in 2013 and has a duration of 2 years.

The hypothesis of the study is that mobile augmented reality technology can be successfully applied in Bulgarian primary schools and has didactic value. To confirm or reject this hypothesis, a pedagogical study was carried out through the development of a system of augmented reality mobile applications and the use of adequate diagnostic tools. The system of MAR applications developed within the project includes the following components:

- A mobile application in which multimedia models of objects from the textbook "Man and Nature" are visualized using augmented reality technology. They can be seen on the screen of a smartphone or tablet.
- Adapted mobile application with augmented reality in astronomy for the needs of students in Bulgarian primary school.

The implementation of these MAR applications in the classroom is organized as a pilot experiment. The experiment involved teachers and 4th grade students from several primary schools. The data obtained from the survey is evaluated using Microsoft Excel. The results clearly show the potential benefits of using MAR in the learning process.

The results of the pilot study undoubtedly reveal that mobile technology for "augmented reality" is positively received by all students. We notice that the use of tablets in the classroom does not distract students. In addition, we can conclude that mobile devices are a suitable tool for education, since there is no need to teach children how to use them beforehand. The data collected shows that mobile technology for "augmented reality" stimulates students' interest in learning content and encourages their cognitive activity. This makes learning more engaging and fun, which is essential for achieving educational effectiveness.

5. DEVELOPMENT OF SELF-CONTROL THROUGH THE ABILITY TO INTEGRATE THE POSSIBILITY OF MOBILE TECHNOLOGIES
Silvia Stoyanova-Petrova, Nadezhda Kafadarova, Nevena Mileva

The article presents the project "Using Mobile Technologies for the Development of Self-Control. The main goal is the use of mobile technologies for the design, development,

implementation and evaluation of innovative exercises for the development of self-control. The study is aimed at supporting professional and academic development, as well as dealing with critical and stressful situations through self-control. The introduction of a system of exercises for the development of self-control through the use of mobile technologies is organized as a pilot experiment. The experiment was conducted with students, future psychologists and persons engaged in professions fraught with professional stress. The evaluation of the effectiveness of the mobile technologies used in the development of self-control was achieved through various questionnaires.

The use of mobile technologies creates a space to generate positive experiences and strong motivation, potentially increasing engagement in their use. This is crucial for the development of self-control, because despite the positive effects on growth, the actual development of self-control and self-discipline is not always associated with positive experiences and requires considerable effort.

As a pilot experiment, a system of exercises aimed at developing self-control through the use of mobile technologies in the training of psychology students, as well as in the work of professionals in critical and highly stressful professions (social workers, educators, health professionals and taxi drivers) was organized.

The content of the exercises and the progress in mastering self-control through mobile technologies are assessed using various questionnaires. Initially, attitudes towards the development of self-control, attitudes towards the use of mobile technologies for the development of self-control and the levels of development of self-control will be considered.

After the pilot experiment is completed, the levels of development of self-control will be re-evaluated to assess the effectiveness of the training. In order to determine the effectiveness of the training, a comparative analysis of the different approaches and technologies used in the training process aimed at developing self-control will be carried out.

6. INTELIGENT SENSOR NODE FOR MEASURMENT OF TEMPERATURE AND WIRELESS TRANSIMISSON OF COLLECTED DATA TO REMOTE WEB SERVER
Dimitar Tokmakov, Nadezhda Kafadarova, Ventsislav Nachev

This article presents the design and practical implementation of an intelligent wireless sensor node for temperature measurement and transmission of collected data to a remote server using Wi-Fi and the Internet as a communication medium. MySQL with Node.js technology. The preliminary results of the study of the entire communication system show thatthe intelligent sensor node can also be used to wirelessly transmit data from measurements of various physical quantities, which makes it applicable in households, industry, education and healthcare. It is possible to integrate both digital and analogue sensors for physical quantities that are measured simultaneously. a server using the Internet as a transmission medium.

7. STUDY OF HIGH POWER COB LED MODULES WITH RESPECT TO TOPOLOGY OF CHIPS
Nikolay Vakrylov, Anna Andonova, Nadezhda Kafadarova

The thermal influence of the topology of COB (Chip-on-Board) LED modules has been investigated. For this purpose, CFD simulations of a powerful thermal model of a COB LED module are performed and the heat distribution at different locations of LED chips is analyzed. Simulation experiments were carried out using substrates made of ceramic materials – aluminum oxide (typical), aluminum oxide (94%), aluminum oxide (96%) and AlN. The thermal efficiency of four different structures of COB LED modules with different operating

modes and environment was investigated. The results of the simulation are verified with thermal measurements.

The study shows that the location and distance of LED chips are of significant importance when designing LED arrays. The optimal structure is the one with a chip spacing of 3 mm, because it makes it possible to establish a sufficiently dense package with good thermal characteristics in a wide range of ambient temperatures. In terms of the substrate used, the results show that the optimal substrate is aluminum oxide (96%). It has high thermal conductivity and offers a low thermal resistance close to that of AlN. The study of the location of the LEDs in the array shows that the optimal distribution of heat in the structure is offered by the square array.

8. MODERN COMMUNICATION TECHNOLOGIES IN THE PROCESS OF RESEARCH IN PHYSICS WITH APPLICATION IN HIGHER EDUCATION
Nadezhda Kafadarova, Silvia Stoyanova - Petrova

In this article we present a research project "Integration of communication technologies in the process of research in physics with application in education". The aim of the team is to stimulate the conduct of quality and competitive research in the areas in which the Faculty of Physics (FF) of the University of Plovdiv prepares students and PhD students: 4.1 Natural Sciences and 5.3 Communication and Computer Technology. By conducting the study, additional scientific results are provided in the main scientific priority areas of the Faculty of Physics in the next two years. The results will raise the prestige of the Faculty of Physics and the University of Plovdiv and will contribute to the successful accreditation of the Faculty.

Through the integration of communication technologies in the process of research in physics with application in education, the aim is to support the academic growth of team members, as well as the training, development and defense of doctoral dissertations by PhD students.

In this way, the project encourages the development of the main scientific directions and potential of the Faculty of Physics of the University of Plovdiv in the next two years.

9. OUR EXPERIENCE IN ELABORATION OF A SYSTEM OF EXERCISES FOR DEVELOPMENT OF SELF-CONTROL BY USING MOBILE TECHNOLOGY
D. Stoyanova, S. Stoyanova-Petrova, N. Kafadarova, N. Mileva

The purpose of the article is to present our experience in the design and development of innovative exercises for the development of self-control through the use of mobile technologies. Scientific research is subject to the hypothesis that the development of self-control through the use of mobile technologies can be integrated into the educational process, to overcome difficulties related to learning and the development of various competencies, to support personal growth and minimize bad habits. Preparing a set of exercises for the development of self-control using mobile technologies includes the following steps:

• Creating a conceptual model of self-control, which is used as a basis for building exercises and activities for its development.

• Design and preparation of scenarios and exercises for the development of self-control through the use of mobile technologies.

• Mobile application for visualization of multimedia resources by scanning QR codes. This Android app uses the mobile device's camera to scan the QR code printed on a special sticker. By reading this code, the application redirects the user to the multimedia information related to the corresponding self-control exercise. This information is in the form of audio-visual information.

• Creation of audio-visual and multimedia resources for mobile devices in accordance with the developed system of exercises for the development of self-control.

The end result of research in the field of psychology, mobile technologies and didactics is a training package for the development of self-control through the use of mobile technologies. The application of this package in the training of students studying psychology, as well as in the workplace of persons practicing stressful professions (social workers, teachers, medical workers and taxi drivers) was organized as a pilot experiment.

The developed exercises fully meet the objectives of the training and support the development of various competencies. The program for the development of self-control will complement both university education and professional development programs. The program can also be used in dealing with various bad habits and improving health and in dealing with critical situations. The study of the content of the exercises and the progress in mastering self-control through the use of mobile technologies is carried out through various questionnaires. Initially, attitudes to the development of self-control, to the use of mobile technologies for the development of self-control, as well as the levels of development of self-control were studied. After the pilot experiment was completed, the level of development of self-control was again assessed to show the effectiveness of the training. On the other hand, a comparative analysis of the different approaches and technologies used in the training process aimed at developing self-control is carried out.

10. EVALUATION OF A SYSTEM OF EXERCISES FOR DEVELOPMENT OF SELF-CONTROL BY USING MOBILE TECHNOLOGY
Nadezhda Kafadarova, Silvia Stoyanova-Petrova and Diana Stoyanova

The article describes a scientific study that is subjected to the hypothesis that the development of self-control through the use of mobile technologies can be integrated into the educational process, to overcome the difficulties associated with learning and the development of various competencies and to support personal development and minimize habits that hinder successful implementation. The analysis focuses on the study of the didactic potential of mobile technologies for the development of self-control in various situations.

The goals and objectives of the study described in this article are directly related to:

- Improving self-control in the working environment of persons employed in professions with great professional stress – in the work of teachers, social workers, medical workers, etc.;
- Increasing the effectiveness of teaching and professional realization of students who are future psychologists;
- Improving well-being and life satisfaction and achieving a healthier life;
- Providing online mobile digital resources for the development of self-control;
- Increasing knowledge about the possibilities for the development of self-control, the use of innovative learning technologies.

The end result of the conducted scientific and applied research in the field of psychology, mobile technologies and didactics is a package that contains the following elements:

- Conceptual model of self-control;
- Scenarios and exercises for the development of self-control using mobile technologies;
- Audiovisual and multimedia resources for mobile devices in accordance with the developed scenarios and exercises for the development of self-control;
- Tools for assessing the development of self-control and tools for assessing progress in the development of self-control through the use of mobile technologies.

The implementation of this package in the training of students – future psychologists, as well as in the work of persons employed in professions that are filled with a lot of professional stress, was organized as a pilot experiment.

The experiment included:

- Acquaintance of participants with the essence and importance of self-control for achieving goals in various activities, for mental well-being and health;
- Introducing participants to the possibilities of using mobile technologies for the development of self-control;
- Familiarization with the content of the developed exercises;
- Conducting trainings for the development of self-control in students - future psychologists and persons dealing with professions that are critical and full of professional stress;
- Assessment of progress in the development of self-control;
- Evaluation of exercises for mobile devices;
- Assessment of attitudes towards the learning process, aimed at developing self-control through the use of mobile technologies.

11. USING A WIRELESS SENSOR NETWORK FOR MEASURING THE OXYGEN LEVEL IN INDUSTRIAL ENVIRONMENT
Dimitar Tokmakov, Nadezhda Kafadarova

This article presents the design and practical implementation of the Wireless Sensor Network (WSN) and its use to measure the oxygen level in the air in a manufacturing plant. It consists of 4 wireless sensor nodes with an oxygen sensor that transmits the oxygen level to a wireless base station and measures the oxygen level in 4 zones in a manufacturing plant. The metering system has 2 threshold levels for oxygen - 19% and 18% and has automatic events for these levels. Data from 4 oxygen wireless sensors is also transmitted to a web server on the Internet for data backup and visualization.

This work presents the results of the design, implementation, testing, and operation of a wireless sensor network to measure and monitor oxygen concentration in an industrial facility.

The developed energy-efficient communication protocol between the wireless nodes and the base station provides approximately 3 months of autonomous operation of the wireless sensor node on a single charge of a 2100mAh Li-ion 3.7V rechargeable battery (type 18650). The measurement data is visualized on 4 LCD displays, each of which corresponds to a specific measurement area.

The base station is programmed to handle critical situations, such as detected oxygen levels of 19% and 18%, alarm activation, nitrogen valve shutdown, and room ventilation activated.

The use of a wireless sensor network provides extreme flexibility in sensor placement (eliminating the need for cables), the ability to easily change the physical location of sensors, and the seamless addition of additional sensors and measurement points, among other benefits.

12. USING MOBILE TECHNOLOGY TO ENHANCE LEARNING FOR DISADVANTAGED GROUPS: DESIGN OF EDUCATIONAL SCENARIOS
N. Mileva, S. Stoyanova-Petrova, N. Kafadarova

This article focuses on improving the conditions for educational integration through the use of mobile technologies, which will increase students' motivation and participation in

the educational process. The emphasis is placed on disadvantaged learners – groups at risk, whose ethno-cultural characteristics, special needs and socio-economic situation significantly limit their opportunities for adequate education. The integration of these groups depends mainly on their training and the knowledge they acquire. Mobile technologies facilitate memorization and learning by offering visual and audio stimuli and are therefore suitable for people with deficits. The following educational scenarios are presented in the article:

1. Increasing the interactivity in the education of Roma children using mobile devices. The use of multimedia resources in education from mobile devices would be appropriate, as they include something new, figurative and attractive, which has a real chance of having a beneficial effect on the motivation of the minority group.

2. Training of learners with hearing impairments, supported by mobile devices. Our goal is to integrate students with hearing difficulties into the learning process by using innovative educational technologies for learning through mobile devices.

3. Use of mobile technologies to expand training opportunities for people with musculoskeletal disorders. Learning through mobile devices has the potential to increase access to education for people with reduced mobility, create a supportive learning environment independent of time and place - removes spatial barriers - physical classrooms are redundant in the traditional sense of the word, and students can take courses from the place and at the moment of their choice.

4. Use of mobile devices for distance learning of the unemployed. This scenario will focus on people who do not have access to education due to distance, lack of financial security, socio-economic exclusion.

For the purposes of the study, a mobile application with augmented reality for education has been developed. Augmented reality technology will be used to visualize models of objects that can be seen on the display of a smartphone or tablet. The end result of the integration of digital educational resources both in the developed mobile application with augmented reality and in the DIPSEIL system and their implementation in education on the basis of the developed conceptual model, is the package consisting of the following structural elements:

• Mobile application with augmented reality;
• DIPSEIL e-learning platform;
• Innovative educational technologies;
• Digital educational resources for mobile devices.

The introduction of this package in the training is organized as a pilot experiment, in the conduct of which we will rely on the assistance of the families of disadvantaged students, as well as from the social partners and non-governmental organizations.

The pilot experiment will be organised and conducted in accordance with the four scenarios with:

• Roma students from several schools in the region;
• Students with hearing impairments from the Secondary Specialized School for Children with Hearing Impairments – Plovdiv;
• Students with musculoskeletal disorders from the University of Plovdiv "Paisii Hilendarski";
• Unemployed people from Smolyan district (Bulgaria) who do not have access to education due to remoteness, lack of financial security, socio-economic isolation. Assistance will be sought from the Employment Agencies for their professional integration.

13. USE OF MOBILE TECHNOLOGIES TO CREATE DIGITAL RESOURCES FOR EDUCATIONAL INTEGRATION OF DISADVANTAGED GROUPS

Nevena Mileva, Nadezhda Kafadarova, Silvia Stoyanova-Petrova

The aim of the article is to share our experience in creating digital learning resources for mobile devices in order to improve the educational integration of disadvantaged learners in the education system – groups at risk whose ethno-cultural characteristics, special needs or socio-economic status significantly limit their ability to adequately education. The work is carried out within the framework of the mRIDGE project. This will lead to the development and adaptation of training modules, upskilling of teachers working with students at risk, new teaching methods using mobile technologies and devices, and will generally have an impact on the socio-economic inclusion of disadvantaged groups. The following educational scenarios are introduced: Promoting interactivity in the education of Roma students through mobile devices; Training of students with hearing impairments using mobile devices; Use of mobile technologies to expand the learning opportunities of students with musculoskeletal disorders; Use of mobile devices for distance learning of unemployed persons.

• A conceptual model has been developed for the creation of digital learning resources for mobile devices in order to improve the educational integration of disadvantaged learners in the education system.

• The specifics of the training of the target groups are outlined.

• Four educational scenarios have been implemented.

14. ENHANCING OF INTERACTIVITY IN TEACHING OF ROMA CHILDREN USING MOBILE DEVICES

R. Valcheva, H. Dimitrov, M. Dimitrova, N. Mileva, N. Kafadarova, S. Stoyanova-Petrova

The purpose of our article is to present our experience in teaching Roma children using mobile devices. This is done within the framework of the mRIDGE project. One of the main objectives of the study is to attract and retain Roma students in school through engraving, innovation and visualization using augmented reality technology. Naturally, behind this goal is the idea to support the work of teachers working with marginalized groups for whom education is not a priority. The acquisition of mobile devices compensates for the lack of technology for Roma students, while the use of digital resources draws the group into the contemporary context of the information society. The feeling of a child living in extreme poverty that he can be equated with others essentially overcomes the imbalance in the group and leads to an increase in motivation and therefore a guarantee for the progress of integrative processes. The concept of educational environment does not only fit within the boundaries of the school – classroom, school corridors, school library, science laboratory, but also family, sports club, etc., and last but not least, the student's mobile device. The teacher considers the student's mobile phone as a tool in the educational process. Significant progress has been made in the science education process for both students and teachers. A pilot experiment was conducted in two disciplines: "Man and Nature" and "Physics and Astronomy". Digital resources, collected in an understandable and effective way for the group, increase the percentage of memorization, activate various senses, affect emotionality and provoke a thought process.

In general, we can say that the use of mobile devices in the education of disadvantaged children and the creation of digital educational resources for them moves the integration of the group significantly forward. The use of the combination of mobile devices and digital educational resources improves sociocultural competence, which leads to better understanding and consideration of information. The introduction of innovations relies on a positive emotional perception of technological innovations, especially in children, whose social status deprives them of many of the privileges of the information society. The methodical context that the "augmented reality" technology creates is too close to a game situation that corresponds very precisely to the concept of the world of the Roma child. The effort to perceive and work with information seems to be lacking because new knowledge is made attractive. One of the unexpected beneficial effects of the project on the group's communication is the pursuit of awareness. The change in four characteristics of students that are fundamental to success in the learning process is impressive: "persistence of attention", "interaction with other team members", "readiness for partnership" and "activity". The biggest change is in science classes, where mobile devices are used. This is also beneficial for educators whose spatial ideas about the learning process are freed. From the point of view of managing the learning process, the benefits are also positive – the mobile devices and the platform that the project offers for self-education of teachers and the creation of electronic resources is a very economical and budget-friendly approach to achieving a modern educational environment. The type of work with multimedia resources offered by the project solves a number of issues related to the pedagogues' mastery of too large differences in the needs of students, including students from the same class. Differentiating work by offering different digital resources to different students also implies easier integration of students with special educational needs. Easy access to the resources of the platform allows the exchange of good practices to be used in the learning process. Educators are gradually realizing the huge difference between using multimedia and an interactive whiteboard and offering electronic resources through a mobile device. On the one hand, as we have already mentioned, the easy portability of the device allows different spatial solutions to carry out the lesson, on the other hand, the textbook becomes flexible, taking both novelties and adapting the learning content to different needs and allowing different groups of students to work with different multimedia resources at the same time. A mobile device optimizes time by allowing you to take into account the different speed at which children perceive learning material and work on different types of deficits at the same time. One of the great merits of the study is the transformation of the student from a passive into an active participant in the learning process. By independently accessing the educational material with the mobile device, the child feels important. The electronic resource, compiled in an understandable and effective way for the group, increases the percentage of memorization, activates various senses, affects emotionality and provokes a thought process. No textbook, including the electronic version, in which they already exist widely, offers such a dynamic of learning content and such freedom for the teacher to interpret the learning material according to the needs of students. Along with the spatial independence provided by the mobile device, the "augmented reality" technology has been an impressive success for the school. The effect is tangible for everyone who works in the specific environment, but above all it refers to the changed emotionality, the readjusted attitudes towards work in both students and teachers. The fact that the project activities are discussed in an out-of-school environment by students and parents and that teachers are ready to use technology is a guarantee not only for sustainability, but also for the development of the idea.

15. TRAINING HEARING IMPAIRED STUDENTS WITH THE HELP OF MOBILE DEVICES

N. Garova, S. Kudenko, I. Raychev, N. Mileva, N. Kafadarova, S. Stoyanova-Petrova

In this article, we would like to share our experience in helping disadvantaged children integrate into the educational system by introducing digitally enhanced learning using mobile devices. This is done within the framework of the mRIDGE project. This project offers opportunities to turn the class into pleasant and attractive moments that pass imperceptibly for both students and teachers. In addition, the mRIDGE project provides perspectives in terms of integrating mobile technologies into the overall learning process - in all subjects. In order to be able to fully integrate into society and the labor market and thus be useful to oneself, one has to go a long way in development, accumulation of knowledge and building skills. Children with hearing impairments or multiple disabilities do not have sounds and developed speech, have no idea of the world or have only minimal ones. Children with hearing impairments do not have a rich vocabulary; They don't use a lot of scientific concepts. Those who are present in their speech are elementary and mostly related to the surrounding world. In most cases, parents and teachers support the personal development of students with special educational needs, insofar as they become useful young people for themselves and for society. In this context, it is very important for children to build knowledge about the world around them, to increase their vocabulary with the concepts learned in the classroom, to learn skills and expand their worldview. For this purpose, they should not lose interest in school and school subjects. Biology and health education are one of the subjects that should be included in the experiment. Children learn about anatomy and get answers to interesting questions about the human body in particular and nature in general. Visualization or animation using IT resources contributes to the understanding of systems. New technologies and the different methods we try to use in the educational process stimulate the interest of students. An individual approach is constantly applied; Specific learning activities and implementation opportunities are considered for each student individually. The research methodology consists of the following steps:

1. Determination of the main training groups;
2. Selection of subjects and lessons to participate in the experiment;
3. Creation of training materials useful for mobile devices;
4. Conducting experimental lessons with students with hearing impairments using mobile devices;
5. Analysis of results.

The results of the survey show that interest in schoolwork has increased, and knowledge in certain areas has increased. Proof of this are the higher grades of students compared to the last school year and the difference in grades between the initial and initial levels of the current one. The conclusions are: "mRIDGE" has contributed to the development and support of the education of students with hearing impairments; IT resources complement textbooks, support the work of the teacher, increase students' interest in education and motivate their desire for systematic school attendance and self-education.

The students from the second and third subgroups showed great interest in the classes in which we used IT resources. Those who have retained intelligence have coped extremely quickly with working with tablets. The information provided in this way impressed them. When they look at the pictures in the textbook, their attention is not focused. They move their eyes quickly and often cannot respond to what they see. After watching the video, they recreate what they see mainly with gestures. They do not have the vocabulary to reproduce or use a narrative. They answer short questions and show an understanding of basic phenomena or processes. The fact that they cannot reproduce the text is due to many factors: individual capacity, linguistic ignorance, undeveloped memory, etc. But more importantly, thanks to the resources of the mRIDGE platform, they understand the meaning of the process, remember certain actions they

need and gain practical skills. For example, why do we need precautions when having sex, what to do if there is lightning, how to protect ourselves from flooding, and the like. The majority of the group are Roma children, entirely dependent on family financial difficulties, the lack of a positive attitude towards school, partly caused by the parents' own illiteracy, and often, especially during the cold winter months, they stay at home. The lessons are boring for them, the material studied is difficult to understand, but mobile technology attracts their attention. The IT resources used in the project impressed them with their attractiveness and diversity. They saw how certain phenomena and processes take place in nature, appreciated the need to study them and develop skills for prevention and protection in certain specific cases or in natural disasters.

The most active in the classes are the students from the first group: ambitious, diligent, diligent. They quickly coped with the use of the tablet and the code. Students carefully follow the interpretation into sign language, read the text, memorize and reproduce the most important things. They are not limited to what they see, they ask follow-up questions. Look for more information. When they are hired on their own, they are active and willing to show the best possible knowledge. If the movie is longer and they have not been able to understand all the essential points, they repeat the viewing and complete the answers. This is best seen in classes where the teacher uses worksheets. Students write down the answers on them and within the lesson it is understood to what extent they have mastered the taught material and the resource monitored by the platform.

The pedagogical team of Sofia University for students with hearing impairments "Prof. Dr. Stoyan Belinov" – Plovdiv united around the opinion that the study turned out to be extremely important for the education and development of the students from our school. The subjects Geography and Economics and Biology and Health Education became their favorites. Interest in schoolwork has increased, and knowledge in certain areas has increased. Proof of this are the higher grades of students compared to the last school year and the difference in grades between the initial and initial levels of the current one. The development has contributed to the development and support of the education of students with hearing impairments; IT resources complement textbooks, support the work of the teacher, increase students' interest in education and motivate their desire for systematic school attendance and self-education.

16. EVALUATION OF THE DISTANCE LEARNING OF UNEMPLOYED PEOPLE
S. Stoyanova-Petrova, N. Kafadarova, N. Mileva

This article presents the results of the evaluation of distance learning for the unemployed. Our pilot experiment is aimed at people who do not have access to education because it is far from their place, due to lack of finances or due to socio-economic isolation. In times when large groups of people permanently remain out of the labor market, taking measures to increase employment and organizing retraining and motivation of the unemployed are of paramount importance. Obtaining additional training and qualification is a prerequisite for starting a job. For our experiment, we have developed an "Introduction to Electronics" course for initial qualification in accordance with the specifics of the DIPSEIL e-learning platform and will reflect the results of the assessment. The indicators for evaluating the course and its quality are defined as follows:
• Adequacies: the coherence between, on the one hand, inputs, processes, products and objectives, and on the other hand, expected and social needs. Qualitative indicators of adequacy in education are defined as consistency between courses with the needs assessment.
• Efficacy: the consistency between products and results with the objectives determines the efficacy or good results that the course achieves according to previous needs.

• Efficiency: the coherence between the inputs and the process, and the product defines efficiency, identified as the appropriate use of resources to achieve the objectives.

• Satisfaction: coherence between needs and results is a measure of impact.

• Excellence: means the best practices for achieving the objectives in response to needs, or in other words, the optimal level of coherence between all components presented in the systemic model of quality of educational institutions.

Three specific tools are used to collect information on the performance indicators, namely: "Questionnaire on attitudes towards learning through an Internet-based environment", "Learners' achievements", "System usability questionnaire". "Satisfaction" is measured by learners through a "Course Evaluation Questionnaire" developed to assess the overall learning process, includes the course design, platform and learning strategies used during the course, as well as their satisfaction with all elements included in the course.

The course "Introduction to Electronics" is aimed at people who do not have access to education because it is far from their place, due to lack of finances or due to socio-economic isolation. In times when large groups of people permanently remain out of the labor market, taking measures to increase employment and organizing retraining and motivation of the unemployed are of paramount importance. The use of the Internet as a learning medium advises to examine students' attitudes towards learning in an Internet-based environment, considering it as a variable that can hinder the change in learning outcomes. For this purpose, we provided the students with a questionnaire "Attitude to learning in an Internet-based environment". The results obtained in the questionnaire, with an overall average value of 4.31 (scale 1-5), confirm the positive attitude of students to learning in an Internet-based environment. The DIPSEIL system, as a learning environment for the Introduction to Electronics course, was evaluated through the "System Usability Questionnaire" by students, obtaining an average of 6.25 (scale from 1 to 7), which implies a very high grade. The usability and functionality of the platform presents a good rating with the organization of the screens and its ease of use. These results are confirmed by the results obtained in the points in the course evaluation questionnaire assigned to the education platform. The results of the Introduction to Electronics course, followed by 11 learners, yielded an overall average of 8.55 on achievement, in a range of 1 to 10, across the nine tasks. The learning achievements of the learners in the course are very positive, with very good learner ratings. 7797 Regardless of these learning outcomes, learners were asked to respond to the 'Course Evaluation Questionnaire' developed to assess the overall learning process, including the course design, platform and learning strategies used during the course, as well as their satisfaction with all elements included in the course. The results are derived from the achievements of 11 trainees for the course. The course assessment by learners through the "Course Assessment Questionnaire" received an average value of 4.38 (scale from 1 to 5). In this way, learners show great satisfaction with the course. In conclusion, all trainees have successfully completed the course "Introduction to Electronics" and have received a certificate from the University of Plovdiv. Three of them are already employed in industry; Five have sent their documents for a new job.

17. APPLICATION OF CFD MODELING TO SOLVE PROBLEMS IN THERMAL DESIGN OF LED APPLICATIONS IN THE INITIAL PROJECT PHASE
Nikolay Vakrylov, Anna Stoynova and Nadezhda Kafadarova

The article discusses the use of compact models and the thermal design of LED applications. The study shows that despite the simplified representation of thermal behavior, compact models predict the temperature of the systroma with sufficiently good accuracy in the initial design phase. Methods to further improve the accuracy of forecasting are evaluated.

In this study, a detailed thermal model of a high-power LED based on Cree XP-E in the Flotherm thermal simulation environment has been modeled. The thermal parameters obtained from the detailed model simulations are used to create two types of compact models that can be used to solve thermal design problems of LED devices operating in a natural convective environment based on this LED package.

An assessment of the predictive possibilities for the transition temperature of the detailed model and compact models is made and the obtained values are verified by thermographic measurements of the physical prototype of the simulated structure.

18. TECHNOLOGY ENHANCED EDUCATION BY QR CODES
S. Stoyanova-Petrova, N. Kafadarova, D. Stoyanova, N. Mileva, S. Sotirov, N. Vakrylov

The advantages of mobile technologies lead to their rapid implementation in education. QR codes and mobile devices are increasingly being used as learning tools in conventional education. They support the learning process by introducing more attractive, motivating and technologically improved learning materials. The article describes the approach to the implementation of QR codes in electronics education in higher education. In this study, QR codes were added as auxiliary materials to the laboratory exercises of the electronics course at the University of Plovdiv. Multimedia materials have been created in the form of a video for the teacher, explaining the methodology of the exercise. Through the use of QR codes, students have access to practical guides and other information related to subject matter practices. A QR code has been developed for each laboratory exercise, which is placed next to the corresponding layout in the electronics laboratory. This helps students in carrying out laboratory practices by presenting them with the procedures of the practical session. This methodology allows adapting the learning process to the speed of learning the learning material of each student. This means greater flexibility and convenience to suit students' active learning process.

The results of the experiment on the use of QR codes in electronics education in higher education showed the positive attitude of students to this technology. Most of them highly value QR codes as a learning tool that stimulates students' interest and engagement, boosts their motivation, and develops self-paced learning skills.

19. TRAINING OF JORDAN TEACHERS IN THE USE OF MOBILE TECHNOLOGIES IN EDUCATION
N. Kafadarova, S. Stoyanova-Petrova, N. Mileva

Many Jordanian universities and higher education institutions have recognized the value of the internet in changing the way people learn. Traditional classroom courses can be complemented with interactive materials on the web, and old-fashioned distance learning courses can be transformed from correspondence courses or TV lectures into an e-learning environment.

However, few institutions in Jordan have been able to adopt e-learning in a way that allows for a wide innovative use of learning technology throughout the institution. Instead, many rely on individual educators or departments to make their own decisions about how to implement an e-learning environment that best suits their needs. The result is a hybrid of incompatible solutions that make it difficult for educators to share their work.

This article presents our work within the mEQUITY project. This project aims to develop an adaptive curriculum in education that is based on digital learning resources for mobile devices and meets the requirements for modernization and accessibility of the Jordanian

higher education system in order to improve the educational integration of disadvantaged learners into the education system – groups at risk whose special needs or socio-economic status significantly limit their ability to adequately educate themselves. At the University of Plovdiv, preliminary training of Jordanian teachers on the use of mobile technologies in education was conducted. This training was organized with different groups of teachers. Various plans-scenarios for the implementation and organization of the learning process, in which QR codes and mobile technologies are prepared.

The DIPSEIL training was conducted by the team of the University of Plovdiv (PU) in October 2017 in Amman, Jordan with lecturers from three Jordanian universities. The number of participants was 10 teachers. The courses to be further developed by the lecturers from the Jordanian universities in both scenarios were discussed.

20. A SYMULATION OF STEADY STATE THERMAL MODEL OF PHOTOVOLTAIC/THERMAL SYSTEM
Nadezhda Kafadarova, Nikolay Vakrylov, Rumen Popov

Growing concern for the environment and the constant rise in the price of conventional energy sources are leading to an increase in interest in renewable energy sources. Photovoltaic solar technology is a relatively new solar energy conversion technology that converts solar radiation into both usable electrical and thermal energy. At the heart of this technology is the negative temperature efficiency of crystalline photovoltaic cells, which leads to reduced performance of installed photovoltaic panels at high radiation levels. Commercially available photovoltaic modules have a relatively low efficiency of no more than 20%, which means that 80% or more of the incoming solar radiation is lost by conversion to heat, raising the operating temperature of the module. The low-temperature liquid, usually water or air, circulates through a heat exchanger attached to the back of the PV system to extract excess heat from the panel, thereby cooling it during operation. The dissipated heat can be used for low-temperature applications such as heating and ventilation of buildings or for drying in agriculture and industry. In this study, a temperature model of a photovoltaic/thermal (PV/T) solar collector was developed, which was used to investigate the effects of various parameters on system performance.

In this study, a thermal model of a photovoltaic/T solar collector was developed to determine and evaluate system parameters at different panel temperatures. Simulations of the photovoltaic/T system were conducted at panel temperatures of 60°C, 70°C and 80°C, demonstrating that this type of solar collector can successfully serve as an alternative to conventional hot water systems.

Analyses show that even at a panel temperature of 60°C, the liquid in the system reaches a sufficiently high temperature of 48.7°C. At a panel temperature of 70°C, the liquid at the heat exchanger outlet increases its temperature to 54.8°C. The liquid in the photovoltaic collector heat exchanger achieves a temperature of 61.1°C at a panel temperature of 80°C, proving the applicability of this type of system even at a relatively low ambient temperature of 20°C.

21. DESIGN AND DEVELOPMENT OF AN ELECTROSTATIC VOLTMETER BASED ON SURFACE POTENTIAL SENSOR
Sotir S. Sotirov, Dimitar M. Tokmakov, Nevena S. Mileva, Silvia V. Stoyanova-Petrova, Nadezhda M. Kafadarova

This article presents the design and development of an electrostatic voltmeter based on a surface potential sensor. For the implementation of the device designed by us, a sensor for

measuring surface potential EFS-22D was used, consisting of a measuring probe and an electronic transducer for measuring voltages in the range from 0V to 900V at a distance between the sample and the surface of the probe within 1 – 3.5 mm. that block the electric field. The movement of these electrodes is carried out with the help of a piezoelectric element. The surface potential measured by the sensor probe is converted into an analog voltage ranging from 0 to 4.5V, which is then converted to a digital value by a 15-bit sigma-delta analog-to-digital converter connected to a microcontroller. The measurement data is transmitted from the microcontroller to a personal computer via a Bluetooth module. A user software has been developed that allows recording the obtained values from the measurements; their visualization in both digital and analogue form; digital filtering of noise from the sensor; and statistical analysis of the data obtained.

By using digital low-frequency filtering of the measurement results, a significant reduction in the noise of the electrostatic voltmeter is achieved and an increase in the measurement accuracy at the beginning of the measured range of 0-50V is achieved.

22. REMOTE EVALUATION OF SOFTWARE ENGINEERING COMPETENCES
Boris Mishnevs, Vacius Yousasb, José Luis Fernández Alemanc, Nadezhda Kafadarova

The article focuses and examines the problems related to the remote assessment of software engineering competencies using the progressive model of competence representation. An original approach to the assessment of competencies in a Master's programme in Software Engineering is proposed as a combination of academic competencies and professional competences from the European Competence Model (e-CF). Examples for describing the competencies in 16 disciplines of the proposed joint master's program in software engineering have been developed. Several types of rubrics are reviewed to assess software engineering competencies and rubric templates are created. The developed models and templates can be used by universities and IT enterprises to evaluate the learning outcomes, as well as to assess the competencies of graduates of the Master's program in Software Engineering.

We have developed a methodology for remote assessment of the competence of graduates of the Master's program in Software Engineering. Applying the methodology can be attractive to employees and employers. The employee can test the graduate's competency claims before hiring them. The employer can check their competence to understand their level of acquired competence.

The methodology is based on the European e-Competence Framework, which provides 40 competences for all areas related to information and communication technologies. The novelty of the approach is that we have added academic competencies based on the specific disciplines of the proposed Master's program in Software Engineering.

23. INTRODUCTION OF THE RESEARCH OF ELECTRONIC EQUIPMENT HEAT TRANSFER IN THE TRAINING OF ENGINEERING STUDENTS
N. Kafadarova, N. Vakrylov, D. Tokmakov, N. Mileva

In this article, the authors share their experience in minimizing the difference between educational research and educational practice. Research has a practical impact if it helps practitioners gain a different understanding of their practice. This is more true for university engineering education. In order to bridge the gap between education and scientific work, practical exercises were conducted with students to introduce the scientific study of the temperature of electronic devices and systems into their educational program.

Heat has a negative impact on the performance and reliability of electronic devices and systems, and therefore heat management is one of the important aspects of creating new electronic products. The main challenges in the design of modern electronic devices are the ever-increasing integration of elements and power density in chips, which requires the use of technical tools such as CFD tools to assist in the design and clarification of complex interactions related to heat transfer. This article presents the results of engineering students in the design and development of an amplifier cooling built on a TDA1516BQ integrated 2 x 12 TDA1516BQ W amplifier. The simulations aim to ensure good heat dissipation from the amplifier box, despite its compact size, and to ensure high reliability even at extreme ambient temperatures. In order to study the thermal behavior of the amplifier, a digital model was created, including submodels of all components and parts of the structure related to the heat transfer processes in the box. The amplifier box itself is modeled in detail and includes all walls, partitions and openings for circulating liquid flows in and/or the surrounding space near the box. A thermal model of the printed circuit board and the components of the two integrated circuits (TDA1516BQ) for the two channels of the amplifier was also created. The results of thermal analysis, which are carried out through simulations, are verified by temperature measurements using thermocouples placed at certain radiator control points and integrated circuits.

After the study, conclusions are drawn about the motivation of students to carry out research work in the process of their studies.

The article demonstrates real problems with heat management on a powerful amplifier based on TDA1516BQ. With the help of specialized software, the students created a three-dimensional model of the amplifier and studied the heat transfer in its box. The heat transfer study includes simulations to design an appropriate cooling solution for the small size of the amplifier case. Surveys give students the opportunity to see:

- Thermal effects caused by the different thermal conductivity of the radiator;
- Thermal effects due to the anodizing of the surface of an aluminum heat sink and in particular increasing the cooling efficiency by improving radiant heat transfer.
- Thermal effects caused by forced cooling with a fan and its location in the box.

The methodology used to introduce students to the problems of heat management, combining computer modeling, simulations and real-life experiments, significantly increased students' interest in this engineering field and their desire to participate in new projects related to the design of electronic devices and systems.

24. USING QR-CODES IN TEACHING ELECTRONICS – AN APPROACH TO INCREASE STUDENTS MOTIVATION
S. Stoyanova-Petrova, N. Kafadarova, D. Stoyanova, N. Mileva

The main purpose of this article is to present our experience of using QR codes in electronics education in engineering higher education. QR codes placed on the relevant mock-up or apparatus in the electronics laboratory are used to access short videos on the topic of the laboratory exercise. The size of the videos provides an acceptable download time, making them compatible for use with smartphones and tablets. QR codes allow students to watch the multimedia material multiple times, allowing them to follow their own pace of learning. The new approach was used in the 2017/2018 academic year with 40 first-year students. To compare the motivational impact of using QR codes, lab exercises were taught using two different learning scenarios – a traditional learning environment (control group) and an inclined environment that included QR codes (experimental group). At the end of the course, all participants were given an IMMS questionnaire for collecting quantitative data. Only students

from the experimental group were asked to fill out a questionnaire that collected information about students' attitudes towards the use of QR codes and mobile devices in education. The article presents the results obtained from both quantitative and qualitative data, which show the significant impact on the motivation of students who have the built-in QR codes in the learning process. In this article, we present the results obtained from both quantitative and qualitative data, which show the significant impact on student motivation that have embedded QR codes in the learning process.

The use of QR codes can be seen as an effective strategy for improving students' motivation in learning electronics. The results of our research confirmed the findings of the preliminary study that QR codes can stimulate students' interest in learning material, increase their learning satisfaction, and create a positive expectation of personal success.

25. OUR EXPERIENCE IN USING PERFORMANCE SUPPORT LEARNING IN "THERMAL MANAGEMENT OF ELECTRONIC EQUIPMENT" COURSE
Nadezhda Kafadarova, Diana Stoyanova, Silvia Stoyanova-Petrova, Nevena Mileva and Nikolay Vakrilov

This article describes our experience in using performance support training to gain new knowledge and competencies from future and current heat transfer modeling engineers in electronic components and systems. A curriculum for an e-learning course and multimedia resources for thermal control of electronic systems has been developed together with the business.

The theory and practice at the DIPSEIL Laboratory at the University of Plovdiv include the application of innovative approaches to Internet-based learning and the development of new tools in the instructional design of engineering education and training courses oriented towards the implementation of tasks. It is very effective as a means of providing timely and relevant information to learners.

The DIPSEIL course "Thermal Control of Electronic Equipment" was developed within the project "Engineering Education and Science for the Benefit of Business in the Design of Heat Transfer of Electronic Equipment". Multimedia training resources have been created for the course. The knowledge and experience that students will gain from this course is not limited only to applications to current electronic systems, but also to future technologies. The course will be offered as an elective course for PhD and Master's students in "Telecommunication and Information Systems" and "Informatics and Computer Engineering" in the academic year 2019/2020. To achieve the goal of the project, the following future activities are planned:

• PhD students create a 3D computer model of a real prototype of an electronic system provided for the project purposes by an electronics manufacturing company. The modeling will be carried out using the specialized FloTHERM software. The assessment of the accuracy of the simulation results will be carried out through experiments involving contact and non-contact temperature measurements of the working prototype. Experimental procedures will include measuring contact temperature by thermocouples and non-contact measurement by infrared thermography. For this purpose, the non-destructive method of thermographic diagnostics with a thermal imaging camera FLIR will be used.

• The results of the evaluation of student projects in DIPSEIL will be analyzed. The developed thermal models of electronic equipment prepared by PhD students will be evaluated. From the results obtained, conclusions will be drawn about the level of students' achievements and the degree of use of the knowledge, skills and competencies set out in the requirements of the curriculum.

26. USING QR CODES IN DENTAL PRACTICE
N. Kafadarova, S. Stoyanova-Petrova, N. Mileva, D. Stoyanova

Quick Response (QR) codes are two-dimensional barcodes that are used to encode and decode information. QR codes can have a wide range of applications in various aspects of dentistry. They can be used as a tool in dental education, product promotion, and practice management. By scanning the QR code, the dentist can access clinical information and diagnostic support through easy access to online medical and dental textbooks, trusted videos, professional guidance, drug references, and dental material information and instructions.

This study analyzed dentists and patients' perceptions of the effectiveness of using QR codes in everyday dental practice. The study was conducted over a period of 3 months in 2018 among 4 dentists and 46 of their patients. QR codes were placed near dental products, materials or tools in the workplace. Dentists used QR codes to link to short videos that are useful as tips for successfully completing dental treatment with specific new tools and common mistakes, thus contributing to patient safety. In addition, they were used to show patients in advance the different procedures and their sequence that are necessary for successful treatment. In order to take advantage of the time that patients pay on their mobile devices while waiting in the dentist's office, QR codes were also placed in the waiting rooms in order to increase patients' knowledge about the latest innovations and new technologies in dentistry. Two types of questionnaires were used to collect qualitative data, completed by dentists and patients respectively. The results undoubtedly demonstrate the positive attitude towards the use of QR codes in everyday dental practice and the confidence that QR codes are the cheapest way to draw patients' attention to the latest innovations in dentistry.

Most of the patients have very positive and encouraging feedback on the use of QR codes in daily dental practice. QR codes were well received, and patients preferred to use them over traditional methods of obtaining information about dental treatment.

On the other hand, the clinic's dental staff was highly satisfied with the QR codes and multimedia materials. Although this study did not demonstrate significant differences in dentists' satisfaction when using QR codes in their clinic, the results demonstrated generally high levels of acceptance of the effectiveness of QR code technology, as well as positive feedback on ratings.

Overall, the use of QR codes has been a creative and positive way to integrate technology into dental practice to provide patients and dentists with instant insights. The inclusion of emerging technologies supports dentists with clinical reasoning skills to facilitate higher levels of practice. By providing online resources that can be accessed at any time, dentists can access the information in a timely manner that meets their individual needs.

27. OUR EXPERIENCE IN USING DIPSEIL E-LEARNING SYSTEM AND QR-CODES IN TEACHING "ANALOGUE CIRCUITS" DURING COVID-19 PANDEMIC
N. Mileva, D. Stoyanova, N. Vakrylov, S. Stoyanova-Petrova, N. Kafadarova

The COVID-19 pandemic has affected education systems around the world. To prevent the virus from spreading widely, most governments have closed educational institutions, which has led to a rapid rise in e-learning and distance learning.

In this article, we present our experience in teaching "Analog Circuits" at the University of Plovdiv during the coronavirus pandemic. From the beginning of March to the end of June, the university suspended all face-to-face classes and switched to online learning. Only some laboratory exercises remained face-to-face, but were postponed until mid-July. The DIPSEIL e-learning system, QR codes, and smartphones were used as learning tools. Our team has more

than ten years of experience in implementing a performance-oriented approach through the use of the DIPSEIL learning management system and more than five years of practice in the use of QR codes in education. DIPSEIL is a distance learning platform in which course content is based on learning tasks. The courses are structured to provide individualized online access to all necessary information, instructions, tips, tools, and software to allow the student to complete a task with minimal support from teachers. The forum tool allows students and teachers to exchange ideas and participate in a discussion about learning assignments and course content. QR codes were used during the face-to-face laboratory exercises. They were printed and attached to apparatus or educational training kits. By scanning QR codes, students can access short how-to videos that provide:

- instruction manual for some of the meters;
- refreshing the main theory just in time;
- Step-by-step instructions for conducting the laboratory exercise.

Observations, questionnaires and reflections of students are used to collect data. Most students report a positive experience from the entire online training in "Analog Circuits". They believe that the DIPSEIL system is stable, but there is a delay in receiving feedback from teachers. All students are confident that QR codes have helped them refresh their knowledge and complete lab exercises faster.

The academic year 2019/2020 was a challenge for both students and university staff. Most students report a positive distance learning experience in this course. They believe that the DIPSEIL system is stable, but there is a delay in receiving feedback from teachers. The majority of students are convinced of the usefulness of QR codes in face-to-face laboratory exercises. They believe that QR codes have helped them refresh their knowledge and increased their confidence in working with laboratory equipment. According to the observations of teachers, the developed multimedia resources, accessible through QR codes, help students perform laboratory exercises faster and more accurately.

28. IMPROVING THE SOCIAL INCLUSION OF CHILDREN WITH VERBAL COMMUNICATION BY USING A TESI TOOL: PILOT RESULTS
Diana Stoyanova, Nadezhda Kafadarova, Silvia Stoyanova-Petrova, Nevena Mileva

In this article, we present the results of a pilot study of the TESI project – Adaptive Personalized System for Creating Expressive Tools in the Social Inclusion of Learners with Verbal Communication Difficulties. The TESI project focuses on the social integration of people with verbal communication disorders who are at risk of social isolation. The international project TESI is implemented in 2018 - 2019. Within the framework of the project, an adaptable, accessible and easy-to-use software application called TESI Tool has been developed. The TESI Tool helps children with different types of verbal disorders (children with Down syndrome, intellectual difficulties, speech and language disorders, autism) in their daily lives, at the school or center where they study. The role of TESI is to help these children express themselves, to support their interaction with parents and teachers. This is a prerequisite for the formation of skills and the acquisition of certain knowledge, tailored to their capabilities. The pilot experiments were carried out with four target groups:

A. TESI users:
   o Children with language difficulties, most of whom are pupils in special schools, and migrants with language difficulties (both children and adults);
   • Young people with difficulties in social integration – refugees.
B. Teachers and other professionals working with TESI users from target group 1
C. Parents/guardians of children with language difficulties from the target group;

D. Students from the three partner universities studying social work or pedagogy – future teachers.

The results of the pilot experiments with the target group show that the TESI tool can support the education of children with special educational needs. It helps these children communicate and improves their expression skills. It can contribute to their socialization and integration into society. For target groups 2 and 3, the main result is improved communication with people with verbal impairments. Students from target group 4 report that their experience in working with children with disabilities is of great benefit to their professional development.

The results of the pilot experiments with target group 1 identify the following benefits of working with the TESI application:

• Enriching the vocabulary with words and concepts in the field of eating, dressing, playing, health, shopping, moving in a familiar environment, public transport, communication in the family, communication at school and with strangers, the learning process;

• Achieving the correct pronunciation of difficult sounds, including them in words and expressions;

• Development of emotional security necessary for communicative activities;

• Improving the persistence of attention, achieving better concentration;

• Development of thought processes and memory;

For target groups two and three, the main result is the improvement of communication with people with verbal impairments. Students from target group 4 report that their experience in working with children with disabilities is of great benefit to their professional development. All students are convinced that they will recommend the use of mobile technologies and especially the TESI Tool in the education and support of children with disabilities.

29. EVALUATION OF THE APPLICABILITY, EFFICIENCY AND QUALITY OF PHD STUDENTS' THERMAL DESIGN PROJECTS BY BUSINESS
N. Kafadarova, S. Stoyanova-Petrova, D. Stoyanova

A modern trend in the production of electronic equipment is the shortening of the time to market with an increasing focus on the speed of product development. On the other hand, the constant decrease in the size of electronic components and the degree of integration causes heat stress, which can lead to damage to electronic devices. Therefore, it is necessary to find an adequate thermal control method that improves heat transfer in the electronic system and effectively removes heat dissipated by electronic components. It became necessary to provide electronic design engineers with models and methods for the design of heat transfer during the conceptual phase of electronics design.

The article presents the results of the evaluation of thermal models of electronic systems developed by PhD students within the scientific project "Engineering Education and Science for the Benefit of Business in the Design of Heat Transfer of Electronic Equipment" at the University of Plovdiv, which was launched in May 2019. The evaluation of the developed projects was made by business representatives through methods proposed by the company and questionnaires developed by them. These methods were supposed to assess the key competencies of PhD students in the field of thermal management, which are defined by the business. The company participants who developed the questionnaires and conducted the interviews evaluated the three projects, focusing on the three main criteria for optimizing the design process: applicability of the models, efficiency of the design process, quality of products. Finally, the results were described and interpreted separately for each participant.

From the results obtained, a conclusion is made about the level of achievement and the degree of assimilation of the knowledge, skills and competencies set out in the requirements of the curriculum. The most successful model is selected that shows the degree of preparation of

this PhD student to develop product designs that meet the specifications for performance, price and schedule. Based on the training set out in the project, PhD students will be able to perform conceptual design and thermal analysis (CFD), prepare project sketches, models and drawings; choose materials; and the development of specifications of systems, subsystems and components.

30. OUR EXPERIENCE IN STUDENTS TRAINING IN THE ENGINEERING DISCIPLINE "THERMAL DESIGN OF ELECTRONIC EQUIPMENT" UNDER LOCKDOWN
N. Vakrylov, N. Kafadarova, D. Stoyanova

In this article, the authors share their experience in distance learning of students from the University of Plovdiv in the engineering discipline "Thermal Design of Electronic Equipment" in an emergency situation related to Covid-19. The possibilities for training and accumulation of knowledge in the field of engineering by performing scientific work related to the study and optimization of the temperature of a stable current generator are demonstrated. High operating temperature is one of the main factors in the occurrence of failure of electronic systems. Therefore, identifying the thermal behavior of electronic components during the design phase is crucial to ensure reliable operation without the risk of overheating. A large range of expensive thermal diagnostic tools and laboratories with specialized equipment are usually used to determine the thermal behavior of electronic systems. At the current critical moment, in response to the coronavirus pandemic, students are using an Internet-based approach to design and access fully web-based CFD (Computational Fluid Dynamics) software tools to create virtual models and test various structural modifications of electronic equipment from home, without physically visiting specialized laboratories of the discipline "Thermal Design of Electronic Equipment" at the university. With the support of their academic mentors, students conduct in-depth thermal analyses that allow them to gain knowledge related to heat transfer and thermal effects, as well as the thermophysical properties of materials used in electronic systems. Based on the obtained quantitative temperature estimates at various points of interest, technical solutions are proposed to optimize the cooling of a virtual test model of a stable current generator. Having gained sufficient knowledge about the mechanisms of heat transfer through virtual models, the students prepared a physical prototype of the device with various cooling options. The prototype of the stable current generator contains a small number of electronic components and a simple circuit so that it can be made by students at home. Then, using a mobile infrared camera, the students performed thermal diagnostics of the stable current generator prototype and designed cooling solutions to verify and verify the results and heat transfer patterns in the structure obtained through virtual simulation instruments. Through the thermal analyses and experimental measurements, a significant decrease in the temperature of a powerful bipolar transistor, which is the main source of heat of the stable current generator, has been achieved. Heating this transistor during normal operation is crucial for the reliable operation of the device. The applied approach allows students to fully conduct their studies in the discipline "Thermal Design of Electronic Equipment" safely, despite the difficult conditions of the coronavirus pandemic.

With the support of their academic mentors, in this difficult time, students acquire knowledge on how to:

• Application of infrared thermography in the thermal design of electronic equipment.

• Work with specialized software for modeling and simulation of the thermal behavior of test structures.

• Modeling different designs of cooling radiators and how to evaluate their thermal efficiency so that there is no danger of overheating.

• Verification and verification of the results obtained from numerical modeling and simulations of heat transfer of a test structure by infrared thermographic measurements.

The proposed training approach allowed students in emergency situations to acquire sufficient knowledge in the field of thermal design of electronics.

31. USING QR CODES IN THE TELECOMMUNICATION LABORATORY
Diana Stoyanova, Nikolay Vakrylov, Silvia Stoyanova-Petrova, Nadezhda Kafadarova, Nevena Mileva

Laboratory work plays a very important role in the training of telecommunications engineers. It develops students' technical thinking, the ability to transfer knowledge learned from lectures to solve practical problems in the field of telecommunications. Lab work is time-consuming for educators. Sometimes professors spend much more time explaining the lab setup than discussing the results of the experiments. On the other hand, students' lack of knowledge about the proper handling of laboratory equipment can lead to the failure of the experiment. This article presents our experiment for the use of QR codes in the telecommunication laboratory of the University of Plovdiv "Paisii Hilendarski". The integration of QR codes into laboratory work aims to: reduce explanation time, reduce mishandling of laboratory equipment, increase the efficiency of students' laboratory work. With QR codes placed next to the apparatuses or educational mock-ups for learning, students can access short instructional videos that provide:

- information on the procedure for the operation of laboratory equipment;
- basic theory;
- step-by-step instructions for conducting the experiment.

Observations, reflective analysis of the learning process and questionnaires are used to collect data. The results are very satisfying: using QR codes, students complete their lab tasks faster and more correctly, appreciate highly developed video resources, and support the use of QR codes in the classroom.

This study investigated the use of QR codes in the telecommunications lab. Although there was no statistically significant difference between the achievements of students in the experimental and control groups, the results of direct observations were positive. With the help of QR codes, students complete their lab assignments faster and more correctly. The results of the questionnaire show that students appreciate highly developed video resources and support the use of QR codes in laboratory work. This gives us reason to assume that QR codes have the potential to be used in laboratory exercises.

32. THE TESI PROJECT: IMPLEMENTATION AT PLOVDIV UNIVERSITY WITH STUDENTS – FUTURE TEACHERS
N. Kafadarova, D. Stoyanova, S. Stoyanova-Petrova, N. Mileva

The TESI project focuses on the social integration of people with verbal communication disorders who are at risk of social isolation. It is dedicated to conceptualizing and developing social competence related to the personal, social and professional development of people with verbal communication disorders by creating an adaptive, accessible and easy-to-use software system (TESI Tool) that will enrich their opportunities for personal expression.

TESI Tool uses visual cues to help users overcome their communication deficiencies. Visual cues are stored in a common library and shared between users and caregivers registered in the system. Users can create so-called expressions and instructions by arranging these visual cues on the screen of a tablet or smartphone.

In this article, we present the result of the implementation of the TESI project at the University of Plovdiv with students – future lecturers. Students who are studying to become teachers are the fourth target group in the TESI project. According to the pre-established criteria, 10 students were selected to participate in the pilot project. After initial training in using the TESI Tool, these students experimented to work with children with hearing impairments at the Sofia University for Hearing Impaired Children "Prof. Dr. Stoyan Belinov", Plovdiv with the help of this software. Our research shows that the decision to include students – future teachers in the project is correct. They all believe that their experience in working with children with disabilities is of great benefit to their professional development. As future teachers, they recommend the use of mobile technologies and especially the TESI Tool in the education and support of children with disabilities. It can contribute to their socialization and integration into society.

At the end of the pilot project, the ten students were interviewed again to determine their attitude towards the TESI Tool. They all believe that their experience in working with children with disabilities is of great benefit to their professional development. As future teachers, they recommend the use of mobile technologies and especially the TESI Tool in the education and support of children with disabilities.

33. THERMAL DESIGN: BASIC STAGES, PROBLEMS AND SOLUTIONS
Nikolay Vakrilov Vakrylov, Nadezhda Miteva Kafadarova

The article discusses the stages in the development of a project in the field of thermal design and how to reduce possible risks in the initial stage of product development for thermal engineers. An approach is proposed to evaluate the thermal efficiency of three test PCB structures through CFD modeling and simulations of heat transfer processes. The thermal regime of a COB LED module with a cooling radiator designed for it is predicted by CFD simulation. Experimental measurements were carried out with a prototype of the COB LED module, which showed good compliance with the results of the simulations.

The article examines the stages in the development of a project in the field of thermal design and possible scenarios for reducing the risks associated with high temperature. An approach including thermal modeling and simulations for evaluating the thermal behavior of printed circuit boards of different geometric dimensions and topology is proposed. Based on the thermal simulation data, the PCB with optimal thermal performance was found. The study offers an approach based on thermal modeling and simulations to evaluate the thermal efficiency of a heat sink designed to cool a high-power COB LED module.

Non-contact thermal measurements were made using infrared thermography to evaluate the accuracy of results obtained with computer simulation tools. The results of infrared thermography show sufficient accuracy and prove that simulations are an indispensable tool in the thermal design of electronics.

34. NUMERICAL THERMAL ANALYSIS OF THE PCB CONSTRUCTION IMPACT
Nikolay Vakrylov Vakrylov, Diana Velkova Stoyanova and Nadezhda Miteva Kafadarova

This study presents CFD-based computer modeling and thermal simulations for temperature quantification and diagnosis of critical fields with a higher risk of failure in DC-DC converters. During thermal analyses, the influence of structural and technological factors on the substrate is assessed: the percentage of fillers, the thickness of the inner copper layers. Thermal analyses were carried out at different ambient temperatures and extreme heat loads.

The present research focuses on heat transfer problems in the DC-DC converter board by using thermal simulations. The thermal analyses carried out show that:

- The high filler content of FR4 pads helps reduce the temperature of components in areas subjected to high thermal stress, even at extreme ambient temperatures.
- The thickness of the inner copper layers does not significantly affect the heat transfer processes in the volume of the board.
- The DC-DC converter can operate in a stable and reliable manner even under maximum load.

35. PILOT RESULTS FROM UNIVERSITY – BUSINESS COLLABORATION IN TEACHING "THERMAL MANAGEMENT OF ELECTRONIC EQUIPMENT" COURSE
Diana Stoyanova, Silvia Stoyanova-Petrova, Nadezhda M. Kafadarova, Nevena S. Mileva and Nikolay Vakrylov

The article presents the pilot results of teaching a course "Thermal Management of Electronic Equipment" at the University of Plovdiv. The course curriculum is prepared in conjunction with the business. The results were positive: students highly appreciated the quality and relevance of the course and showed a "very good" average learning outcome in DIPSEIL. During the pilot project, PhD students developed thermal models of a real electronic system. Business
The representatives highly appreciated these models, which is indicative of the quality of the course.

The overall evaluation of the course "Thermal Management of Electronic Equipment" was made by:

• The results of the assessment of students' skills and knowledge in DIPSEIL;

• The results of the questionnaire filled in by the students for assessment of the quality and relevance of the course;

• The accuracy of the developed computer models of a real electronic system created by a company in the field of electronics.

The results of the evaluation questionnaire showed that the students have a positive attitude towards the developed course "Thermal Modeling and Characterization of Electronic Systems". They believe that the course content is up-to-date and aligned with the objectives of the course. They believe that this has contributed significantly to their professional growth and the development of the skills needed by professionals in the field of heat management. The average learning outcome of students in DIPSEIL is very good. The business representatives appreciated the highly developed thermal models of real electronic systems, which is especially indicative of the quality of the course.

36. UNIVERSITY – BUSINESS COLLABORATION IN TEACHING THERMAL MANAGEMENT OF ELECTRONIC EQUIPMENT
Nadezhda Kafadarova, Diana Stoyanova, Silvia Stoyanova-Petrova, Nevena Mileva, Veselin Mengov

The reduction in the size of modern electronic systems, combined with a significant increase in heat dissipation, requires the development and use of original and innovative thermal models aimed at effectively reducing the impact of heat. Taking into account the need to train specialists in the field of thermal control of electronic equipment, we developed the project "Engineering Education and Science for the Benefit of Business in the Design of Heat Transfer of Electronic Equipment" at the University of Plovdiv, which was launched in May

2019. One of the main objectives of the project is the development of a course "Thermal Control of Electronic Equipment", which is offered as an elective subject for PhD and Master's students.

The course curriculum has been developed in collaboration with business representatives, giving them the opportunity to actively participate in the training of future thermal design specialists. The course is uploaded to the web-based performance support environment DIPSEIL. DIPSEIL focuses on the learner's activity and self-learning, aided by assignment instructions, educational materials, additional resources, and expert advice. A plan has been developed to assess the acquired knowledge and competencies of PhD and Master's students in the field of heat transfer in electronic equipment as a result of the use of an e-learning environment.

The assessment will be carried out in two stages: in the first stage, university professors will evaluate the achievements of students according to the results of their studies during the course. At the second stage, business representatives will evaluate the quality of education based on thermal models developed by students.

The study started with a needs analysis and a description of the profile of the target groups with their main characteristics. We conducted a study and summary of the key competencies, knowledge and skills required by employers for the position of "Thermal Design Engineer for Electronic Systems" and determined the preliminary knowledge and expectations of the students from the course. The activities in the study are aimed at ensuring and improving the quality of training of PhD and Masters students from the University of Plovdiv, increasing their practical training in the field of designing electronic equipment for heat exchange and creating digital thermal models.

37. RESULTS FROM THE PILOT EXPERIMENTS WITH PHD STUDENTS WITHIN THE PROJECT „ENGINEERING EDUCATION AND SCIENCE FOR THE BENEFIT OF BUSINESS IN THE DESIGN OF HEAT TRANSFER OF ELECTRONIC EQUIPMENT"
Nadezhda M. Kafadarova, Silvia V. Stoyanova-Petrova, Nikolay Vakrylov and Diana Stoyanova

The article presents the results of the pilot experiment with PhD students within the scientific project "Engineering Education and Science for the Benefit of Business in the Design of Heat Transfer of Electronic Equipment" at the University of Plovdiv. A company in the field of electronics gave three PhD students a project on the topic: "Thermal Design and Simulations of Heat Transfer of a Desktop Computer System". During the pilot experiment, PhD students developed a thermal model of a desktop computer.

During the pilot experiment, three PhD students developed a thermal model of a desktop computer system. This project was assigned to PhD students by a company in the field of electronics. Modeling is carried out using the specialized FloTHERM software. The assessment of the accuracy of the simulation results is carried out through experiments involving contact temperature measurement with thermocouples and non-contact measurement using a FLIR thermal camera.

The quality of the developed thermal models was evaluated by business representatives using a list of control criteria. The final result is formed taking into account:

• Developed a thermal model of a desktop computer system;

• Accuracy of simulation results performed by experiments with contact or non-contact temperature measurement;

• Competencies of PhD students in thermal modeling, assessed through a short interview. The final result of all PhD students was excellent.

The quality of the developed thermal models was evaluated by business representatives using checklist criteria. The final result is formed taking into account:

• Developed a thermal model of a desktop computer system;

• Accuracy of simulation results performed by experiments with contact or non-contact temperature measurement;

• Competencies of PhD students in thermal modeling, assessed through a short interview.

The final result of all PhD students was excellent.

38. APPLICATION OF INFRARED IMAGING IN THE FIELD OF ELECTRICAL ENGINEERING
Nikolay Vakrylov, Nadezhda M. Kafadarova and Delko A. Zlatanski

The paper presents how infrared thermography can be used in the field of electrical engineering to monitor the thermal behavior of electrical machines to detect potential weaknesses and malfunctions. In laboratory conditions, thermographic measurements of an electric generator for direct current under different operating modes were made on a test model and its thermal characteristics were analyzed to improve reliability.

The research in this article presents the application of infrared thermography in the field of electrical engineering to carry out inspections of the condition of electrical equipment during its operation.

In controlled laboratory conditions, infrared diagnostics of a DC generator is performed in different operating modes.

The thermal analyses carried out show the problem areas with high thermal load to select the optimal mode of operation of the DC generator and improve reliability.

39. DEVELOPMENT OF WEB INTERFACE FOR A REMOTE ACCESS TO TELECOMMUNICATIONS LABORATORY
V. Mengov, S. Sotirov, N. Kafadarova

In this article, we share our experience in creating a remote laboratory in the discipline "Fundamentals of Telecommunications" for students of the Bachelor's degree in Engineering at the University of Plovdiv.

In the current context of the COVID19-year pandemic, the development of strategies for the implementation of ICT in education is becoming increasingly important. One of the areas we are working on is the creation of remote laboratories for educational purposes. They can be used not only in distance learning, but also in traditional learning. Among the advantages offered by remote laboratories are the possibility of unlimited access both in time and on site, safety during experiments and laboratory exercises, access to unique equipment. The remote laboratory is a real laboratory that allows for control and monitoring of the object of study and the measuring instruments and equipment used, and remote access is carried out through the telecommunication network. In this article, we present a system for remote access to training resources in communication technologies, created by a team of the University of Plovdiv to meet the new conditions for distance learning during COVID19 crisis. The remote laboratory developed for this purpose includes three new laboratory experimental installations for the implementation and study of amplitude modulation, pulse-code modulation and pulse-width modulation, two functional DDS generators based on IC ADS9833 and the inclusion of the GWInstek GSD-2000A measuring digital oscilloscope in the circuits. The main parameters of the signal - form, frequency, generator control and amplitude can be changed. The designed hardware is powered through the USB port of the personal computer. In this article, we present

in detail the web-based interface through which remote access to the newly developed hardware and measuring equipment in the Laboratory of Fundamentals of Telecommunications is carried out. It visualizes in graphical form the results obtained from the measurements. For the development of the web interface, python and javascript libraries were used, containing functions through which control commands are transmitted to laboratory experimental installations and measuring equipment. The interface is adapted to execute the required set of commands to the digital oscilloscope and function generator. It is possible to send additional commands to the oscilloscope. The interface also provides access to the necessary theoretical information for measurements, as well as a user manual for operating the oscilloscope. A PyVISA driver is used to connect the laboratory server to the oscilloscope. During the laboratory exercises, students have the opportunity to change different signal characteristics (shape, frequency, amplitude) of the carrier and modulating signal.

The results of laboratory measurements are plotted graphically using a Python bokeh library. The developed system allows students to fully perform their laboratory exercises in the discipline "Fundamentals of Telecommunications" safely in the difficult conditions of COVID19 pandemic.

This article presents a system for remote access to training resources in communication technologies and the development of a web interface for remote access to a telecommunication laboratory, created by a team of the University of Plovdiv in response to the new conditions for distance learning during COVID19 crisis. The team aims to improve the quality of the learning process; to support self-learning and provide conditions for distance learning. Through the established system for remote access to learning resources and a telecommunication laboratory, students can perform their exercises without being present in the laboratory. Working with real measuring equipment improves their engineering training.

40. NEW TRENDS IN ONLINE TEACHING-LEARNING IN "ELECTRICAL ENGINEERING" HIGHER EDUCATION COURSE DURING A PANDEMIC
Silvia Stoyanova-Petrova, Diana Stoyanova, Nadezhda Kafadarova, Sotir Sotirov, Nevena Mileva

In today's society, engineers work in a complex professional environment that requires them to constantly improve their knowledge, skills, and competencies. The training of such specialists requires the introduction of innovative methods in education. These methods should develop students' skills based on a thorough understanding of engineering and scientific principles. The development of ICT in recent years provides great opportunities to improve existing teaching methods in higher education.

In this article, we present the project "New Trends in Electrical Engineering Training in the Context of a Pandemic".

The main goal of the project is the implementation of innovative methods and tools in the training of "Electrical Engineering" for engineering specialties in the context of a pandemic. The achievement of the goal is carried out through the implementation of the following tasks:

1. Development of a course "Electrical Engineering" in the project-based e-learning system DIPSEIL. This includes:
- a. Development of technology (a set of methods, forms and means) for the implementation of distance and/or blended (distance and face-to-face) training in the specialty "Electrical Engineering".
- b. Equipping a modern electrical engineering laboratory: developing new laboratory models for electrical engineering training and purchasing new measuring instruments.

- c. Development of multimedia training resources for the course "Electrical Engineering", namely:

  §Multimedia resources related to the theory of each of the tasks in the course.

  § Multimedia resources related to the methodology for simulations of electrical circuits through Multisim ™.

  § Video files demonstrating how laboratory exercises are conducted. Video files that serve as a guide for working with measuring equipment. Video files will also be available via QR code during in-person hours.

2. Pilot experiment with students and analysis of the learning outcomes obtained.

The research of the project is aimed at meeting the needs of the two target groups (students and teachers):

- Using innovative teaching methods, students gain knowledge and experience in terms of designing electrical circuits and working with modern measuring equipment, which is a necessary prerequisite for their future implementation.
- The developed technology for the application of distance learning in "Electrical Engineering" can be used both by teachers of electrical engineering and by teachers of other engineering disciplines (e.g. analog and digital circuits).

The planned research is in the field of ensuring and improving the quality of education of students at the University of Plovdiv and increasing their practical training in electrical engineering through the application of innovative teaching methods. Through the planned activities, students will gain knowledge and experience in terms of designing electrical circuits and working with modern measuring equipment, which are necessary prerequisites for their future implementation. After the pilot experiment, a survey of students' satisfaction with the training in "Electrical Engineering" will be conducted. The main purpose of the survey is to investigate their opinion whether the training is adequate to their previous expectations. The results of the evaluation of the projects prepared by the students in the DIPSEIL system will be analyzed. From the results obtained, a conclusion will be made about the level of achievements and the degree of acquisition of knowledge, skills and competencies set out in the requirements of the curriculum.

41. TEACHING "ELECTRICAL ENGINEERING" DURING THE LOCKDOWN- EXPLORING TEACHERS' AND STUDENTS' PERCEPTIONS ON HOW TO IMPROVE IT

D. Stoyanova, N. Kafadarova, S. Stoyanova-Petrova, S. Sotirov, N. Mileva

The COVID-19 pandemic has changed the way we live, communicate, work and learn. Given today's situation, it is almost certain that distance and blended learning will become the new traditional teaching models.

In this article, we present the results of the survey among 10 lecturers and 74 students regarding their opinion on distance and/or blended learning in the fundamental engineering discipline "Electrical Engineering" – Part I and Part II. The online survey was conducted within the framework of the project "New Trends in Electrical Engineering Training in the Context of a Pandemic. The results of the survey show that most students rate the quality of online lectures highly but are not satisfied with online lab classes. Both students and lecturers believe that the reduced number of face-to-face laboratories is not enough to develop solid practical skills in electrical engineering, which will inevitably affect the future professional career of students. To improve the Electrical Engineering curriculum, we enlisted 55 first-year students to fill out a preliminary questionnaire to identify their prior knowledge and expectations for the course.

The results show that students expect a more practice-oriented teaching process. All of them prefer practical training to theoretical training.

Based on the responses of the surveyed teachers and students, the project team developed the educational technology for distance and/or blended learning in Electrical Engineering to make training more effective, efficient and flexible in the context of a pandemic.

In order to improve distance and/or blended learning in the specialty "Electrical Engineering", Plovdiv Paisii Hilendarski launched the project "New trends in the training of "Electrical Engineering" in the context of a pandemic". The main objectives of the project are:

• Improvement of the existing curriculum in the specialty "Electrical Engineering";

• Development of educational technology for distance and/or blended learning in Electrical Engineering.

During the "Needs Analysis" phase of the project, two studies were carried out. The first was conducted among first-year students to identify their previous knowledge and expectations for that course. The results show that students expect a more practice-oriented teaching process. All of them prefer practical training to theoretical training. The second survey is aimed at the opinion on distance and/or blended learning in "Electrical Engineering" – Part I and Part II of lecturers and students from the Faculty of Physics and Technology of the University of Plovdiv. The results of the survey show that most students rate the quality of online lectures highly but are not satisfied with online lab classes. Both students and lecturers believe that the reduced number of face-to-face laboratories is not enough to develop solid practical skills in electrical engineering, which will inevitably affect the future professional career of students.

Based on the responses of the surveyed students and teachers, the project team will develop the educational technology for distance and/or blended learning in Electrical Engineering to make training more effective, efficient and flexible in a pandemic.

42. INFRARED THERMOGRAPHY AS A USEFUL TOOL IN ELECTRICAL ENGINEERING TRAINING
Nikolay Vakrylov, Nadezhda Kafadarova

Engineering education faces a number of challenges in preparing qualified professionals for the long-term needs of today's wide-ranging industry. For the preparation of future specialists, it is necessary to apply innovative training methods, along with more laboratory work related to solving real problems in practice. In recent years, with the development of information technologies for the training of future engineers, there has been an increasing reliance on computer-based methods to perform routine activities such as design, simulation and verification, etc. Most students acquire enough knowledge to work in an electronic environment, but there is less and less practical component in the educational process.

In addition to computer-aided design methods, students studying in electrical laboratories should be more involved in working with specialized measuring equipment, as well as in applying innovative diagnostic and monitoring tools to machines and equipment. This article focuses on the use of infrared thermography in engineering education as a diagnostic preliminary method for detecting problems and defects in electrical equipment. Thermography is implemented in electrical engineering courses, where the main aspects of the theory and practice of thermography are taught as part of the engineering and technological research programs at the Faculty of Physics and Technology of the University of Plovdiv "Paisii Hilendarski", Bulgaria.

After training students to work with specialized thermographic equipment, thermal diagnostics was performed, which helped students identify the location of potential problem

areas and understand that thermal anomalies are a prerequisite for detecting malfunctions in electrical equipment and machinery. Students are trained to use specialized software, through which they have acquired enough practical knowledge to process infrared images in thermal analysis.

The applied approach allows to acquire in-depth knowledge of fundamental engineering disciplines by discovering a causal relationship between the theory in the teaching materials and the physical processes in reality. In this way, students' interest in difficult engineering disciplines is preserved and their motivation and learning outcomes are improved.

Students who have completed the course have acquired the following knowledge:

• How to apply infrared thermography to detect faults in industrial environments by monitoring the thermal behavior in electrical equipment and machinery.

• What are the factors that affect the accuracy of infrared measurements?

• How to use Flir's specialized ResearchIR software to detect thermal anomalies.

• How to perform infrared diagnostics to detect hidden malfunctions and defects.

In order to prepare well-trained personnel for the industry, the emphasis in student training should be the strong connection between theory and practice. Only in this way can it be ensured that graduating students will be able to adapt well to the professional environment with rapid technological changes and high competition.

43. TEACHING 5G PRINCIPLES TO STUDENTS IN A PANDEMIC
Nikolay Vakrylov, Nadezhda Kafadarova, Tihomir Lovchaliyev

Next-generation 5G mobile networks are essential for growth in many sectors of the European economy and around the world. 5G networks promise exponential progress in many high-potential sectors such as self-driving vehicles, virtual reality, ultra-high-definition (UHD) video transmission, connected healthcare (a model for managing and delivering healthcare through remote healthcare delivery), and many other innovative services. The rapid progress in mobile technologies poses a number of challenges in the training of qualified specialists, which deepens Europe's lagging behind in this area. On the other hand, the Covid-19 pandemic and social distancing have affected all segments of society, including education. In order to maintain the necessary level of education that they provide to students, universities must quickly adapt to the situation.

This article presents the experience of the University of Plovdiv in the training of specialists in the field of 5G technologies in the context of the Covid-19 pandemic. Due to social restrictions during a pandemic, an online course was developed for telecommunications students that provides an in-depth overview of 5G scenarios and 5G services defined by the International Telecommunication Union (ITU-R). A project-based approach was used in the training of students, which allows students to learn what are the scenarios for using 5G, namely Enhanced Mobile Broadband (eMBB), ultra-reliable low-latency communication (URLLC) and massive machine-type communication (mMTC), among others.

Through the applied online approach, students gain in-depth knowledge of how they can categorize 5G services and how they can address some key challenges to improve efficiency, expected key metrics for high data rate, low latency, and high reliability. In this way, successful graduates will be ready to meet the new challenges in the field of the latest generation of 5G networks and deal with new security issues.

In this article, we share our experience in developing a new course "Introduction to 5G Networks" for the needs of students studying telecommunications and their adaptation to e-learning, due to the profound changes in education related to the Covid-19 pandemic. Completing the course "Introduction to 5G Networks" allows students to improve their professional competencies by learning:

• The differences between current and 5G mobile networks.

• To solve problems related to providing low latency in 5G networks to cope with high data speed and volume.

• The opportunities and applications offered by 5G networks for many industries and economic sectors.

• Transmission of low-power data in small geographical areas through so-called small cells.

• Ways to configure, test and manage the 5G network.

• Solving cybersecurity problems.

In the future, the course curriculum will be adapted to changes in the development of 5G technologies in order to expand the capabilities and effectiveness of the training course. Only in this way will it be ensured that graduates will be well prepared for the dynamically developing telecommunications sector.

44. DEVELOPMENT OF HARDWARE MODULES FOR LABORATORY EXERCISES IN REMOTE TELECOMMUNICATIONS LABORATORY
V. Mengov, S. Sotirov, N. Kafadarova

Distance learning is becoming more and more modern and is the only alternative in many areas of higher education in the context of COVID19 pandemics and lockdown. In engineering education and in particular in the training of telecommunication specialties, a significant problem is the remote conduct of laboratory exercises. To acquire engineering knowledge, skills and competencies, students need to work with real meters, studying various parameters of telecommunication equipment. This necessitates the timely development of systems for remote access to real engineering laboratories in universities. Therefore, a team from the University of Plovdiv developed laboratory exercises for distance learning on the basics of telecommunications. These systems include new laboratory models, a methodology for remote training and a web-based interface for connecting to a personal computer, which are part of a system for remote access to a telecommunication laboratory.

In this article, we present the hardware part of the remote access system to the Telecommunications Laboratory and the methodology for remote conducting of the exercises. A model for a remote laboratory system has been developed, which is a hardware module consisting of: two functional generators ADS9833, a microprocessor board ARDUINO UNO, a specialized op-amp LM13700, digital analog switches CD4016. Through this module, amplitude modulation, pulse width modulation and pulse-code modulation can be realized and studied. When performing laboratory exercises, students have the opportunity to change various characteristics of the carrier and modulating signal (frequency, amplitude, shape). A real GWInstek GSD-2000A oscilloscope is used to measure the output signals. Remote access to all modules of the laboratory system is provided, and for this purpose specialized user software with a WEB interface has been developed. The software is installed on a personal computer, acting as a laboratory server, and communication between it and the model is carried out via a USB interface. The Arduino Uno microprocessor board is an essential part of the hardware of the laboratory model. It is used to communicate with the personal computer and to control the individual electronic modules of the laboratory model. ADS9833 digital generators are used to generate the carrier and modulation signal. The change in the amplitude of the two signals is carried out by a digital potentiometer MCP42010. The three integrated circuits are managed by Arduino. For this purpose, they are connected on a common digital bus with a serial SPI interface.

The methodology for performing laboratory exercises in the discipline "Fundamentals of Telecommunications" includes the following three steps: simulation of the specific

electronic circuit using an electronic simulator, study of the circuit parameters of the real laboratory model in the remote laboratory, comparison of the simulation results and actual measurements. In this way, students in engineering specialties will be able to acquire adequate knowledge from working with real models in the remote telecommunications laboratory.

The developed system for remote access to the Telecommunications Laboratory allows students to practice in a real laboratory environment in a pandemic, which will improve the quality of the learning process, support independent learning and provide conditions for adequate distance learning. Remote access to the Telecommunications Laboratory is a suitable tool for distance learning in the discipline "Fundamentals of Telecommunications" for current and future students, giving them the opportunity for flexible and personalized learning - 24/7, multiple repetition of real experiments according to the needs of students.

The next step in the team's work is to conduct a pilot experiment with students. The approbation will provide feedback on the quality of laboratory exercises and the degree of acquisition of knowledge, skills and competencies by students, thus leading to further optimization of the system for remote access to the Telecommunications Laboratory.

45. TEACHER TRAINING FOR TECHNOLOGY-BASED INCLUSIVE EDUCATION
Nevena Mileva, Nadezhda Kafadarova, Silvia Stoyanova-Petrova

A team from the University of Plovdiv focused their research interest on the educational inclusion of disadvantaged people such as people with disabilities, people in socio-economic situations and refugees, by training teachers so that they can actively work for the social inclusion of these groups of learners. In this article, we present our scientific work on conceptualizing and developing technical competence related to the professional development of students-future teachers and current teachers, so that we can create, perceive and use technological tools to enrich the educational opportunities of disadvantaged groups of learners.

The specific objectives of the research are:

A. Analysis of consumer needs in different contexts and existing curriculum in social work and pedagogy at the University of Plovdiv.

The study is aimed at assessing the degree of technology use by these groups of learners and identifying opportunities for their inclusion in technology-based training of disadvantaged groups of learners.

B. Design of a technology-based learning model (TLM) to support the didactic characteristics of technological learning to adapt to the learning conditions of disadvantaged groups.

C. Designing Educational Scenarios:
o Technology-based teaching as a result of the training in the curriculum of students-future teachers at the university.
o Technology-based training as a subject of qualification and pre-qualification programs of current lecturers at the university.

The next objective of the two scenarios is to improve the conditions for equal access to education and training by increasing motivation to participate in the educational process, by facilitating access and through additional activities with disadvantaged students at their place of study.

D. Development and adaptation of applications and digital educational resources.

This objective addresses the need to implement technology-based teaching, summarized in a number of disciplines in inclusive education and in institutions, the education and training needs of disadvantaged groups.

E. Strengthening the institutional capacity of the university through short-term intensive training of lecturers and staff.

The current development improves educational methods and practices by introducing an adaptive curriculum in teacher training, which is based on digital learning resources for mobile devices and is aimed at disadvantaged groups of learners. This takes into account issues such as equal opportunities, equal accessibility, and the promotion of the quality of education.

This development improves educational methods and practices by introducing an adaptive curriculum in teacher training, which is based on digital learning resources for mobile devices and is aimed at disadvantaged groups. The main innovation of the proposed study is through the inclusion of a new technological curriculum in teacher training in order to achieve improvements in the conditions for educational integration – through the use of mobile technologies (QRC, software solutions, augmented reality) to increase the motivation and participation of disadvantaged students in the educational process. The emphasis is placed on disadvantaged learners – groups at risk, whose ethno-cultural characteristics, special needs and socio-economic situation significantly limit the opportunities for adequate education for them. The integration of these groups depends mainly on their training and the knowledge they acquire, namely on the quality of education of future teachers. The technologies mentioned above facilitate memorization and learning by offering visual and audio stimuli and are therefore suitable for people with deficits.

The other innovation is also related to overcoming the imbalance between the availability of mobile devices and the inclusion of these tools and the methodology for their use for educational purposes in teacher training.

46. RESULTS FROM THE PILOT EXPERIMENT WITHIN THE PROJECT "NEW TRENDS IN ELECTRICAL ENGINEERING TRAINING IN A PANDEMIC"
Silvia Stoyanova-Petrova, Diana Stoyanova, Sotir Sotirov, Nadezhda Kafadarova, Nevena Mileva

The main challenge of engineering training is to create a strong link between theory and practice. Only in this way will new generations of engineers be able to adapt to the rapidly changing work environment. This was the reason why the University of Plovdiv "Paisii Hilendarski" launched the project "New Trends in Electrical Engineering Education in the Context of a Pandemic" in 2021. Project-based training, remote access to laboratory equipment, computer simulations via Multisim Live and QR codes were used to support practical classes in electrical engineering. Within the framework of the project, multimedia learning resources were developed, including: multimedia resources related to theory, instructional videos demonstrating how to conduct laboratory exercises or how to work with measuring instruments in the laboratory. Students can access these videos during in-person classes by scanning QR codes located on lab equipment or printed on students' lab materials.

In this article, we present the results of a questionnaire examining students' satisfaction with electrical engineering training. The study was conducted at the end of the pilot experiment in the first half of the 2021/2022 school year. It is attended by second-year students in the specialty "Information and Computer Engineering". The training is blended - 5 weeks in person and 10 weeks online. All practical classes are held in the modern electrical engineering laboratory equipped under the project. Over 80% of the surveyed students indicate that the developed educational materials in electrical engineering have helped them to complete laboratory tasks with minimal help from the teacher. The results showed that using QR codes during face-to-face lab sessions helped students work more confidently with lab equipment. Most of the students are satisfied with the quality of the remote control system of laboratory equipment. Almost 85% of them are of the opinion that practical exercises with Multisim Live

have helped them develop practical skills in simulating circuits and analyzing simulated results. Almost 75% of respondents believe that the course is consistent with their preliminary expectations, which is indicative of the quality of the training provided.

The results of the survey conducted at the end of the pilot experiment show the students' satisfaction with the training in the specialty "Electrical Engineering". They are convinced that the combination of distance and face-to-face learning is a very good option for conducting training in engineering disciplines during a pandemic. Almost 75% of respondents believe that the course is consistent with their preliminary expectations, which is indicative of the quality of the training provided.

The students' answers show their positive attitude towards the technologies used to support their practical training in Electrical Engineering: a project-based e-learning system, remote access to laboratory equipment, computer simulation via Multisim Live and QR codes. The results showed that using QR codes during face-to-face lab sessions helped students work more confidently with lab equipment. Almost 85% of them are of the opinion that practical exercises with Multisim Live have helped them develop practical skills in simulating circuits and analyzing simulated results.

Students are confident that remote access labs can be used successfully in addition to traditional face-to-face laboratory training. In this way, they will be prepared for the demands of the industry and the globalization of the workplace.

47. INFRARED MEASUREMENTS OF TEMPERATURE ANOMALIES IN ELECTRONIC DEVICES
A. Stoynova, B. Bonev, N. Kafadarova and S. Rizanov

The use of infrared techniques is accompanied by inherent difficulties, which often lead to a significant reduction in measurement accuracy. The electromagnetic signal emitted by the electronic device under study is quite complex, and the task of measuring temperature requires non-trivial solutions. When electronic devices are in the process of being evaluated and their respective heating data is analyzed - the analytical process is often aimed at "thermal anomalies". Within the framework of this article, a developed thermographic measuring system is presented. Its functional capabilities are described and experimental data are presented - the result of its use as part of a diagnostic system for integrated circuits; electronic modules and components; PCBs. Emphasis is placed on specific thermal imaging techniques aimed at increasing the accuracy of measurements. The necessary inputs for the uncertainty estimation shall be discussed. A series of experimental measurements of various electronic modules is presented as a means of illustrating the capabilities of the developed equipment.

The developed system and experimental measurements of various electronic modules for the identification of thermal anomalies are carried out jointly with several companies. Infrared measurements of thermal anomalies prove to be an effective tool when it comes to understanding and optimizing the thermal behavior of PCBs and that of various electronic components and modules. In addition to the corresponding heat distribution, the heat generation process can be tracked, diagnosed and documented over a longer period of time, thanks to radiometric video measurement and the ability to store a sequence of thermal images. The infrared camera sends the temperature change data directly to the computer. There the recording process can be analyzed. The main reason why infrared thermography is proving to be an increasingly powerful tool is that temperature data is available and can be estimated for every pixel of each thermogram. This means that thermal imaging data can be analyzed with high accuracy and, if necessary, optimize the thermal state of the monitored electronic device. Proper thermal management can be carried out by carefully selecting analytical steps on

measurement data, which are crucial for monitoring the development of major thermal processes.

48. INTEGRATING RESEARCH AND EDUCATION: "HYBRID AND FUSION PREDICTION OF THE FUNCTIONALITY OF ENERGY CONVERTING ELEMENTS" PROJECT
S. Stoyanova-Petrova, D. Stoyanova, N. Kafadarova, S. Sotirov

The prediction of SOH (health status) and RUL (residual useful life) of batteries is of considerable interest with great environmental and economic effect due to the continuous increase in their application areas aimed at improving people's quality of life and the use of green energy. This is the reason why research teams from two Bulgarian universities (Paisii Hilendarski University of Plovdiv and Technical University of Sofia) launched the project "Hybrid and Fusion Forecasting of the Functionality of Energy Conversion Elements". The project aims to create and theoretically substantiate new hybrid and fusion models for highly accurate predictive estimation of the performance and resource of energy-converting cells, in particular batteries.

The scientific objectives of the project will be realized through the use of new and innovative methods:

• Innovative techniques for measuring and processing battery parameters needed to create hybrid and fusion models and deep learning of a neural network:

    o Applying approaches to increase the accuracy of measurement;

    o A modern method for processing and analyzing the data obtained from thermal imaging images and determining the rate of temperature rise at a given point - design and development of specialized software.

• Innovative software method for determining the degree of battery performance.

The results of the project will be included in a new course "Battery Condition Assessment", which will be uploaded to the web-based DIPSEIL system. The course will be offered to students from Master's degree programs "Renewable Energy Sources and Energy Efficiency" and "Electricity Efficiency" at the University of Plovdiv and "Electronic Systems for Hybrid and Electric Cars" at the Technical University of Sofia. Two innovative learning strategies will be used during the training: project-based learning and problem-based learning. Thus, students will not only gain knowledge, but also learn to solve problems, plan and conduct an experiment to investigate a specific problem. For this purpose, during the laboratory exercises, students will be able to use the developed unique automated system for accelerated aging and remote monitoring of battery parameters, as well as all equipment purchased under the project.

The theme of the project corresponds to the priority areas of the University of Plovdiv "Paisii Hilendarski" and the Technical University of Sofia for the development of clean technologies related to improving the quality of life and digitalization. Therefore, the knowledge and competencies developed during the implementation of the project are extremely important for the future development of the project participants. The project is interdisciplinary, which provides an opportunity to bring together scientists from several different fields – engineers, physicists and programmers.

The inclusion of PhD students, students and young scientists in the research team of the project will increase the interest of young people in the project topic and will give them the opportunity to acquire lasting knowledge and skills in a real environment with exploratory training. The implementation of the project will contribute to the creation of new and enrichment of existing specialized courses and to the creation of lasting interest in the topic by providing funding for the development of bachelor's and master's theses. In this way, the

knowledge gained during the development of the project will contribute to better training and the creation of competitive personnel for the Bulgarian economy.

49. EMBEDDED SYSTEM FOR RADIATION PATTERN MEASUREMENTS OF ANTENNAS
Sotir S. Sotirov, Nadezhda M. Kafadarova and Tihomir T. Lovchaliyev

The rapid development of wireless systems requires the use of appropriate antennas for high-frequency applications. This leads to continuous improvement of methods and systems for measuring the main parameters of these antennas. In this article, we present the developed built-in antenna radiation diagram measurement system. It consists of hardware and software and is designed to work in laboratory conditions. It can be used to measure the performance of antennas of different weights and sizes operating in different frequency ranges.

The system hardware includes the following elements: a transmission system with a source antenna, a receiving system with AUT, a positioning system, a data recording and processing system. The movement of the antenna and the measurement of the signal are synchronized by specially developed software that is installed on a personal computer. The software is based on the Python programming language. The positioning system for the antenna is controlled by an Arduino Uno development board with specially designed firmware. The developed system has been successfully tested to measure the radiation pattern of various types of antennas. The results are presented in Cartesian and polar coordinate systems.

50. RESEARCH OF ANTENNAS FOR THE 5G FIRST FREQUENCY RANGE WITH APPLICATION IN EDUCATION OF ENGINEERING STUDENSTS
Nadezhda Kafadarova, Tihomir Lovchaliev, Nikolay Vakrylov, Sotir Sotirov

The in-depth study of fifth-generation (5G) technology is dictated by the need to meet the growing demand for high-speed communication. The article describes our experience in training engineering students at the University of Plovdiv in the design and analysis of the main characteristics of antennas operating in the first frequency range of 5G. The training is conducted within the course "Mobile Information Systems", and a module consisting of three tasks has been developed. The experiments are carried out through a specially designed experimental setup for measuring the directional action diagram of antennas in the telecommunications laboratory. The experimental setup consists of a stepper motor for rotating 5G antennas of various types, such as dipole, Yagi and others. Signal level measurements are performed by a spectrum analyzer. The data received from the spectrum analyzer is processed by specially developed software that visualizes the directional action diagram of the antennas. For the purposes of training and research, two commercially available antennas are used, with which a preliminary comparative analysis of their characteristics is carried out. Experiments are included in the first assignment of the module. The next task aims to introduce students to the process of designing and manufacturing antennas for 5G. In the third task, a comparative analysis of the characteristics of factory antennas is carried out, which is a good opportunity to master the study material for the design and production of antennas for applications in the first frequency band of 5G.

The results of the study show that the prototype antennas of the students provide good coverage and can be used for 5G applications in the respective operating range.

51. OUR EXPERIENCE FROM THE USE OF INNOVATIVE TECHNOLOGIES IN TEACHING "ELECTRICAL ENGINEERING" DURING THE COVID-19 PANDEMIC

Diana Stoyanova, Silvia Stoyanova-Petrova, Nadezhda Kafadarova, Sotir Sotirov, Nevena Mileva

The urgent transition from face-to-face to online learning during the COVID-19 pandemic has proven to be a challenge for academia around the world. They urgently needed to change their curricula, teaching methods and assessment to adapt to the new situation, namely: limited face-to-face contact and access to laboratories.

The main goal of the research presented in the article is the implementation of innovative methods and tools that will help students develop practical skills during distance or blended learning, namely:

• Using a project-based approach aimed at preliminary preparation of students before attending laboratory classes;

• Inclusion of simulation laboratory exercises in the curriculum, through which students acquire knowledge of designing electronic circuits using simulation software;

• Use of a system for remote access to laboratory equipment, developed by a team of the University of Plovdiv;

• Use of QR codes during face-to-face laboratory exercises.

Each meter in the Electrotechnical Laboratory has a QR code attached. After scanning the QR codes, students get access to instructional videos demonstrating the operation of the appliances.

The pilot experiment was conducted in the first half of the 2021/2022 academic year with second-year students majoring in Information and Computer Engineering.

The results of the observations, questionnaires, assessments obtained from individual tasks in Multisim Live and from the laboratory protocols of students give us reason to believe that the developed educational technology is effective in the conditions of distance or blended learning.

52. OUR EXPERIENCE IN THE TRANSITION FROM FACE-TO-FACE TO DISTANCE LEARNING IN THE DISCIPLINE "ELECTRICAL ENGINEERING"

V. Mengov, S. Sotirov, N. Kafadarova

This article focuses on the development of an experimental electronic model for remote access to a laboratory exercise in the discipline of Electrical Engineering, which is designed to study the amplitude frequency and phase-frequency characteristics of RC and LC filters. The current study is a consequence of the transition from face-to-face to distance learning due to the Covid-19 pandemic. The developed electronic module was created by a team from the University of Plovdiv and has been successfully used for one year in conducting remote access to laboratory exercises in the discipline "Fundamentals of Telecommunications".

Thanks to the unification of the hardware used in laboratory mock-ups for various engineering disciplines, a significant simplification of the maintenance of the developed remote access system is achieved, as well as a significant reduction in the costs required for its construction. When performing the laboratory exercises, students can set the frequency and format of the input signal of the filter. For this purpose, a DDS generator is used, implemented with an integrated circuit ADS9833. The change in signal amplitude is carried out by a digital potentiometer MCP42010. These two specialized integrated circuits are controlled by the Arduino Uno via a common digital bus with a serial SPI interface. In order for students to remotely control this mock-up and set the necessary parameters of the generated signal, the

Arduino Uno board is connected to a laboratory server via a USB interface. The input and output signals of the filter are measured by a laboratory dual-channel oscilloscope GWInstek GSD-2000A. After measuring the parameters of the two signals at different frequencies, the students determined the change in the amplitude of the output signal, as well as the phase difference between the two signals. The results obtained are recorded in a table and then used by students to draw the graphs needed to analyze the characteristics of the filter under study. The filters are implemented as separate hardware modules that can be connected to the main board of the laboratory mockup. This guarantees the freedom of the lecturer to change the type and scheme of the filter, which creates the opportunity to perform a variety of research tasks.

Remote access to the individual modules of the laboratory system (measuring instruments, laboratory models) is carried out through developed specialized user software with a WEB interface. For this purpose, the software is installed on a laboratory server and communication between the software, the laboratory mock-up and the oscilloscope is carried out via USB interfaces. The methodology for performing the laboratory exercise in the discipline "Electrical Engineering" contains simulation of an electronic circuit of the tested filter using a software electronic simulator, study of the filter parameters of a real laboratory model in a remote laboratory by performing real measurements and comparing the results of the simulation and the actual measurements.

The results of the distance learning of engineering students in this laboratory exercise so far show a good understanding of the operation of the studied electronic circuits and their ability to work with both software simulators and real laboratory measuring instruments.

53. SYSTEM FOR REMOTE ACCESS TO ENGINEERING LABORATORY EXERCISES
V. Mengov, S. Sotirov, N. Kafadarova

This article presents a developed software module of a system for remote access to real laboratory exercises in engineering disciplines, as well as its functionalities and characteristics. The need to create such a system is determined by two main factors. First of all, there are the rapidly developing information and communication technologies, which make it possible to update the inert system such as higher education and to provide future specialists with an educational environment and resources adequate to modern business. On the other hand, the COVID-19 pandemic forced traditional face-to-face university education to switch to a distance option very quickly. That is why the introduction of innovative methods and tools in teaching and learning in universities in the context of a pandemic was the main motive in the development of a system for remote access to laboratory exercises and their remote implementation. The system consists of two main modules: a hardware module and a software module. The hardware module contains a laboratory mock-up and measuring equipment. The system software module presented in this article uses a client-server architecture. In the development of the system software, the programming languages PHP, Python3.8, JavaScript, HTML and MySQL are used. The web application of the system uses PHP and PHP libraries, the language is independent of the platform and allows the integration of HTML, CSS, JavaScript into the script code. User information and experiment schedule are stored in the MySQL database. The system supports two types of accounts - student and teacher. The web application interface allows students to book an experiment at a convenient time interval by filling out a standard web form. The home page of the system presents in tabular form a schedule of laboratory exercises and a link to them for registered students. Once the student opens the experiment webpage, he gets access to the theoretical materials related to the experiment being conducted and the button to start the experiment. There is also a connection between the student and the teacher through a developed chat client. The implementation of

the concept of remote access to real laboratories will give universities a powerful tool for training future engineers in a pandemic, since virtual learning cannot completely replace the physical presence of the student in the real laboratory and the experience that is gained there.

The developed system for remote access to experiments allows students to conduct experiments with real laboratory measuring equipment in a pandemic and lockdown. The use of such tools in distance learning improves the quality of the learning process and allows for flexible and personalized learning tailored to the needs of students. According to a survey conducted among students and teachers, the system works stably and offers an easy and intuitive interface to work with and supports the necessary functionality. Students point out as the main disadvantage of this type of training the inability to work in a team in the real laboratory.

One of the future directions for work on the system is to ensure control and supervision of the experiment conducted by the teacher.

54. EXPERIMENTAL STAND FOR INVESTIGATION OF DC ALTERNATOR
Delko Zlatanski, Nikolay Vakrylov, Nadezhda Kafadarova

Innovations in engineering education are essential to improve the quality and competencies of the future engineering workforce. To improve the quality of education, engineering faculties must keep pace with the dynamic changes in engineering science and practice. Only in this way will graduating students be competitive in the labor market and will be able to quickly develop as specialists in new and promising fields. This article demonstrates the possibilities for improving the quality of teaching in the discipline "Electrical Engineering" by applying appropriate research approaches in the educational practice of engineering students. For this purpose, a DC generator test bench has been developed, which allows a detailed study of the physical processes taking place in the power supply system of each car.

This article demonstrates the possibilities for improving engineering education through a research approach in the laboratory practice of engineering students studying the discipline "Electrical Engineering". For good adaptation to the future professional environment, a research configuration of a DC generator with remote control capabilities via the Internet has been developed.

The applied experimental research methodology allows students to improve their technical competencies by learning:
- The principle of operation and design of a DC generator;
- Connecting the main components of the generator;
- The components and operation of the electrical power supply system of a car:
- The operating characteristics of the generator;
- The relationship between generator speed and battery charging and discharging conditions in vehicles.

The proposed approach was evaluated through a study conducted with 4 groups of students from different engineering specialties. The results of the study show that the proposed approach helps to understand the complex physical connections in modern automotive power supply and battery charging/discharging systems.

55. SELF-EFFECTIVENESS OF ENGINEERING STUDENTS IN FACE-TO-FACE, DISTANCE AND REMOTE ACCESS LEARNING
T. Ivanova, N. Kafadarova

The digitalization of the training of engineering students has created new opportunities for conducting practical laboratory exercises. On the other hand, new generations of students

are placing new demands on the self-efficacy of their studies, preferring hands-on learning in a virtual environment. The study of the self-efficacy of the training of students in engineering specialties provokes the creation of three models of training in the part of practical training. The methodology of laboratory exercises for the study of bipolar transistors is adapted for face-to-face training, for distance learning, as well as for training with remote access through an electronic platform for synchronous and asynchronous learning through VPN.

The article presents the specifics of the three models of training, describes the main procedures for performing laboratory exercises in face-to-face, distance and remote learning. The results of the exercises conducted with three groups of students are evaluated on the basis of completed and submitted protocols. The preferences of engineering students in terms of the model of conducting practical exercises were evaluated through surveys.

Results of the students' self-assessment have been obtained regarding:
- o acquired knowledge and skills for bipolar transistor research;
- o the procedures for conducting the laboratory exercise according to the three models;
- o problems in the process of practical training.

An analysis by the lecturer is presented on:
- o acquired knowledge and skills by students;
- o performing practical exercises: accuracy, consistency, safety;
- o accuracy of the final results of the laboratory exercises.

Comprehensive results show that laboratory practical exercises in engineering disciplines can be successfully conducted both in face-to-face and in distance learning and remote access training. Students' preferences correlate with a higher level of acquired knowledge and skills. Students' academic self-efficacy increases with the ability to choose the type of study because it provides opportunities to express their strengths.

Academic self-efficacy finds new spaces for presentation in distance learning and laboratory practical exercises for engineering students. With the possibilities of digital technologies for the use of electronic platforms, models for the use of measuring instruments, specifications of experimental experimental setups with remote access, various procedures for performing laboratory practical exercises in face-to-face, distance and remote learning, for the modern generation of students increases the academic self-effectiveness in a digital environment. Students' perceived academic self-efficacy indicates a growing interest in hybrid and distance e-learning, even when hands-on lab exercises are conducted.

56. DEVELOPMENT OF A SYSTEM OF LABORATORY EXERCISES FOR THE DISCIPLINE "ELECTRONICS" USING THE METHODS: FACE-TO-FACE LEARNING, DISTANCE LEARNING WITH SIMULATIONS AND REMOTE ACCESS LEARNING

T. Ivanova, N. Kafadarova, S. Milev

The rapid and dynamic transformation of education in the direction of its digitalization has led to the creation of personalized electronic platforms according to the specifics of education. The development of new methodologies and systems of laboratory exercises is now an integral part of the preparation of academic disciplines for engineering specialties in order to keep up with the constantly evolving technologies. The University of Plovdiv has developed a system of laboratory exercises in the discipline "Electronics" for training students in engineering specialties. They have been developed for three methods of practical training – face-to-face, distance (through simulations) and remote access training through specialized models. This article describes how to design and develop the individual exercises included in the system. Special attention is paid to their application in the training of three groups of

students. The three methodologies were developed for the laboratory exercises "Study of the transmission characteristics of bipolar transistors", "Study of bipolar transistors as an amplifier" and "Study of analog-to-digital converters". The results of the achievements of students from the engineering specialties in the discipline "Electronics", taught through the developed system, are evaluated according to the knowledge obtained. The possibilities of the three teaching methods in terms of personalizing the training of students in engineering disciplines were evaluated.

It can be seen that face-to-face training has its drawbacks, such as errors in the design of the schemes, which necessitates the elimination of these errors, possible equipment failures, and the limited time available to students. Some schemes require at least 3 hours to complete. The advantages of face-to-face training are that real components are used, the scheme is built independently, only in this method students get in touch with the real work of the constructors, in the other methods the scheme is already constructed by the teacher. In face-to-face training, they can receive direct assistance from the teacher. Distance learning through simulations, on the other hand, is very fast, easy and safe to check and operate, there is no need to correct errors on the part of the teacher. It is possible to make analyses that are not applicable to face-to-face learning. The disadvantages are that the performance and accuracy of devices depends on their design and their manufacturer. In the exercises conducted by remote access, there are no mistakes on the part of the students in the construction of the scheme, since it is already connected by the teacher, the check is fast, easy and safe. The method makes it possible to experiment with schemes that would not be possible in the laboratory, due to the complexity of the scheme and limited time for conducting the exercise.

57. A REVIEW OF INDUSTRY QUALITY IMPROVEMENT STRATEGIES THROUGH DOE STATISTICAL TECHNIQUES
Nikolay Vakrilov and Nadezhda M. Kafadarova

The use of statistical techniques has become a key tool for optimizing quality, productivity and cost control in the production of products or the development of services in the industry.

The article presents methodologies for solving quality problems and improving business through the application of statistical tools. The main approaches such as Six Sigma, Design for Six Sigma and Taguchi Methods are considered to implement strategies to improve the quality and performance of products, processes or services, which are an important factor in achieving high customer satisfaction. The main procedures, phases, activities and key factors for the successful implementation of each approach and when it is appropriate to use it are described. Emphasis is placed on the possibilities of collecting and processing data in the process of experimentation through the systematic application of statistical tools. A number of examples of successful application of DOE in various industrial projects are given to stimulate the use of statistical techniques in quality management by the scientific and engineering community. A comparative analysis of the reviewed methodologies for quality improvement is made and the main advantages and disadvantages are indicated, which will help to choose the right strategy for solving various industrial problems.

58. DEEP LEARNING IN ORAL SURGERY FOR THIRD MOLAR EXTRACTION: EMPIRICAL EVIDENCE AND ORIGINAL MODEL
Deyan Neychev, Ralitsa Raycheva and Nadezhda Kafadarova

Preventive analgesia is an analgesic intervention to affect the postoperative sensation of pain. Controlling postoperative pain is a great challenge for any surgeon. Adequate control

of postoperative pain continues to be a challenge for modern medicine. The advent of artificial intelligence (AI) in all spheres of life, including medicine, has created the technical ability to process various types of data related to many diseases. The application of artificial neural networks in medical science has made it possible to obtain an independent, objective assessment as a consequence of the application of preventive analgesia.

The analysis of the results obtained in the application of the neural network model developed and presented in the article, in comparison with the routinely used statistical methods, shows the presence of a tendency for a positive effect of preventive analgesia. In order to obtain an effective self-learning neural network, it is necessary to use large arrays of correctly selected data that act as input parameters for the neural network. The results obtained from the original model used are comparable to the traditionally used statistical methods. This model objectifies to some extent preventive analgesia in the surgery of third mandibular molars.

The use of a neural network makes it possible to predict the intensity of pain and the need for an additional dose of analgesics. The effectiveness of the applied analgesic procedure is directly proportional to the amount of data fed into the neural network.

59. APPLICATION OF INFRARED THERMOGRAPHY IN IDENTIFYING PLANT OILS
Maria Marudova, Sotir Sotirov, Nadezhda Kafadarova and Ginka Antova

In this article, we present a unique system for identifying edible oils by analyzing their thermophysical properties. The method is based on the use of active infrared thermography. The heating of oils is the result of the optical absorption of laser radiation at a certain wavelength. This approach allows for greater selectivity in distinguishing between different types of edible oils, since the results depend not only on the thermal properties of the particular oils, but also on their optical properties, which are uniquely characteristic of each oil. In addition, the developed system provides a detailed visualization of spatial temperature gradients in the sample volume, as well as their changes over time. It overcomes the limitations of other methods that only determine the thermal conductivity coefficients of oils by resistive heating of the sample. Four types of vegetable oils (extra virgin olive oil, sesame oil, sunflower oil, and rapeseed oil) have been studied in this article. Fatty acid analysis, differential scanning calorimetry, and UV-VIS spectroscopy were used to determine the authenticity, moisture content, and optical properties of the samples examined. Analyses carried out using differential scanning calorimetry showed that no phase transitions of water were recorded in any of the samples of the oils tested. This gives reason to conclude that the oils under study do not have moisture. This is especially important for conducting research and identifying oils using the developed thermographic system. The presence of moisture is a source of error, as it has a significant impact on the thermal conductivity of oils. An analysis of fatty acids was carried out and the established fatty acid composition of the studied oils and its compliance with the data from the literature confirm the authenticity of the examined samples. The absorption spectra were examined using UV-VIS spectroscopy for each of the oils to determine their absorption coefficients at the wavelength of 450 nm used to irradiate the sample.

The developed unique thermographic system for the identification of vegetable oils is based on a combination of the optical and thermal properties of the oils. The shape of the temperature profiles in space and time, which are strictly specific to the oils studied, is analyzed. The system allows visualization and determination of the emerging temperature gradients in the sample volume. The presented system is inexpensive and can be further optimized. Experiments should be carried out in a thermographic laboratory, at controlled temperature and relative humidity of the environment. The measurement time is within 3

minutes and is negligible compared to that of traditional methods such as chromatography. The resulting temperature error depends on the stability of the laser radiation power and the thermal imaging camera temperature error.

The current research will be expanded in the direction of identifying the geographical origin of vegetable fats, establishing the degree of oxidation and detecting counterfeits.

60. THE UTILITY OF EVOLUTIONARY AND GENETIC COMPUTING IN BATTERY MODELING
Stefan Rizanov, Anna Stoynova, Nadezhda Kafadarova, Sotir Sotirov, Borislav Bonev, Vasilena Marinkova

Evolutionary computation and genetic algorithms have gained popularity as a machine learning technique for multi-purpose optimization. In this article, we present their various applications in battery modeling using data-driven methods. Specifics are presented regarding the main mechanisms responsible for the deterioration of the battery, and the main indicators of the condition.

The main models of batteries are reviewed and discussed. A discussion is presented on data preparation and the constraint based on the nature of the machine learning model.

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/N. Kafadarova/