Ministry of Education and Science of Ukraine
Black Sea Universities Network

ODESA NATIONAL UNIVERSITY OF TECHNOLOGY

International Competition of Student Scientific Works

BLACK SEA SCIENCE 2022

PROCEEDINGS

ODESA, ONUT 2022

Ministry of Education and Science of Ukraine

Black Sea Universities Network

Odesa National University of Technology

International Competition of Student Scientific Works

BLACK SEA SCIENCE 2022

Proceedings

Odesa, ONUT 2022

UDC 001.8(063)

Black Sea Science 2022: Proceedings of the International Competition of Student Scientific Works / Odesa National University of Technology; B. Iegorov, M. Mardar (editors-in-chief) [*et al.*]. – Odesa: ONUT, 2022. – 749 p.

Proceedings of International Competition of Student Scientific Works «Black Sea Science 2022» contain the works of winners of the competition.

The author of the work is responsible for the accuracy of the information.

Organizing committee:

Prof. Bogdan Iegorov, D.Sc., Rector of Odesa National University of Technology, Head of the Committee

Prof. Maryna Mardar, D.Sc., Vice-Rector for Scientific and Pedagogical Work and International Relations of Odesa National University of Technology, Deputy Head of the Committee

Prof. Baurzhan Nurakhmetov, D.Sc., First Vice-Rector of Almaty Technological University (Kazakhstan)

Prof. Michael Zinigrad, D.Sc., Rector of Ariel University (Israel)

Prof. Plamen Kangalov, Ph.D., Vice-Rector for Academic Affairs of "Angel Kanchev" University of Ruse (Bulgaria)

Prof. Heinz Leuenberger, Ph.D., Professor of the Institute of Ecopreneurship of University of Applied Sciences and Arts (Switzerland)

Prof. Edward Pospiech, Dr. habil., Professor of the Institute of Meat Technology of Poznan University of Life Sciences (Poland)

Prof. Lali Elanidze, Ph.D., Professor of the Faculty of Agrarian Sciences of Iakob Gogebashvili Telavi State University (Georgia)

Dr. Dan-Marius Voicilas, Ph.D., Associate Professor of the Institute of Agrarian Economics of Romanian Academy (Romania)

Prof. Stefan Dragoev, D.Sc., Vice-Rector for Scientific Work and Business Partnerships of University of Food Technologies (Bulgaria)

Prof. Jacek Wrobel, Dr. habil., Rector of West Pomeranian University of Technology (Poland)

Dr. Mei Lehe, Ph.D., Vice-President of Ningbo Institute of Technology, Zhejiang University (China)

Dr. V. Kozhevnikova, Ph.D., Associate Professor of the Department of Hotel and Catering Business of Odesa National University of Technology, Secretary of the Committee

INTRODUCTION

International Competition of Student Scientific Works “Black Sea Science” has been held annually since 2018 at the initiative of Odesa National University of Technology (formerly Odesa National Academy of Food Technologies) with the support of the Ministry of Education and Science of Ukraine. It has been supported by Black Sea Universities Network (the Association of 110 higher education institutions from 12 countries of the Black Sea Region) since 2019, and by Iseki-FOOD Association (European Integrating Food Science and Engineering Knowledge into the Food Chain Association) since 2020.

The goal of the competition is to expand international relations and attract students to research activities. It is held in the following fields:

- Food science and technologies
- Economics and administration
- Information technologies, automation and robotics
- Power engineering and energy efficiency
- Ecology and environmental protection

The jury includes both Ukrainian and foreign scientists. In the 4 years that the competition has been held, the jury included scientists from universities of 24 countries: Angola, Azerbaijan, Benin, Bulgaria, China, Czech Republic, France, Georgia, Germany, Greece, Israel, Italy, Kazakhstan, Latvia, Lithuania, Moldova, Pakistan, Poland, Romania, Serbia, Slovakia, Switzerland, Turkey, USA.

At the same time, every year the geography has expanded and the number of foreign jury members has increased: from 46 jury members representing 25 universities from 12 countries in 2018, to 73 jury members of the 46 universities from 19 countries in 2022.

More than a thousand student research papers have been submitted to the competition from both Ukrainian and foreign institutions from 25 countries: China, Poland, Mexico, USA, France, Greece, Germany, Canada, Costa Rica, Brazil, India, Pakistan, Israel, Macedonia, Lithuania, Latvia, Slovakia, Romania, Kyrgyzstan, Kazakhstan, Bulgaria, Moldova, Georgia, Turkey, Serbia.

The interest of foreign students in the competition grew every year. In 2018, the students representing 15 institutions from 7 countries have submitted 33 works. In 2021 the number of submitted works increased to 73, authored by the students of 40 institutions from 18 countries.

The competition is held in two stages. In the first stage, student research papers are reviewed by members of the jury who are experts in the relevant fields. In the second stage of the competition, the winners of the first stage have the opportunity to present their work to a wide audience in person or online.

All participants of the competition and their scientific supervisors are awarded appropriate certificates, and the scientific works of the winners are included in the electronic proceedings of the competition. Every year the competition receives a large number of positive responses from Ukrainian and foreign colleagues with the desire to participate in the coming years.

3. INFORMATION TECHNOLOGIES, AUTOMATION AND ROBOTICS

USE OF WEB-TECHNOLOGIES IN THE PROBLEM OF DIGITALIZATION OF THE DORMITORY

Authors: Daria Liakhovska
Diana Kochuk
Advisor: Tetyana Astistova
Kiev National University of Technologies and Design (Ukraine)

Abstract. *The paper considers the use of digital technologies in the field of education on the example of the development of software for automation of internal university processes, namely in the dormitory. The digitalization system was implemented on the basis of the development of two modules: an electronic check in and a module for monitoring indoor air indicators. The development of modules was based on the idea of developing an Internet system for digitalization of the dormitory and software implementation of modules.*

The electronic check-in module is intended for local use on the computer of the person responsible for registering students in dormitories, and for students using cellphone.

The concept of developing a module for monitoring the characteristics of indoor air on the example of Internet of Things technology, in which various gadgets connected to the Internet interact with each other.

The paper analyzes the existing methods of data transmission from sensors for the collection and accumulation of information flows of the dormitory ecosystem. Based on the obtained data and a monitoring system with a user interface with a chatbot was built.

All this will completely transfer some processes that exist in the dormitory and dean's office, to a mobile device or personal computer.

The developed methods will allow to optimize the internal processes of the dormitory, improve the life and ensure the health of the dormitory students from the influence of negative factors.

Keywords: *microprocessor, sensors, GoogleExcel, GoogleForm, internet of things, Processing, TelegramBot, Wi-Fi, interface.*

I. INTRODUCTION

Now is the era of the spread of digital technologies, which penetrate deeply into the very essence of many organizations and radically change the nature of innovation. Digital innovation is part of quality learning around the world.

Ukraine is already investing in information technology to remain competitive in the global market. The use of the latest information technology in the management of educational institutions helps to ensure the efficiency, effectiveness and efficiency of the administration and educational institution. One of the priority areas of education reform at the present stage is the introduction of digital and web-technologies.

In order to maintain the competitiveness of our specialists in Ukraine, digitalization is being actively carried out. The term "digitalization" it is a general term for the digital transformation of society and the economy. Since the modern world has

taken the direction of digitalization, the fact that the educational process will continue to move to electronic format is inevitable.

The modern educational process in higher education and related fields increasingly requires the use of digital and web technologies. Universities are always interested in the proper condition of their dormitories and the high standard of living of their students. We want to offer digitalization in the field of education. Our development will help solve one of the problems of using digital and web-technologies in the field of education, namely in the dormitory.

The dormitory, as part of the higher education process, also needs innovation. The idea of digitalization of the dormitory arose precisely because of the non-optimized internal processes that take place in the dormitory

Our system will completely transfer some processes that exist in the hostel, to a mobile device or personal computer.

II. LITERATURE ANALYSIS

A review and analysis of dormitory Internet information systems revealed that there are many different systems in terms of design and functionality, but there are almost no full-fledged ones, including those designed for electronic settlement using mobile devices.

Existing systems do not allow you to choose a room and register in the online queue for the commandant, but only provide background information and allow you to leave an application for settlement.

To formulate the requirements for functionality for the development of the Internet system of the dormitory of higher education, several existing systems were considered, namely: information resource of Vasyl Stefanyk Precarpathian National University, platform for digitalization of the dormitory of Kyiv Mohyla Academy (in test version), National University software module "Studgorodok").

Consider the systems contain a lot of information that is very useful for students and parents of future residents of the dormitory, but the disadvantages of these systems are that they all use paid Microsoft products, run only on Windows, and complex client-server system and distributed databases data contribute to material complications in the implementation of these complexes

An analysis of existing solutions suggests that none of the considered Internet systems fully meet all the criteria for providing functionality and information content.

We researched all the internal processes of the dormitory and identified a number of problems that can be solved by digitalizing this process.

The architecture of our platform for creating a dormitory digitalization system will be divided into several modules that will work separately and, if necessary, will be able to exchange data.

We can highlight the following modules:

- Module of electronic settlement and registration of students in dormitories;
- Module for monitoring climate control indicators
- Automation of dormitory electronics;
- Module with internal social network [1].

Consider the first two modules of the system, which were implemented in the work.

1. The module of electronic settlement and accounting of students in the dormitories of the university is an urgent technical task, the solution of which will improve the lives of students

The processes of settlement and registration of students are currently not classified or standardized - there are no unambiguous, or any special software that would help reduce the cost of paper and would increase the level of information support of the university.

Due to the lack of automation of the settlement process in dormitories, queues are formed and large, undesirable crowds of people (especially in quarantine). Dormitory commandants and deans during this period were loaded with a large influx of students. The module responsible for the settlement must implement functionality that will reflect the current state of all rooms in the dormitory, be able to choose the floor, room, student who already lived in it, number of places and employment in order to optimize the amount of information to send to the client.

It should also implement an online queue for the commandant, for which you need to implement an algorithm in the theory of queuing, which will optimize the queue and assign a specific time of admission to each student depending on the student's capabilities and employment of the commandant and dean. This task will be the next step in the process of digitalization of the hostel.

It was the task of the software to develop software that would reduce the amount of paperwork, make the dormitory settlement process more transparent to students, and speed up the process.

To achieve this goal during the study, the following tasks were solved:

– to analyze the legal framework that ensures the accommodation of students in dormitories at the national and university levels;

– identify ways and means to achieve this goal, which will be adequate to the material level of the university and the educational system of Ukraine;

– analyze the process of settling students in dormitories, identify places that require a lot of time and operations that can be automated;

– to test the ease of use of the developed software.

2. Module for monitoring indoor air indicators

This module was developed on the example of the Internet of Things "Smart" dormitory, in which different devices interact with each other. Connected data sensors and export of meteorological data to remote storage, will control and influence the work of many processes.

The whole project is Minimum viable product — MVP, which is a product with minimal functionality that can be given to users to use in their tasks. Minimum viable product is used to test ideas in the development of programs with minimal resources. how much the product will be valuable and in demand in the market [2,3]. For our task, Minimum viable product is used to test ideas in the development of programs with minimal resource costs.

The current changes in technology and data transmission, many call the fourth industrial revolution. The most relevant topics in 2020 are artificial intelligence, neural

networks and the Internet of Things. The Internet of Things (IoT) is a concept that allows physical objects to interact with each other or with the outside world, partially or completely without human intervention.

This term was introduced when the number of things and objects connected to the Internet exceeded the number of people. The Internet of Things can be defined as a set of intelligent objects that can respond to the environment and process information, bridging the gap between the physical and virtual worlds and sending it to other objects using Internet protocols [4,6]. It has built-in "sensors" and software that allows the transfer and exchange of data between the physical world and computer systems in automatic mode, using standard communication protocols.

As a result, "the Internet will no longer be a network of connected computers, but will become a network of integrated objects" [5,11]. Currently, with the help of systems such as GSM, WiFi, Bluetooth, ZigBee, Z-Wave, but also beacons, photocells or wireless sensor networks (Wireless Sensor), a new network concept is being created.

An Internet of Things network can help improve eco-processes in a dormitory, home, or business.

Thanks to "smart" hardware and installed software, the device is able to "feel" what is happening around and communicate it to the user through a certain communication channel.

The aim of the study to develop a model for monitoring air indicators was to analyze sensors, data transmission channels and the accumulation of information flows of the ecosystem in the room. with the interface of interaction with the user through a chatbot.

The system will allow you to monitor the ecosystem data in the room where the user lives and respond quickly to dangerous situations that may occur at the facility in real time and at a distance.

III. OBJECT, SUBJECT, AND METHODS OF RESEARCH

Almost all universities in our country offer affordable accommodation in dormitories. Students are usually housed for 10 months - the academic year, after which the student must leave the dormitory. After the summer holidays, students who want to live in a dormitory have to go through a difficult bureaucratic process. Every year, when settling in the dormitories of the university, students and employees of the university are subjected to psychological and physical overload. Confusion caused by difficult paperwork, non-transparency of the settlement process can freeze the first days of the educational process, which can be fatal in further studies, and cause stress to university staff, which will result in their productivity.

The purpose of this work was to develop a system that will help keep the nerves of both students and university officials, reduce the amount of paperwork, make the process of settling in dormitories more transparent for students, save money.

And the development of indoor air monitoring system will allow students to ensure their health from the effects of negative factors and avoid accidents.

The object of research is the process of organizing the management of university dormitories. It is not possible to analyze the object without the subject of research. The dormitory digitalization system was chosen as the subject of the study. The choice of

such a subject area was caused by non-optimized internal processes of the dormitory.

The aim of the study was to develop two modules: one of the modules of the client-server platform for digitalization of a modern dormitory, namely, the module "Electronic Settlement" and identification of students living in the dormitory, and the module for monitoring indoor air.

The research methods for the development of system modules were based on the idea of developing an Internet system for dormitory digitalization and software implementation of modules. During the implementation of the module of electronic settlement of students it was necessary to determine the categories of users of the system, the ability to access the Web-system, to analyze the regulatory framework. The e-student module includes the development of a GooglForm student questionnaire, the creation of an electronic "Standard contract" based on data from the questionnaire, the development of Google Spreadsheets, which is used by the dean's office to create "chess" for populated students. An Excel page with relevant data is created in parallel for the guide. The e-settlement module is intended for local use on the computer of the person responsible for registration of students in dormitories, and for students - with the use of mobile devices.

The concept of developing a module for monitoring indoor air indicators is considered on the example of Internet of Things technology. The development of the system was based on Minimum viable product - a product with minimal functionality. and minimal resource costs. The concept of system development is considered on the example of a smart dormitory, where one of the components of the system is the technology of the Internet of Things, in which different devices are connected to the Internet and interact with each other. The sensors will allow the device to send data to a computer program that will collect and analyze them. This will effectively identify the problem in case of deviations from the standard during the operation of devices and will facilitate the prediction of possible accidents, malfunctions.

IV. RESULTS

Consider the implementation of the first module of the dormitory digitalization system – the module of electronic settlement.

The e-settlement module includes the development of a Google Form for a student living in a dormitory and the creation of an electronic "Standard Agreement", according to the data drawn from the questionnaire. An Excel page with the relevant data is created in parallel for the manual.

Each student has the opportunity to fill out a questionnaire:

– choose a room;
– draw up a document and submit it to the dean's office remotely;
– get a list of necessary documents for settlement in a dormitory;
– avoid the queue for approval of documents in the dean's office and reception by the commandant to resolve personal issues.

The task of electronic settlement also includes the development of a QR-code of a student living in a dormitory.

The algorithm of the system has the following stages:

1. When a student settles in a dormitory, he will be given a QR-code. When scanning the QR-code, it will be redirected to the Google Site, through which the student will be able to get acquainted with detailed information about the university dormitories, contacts of their leaders and the rules of living and using dormitories (Fig. 1).

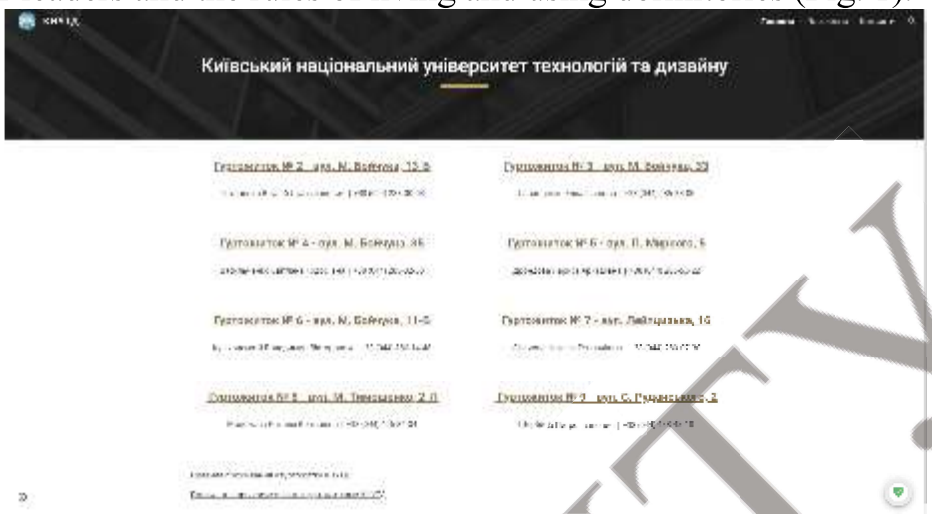

Figure 1. Google Site for student navigation.

2. On the page "Settlement" the student has an opportunity to get acquainted with free rooms (fig. 2) and to submit the electronic application for settlement to a hostel.

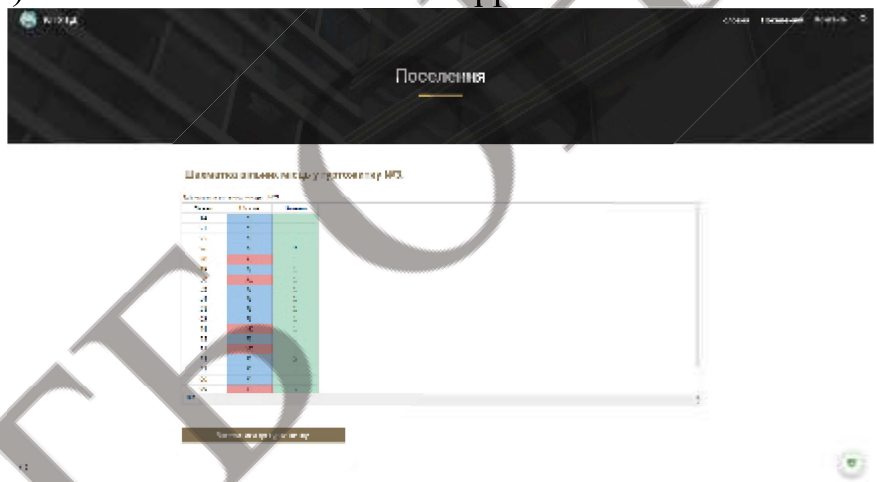

Figure 2. Google Site - "Settlement" page.

3. By clicking the "Settle in the dormitory" button, the student will be redirected to the Google Form to fill in the data required for the contract (Fig. 3).

Figure 3. Google Form to fill in the data.

4. After filling in the form with data and sending it, 4 events will take place:

– All student data is sent to the Google Spreadsheet (Fig. 4), which will be used by the dean's office to create a checkerboard for settled students (Fig. 5).

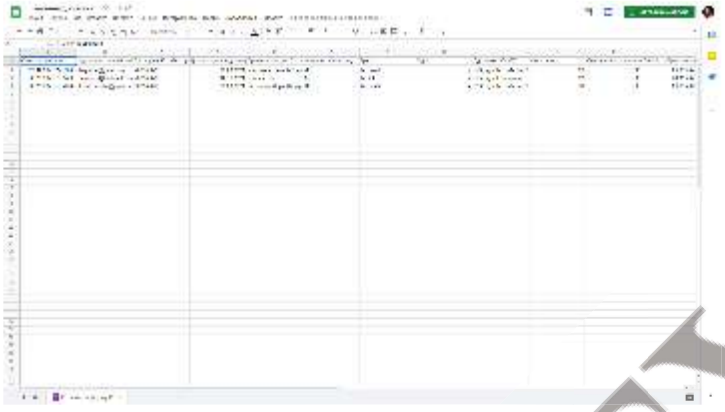

Figure 4. Google Excel as a list of students who have completed the form.

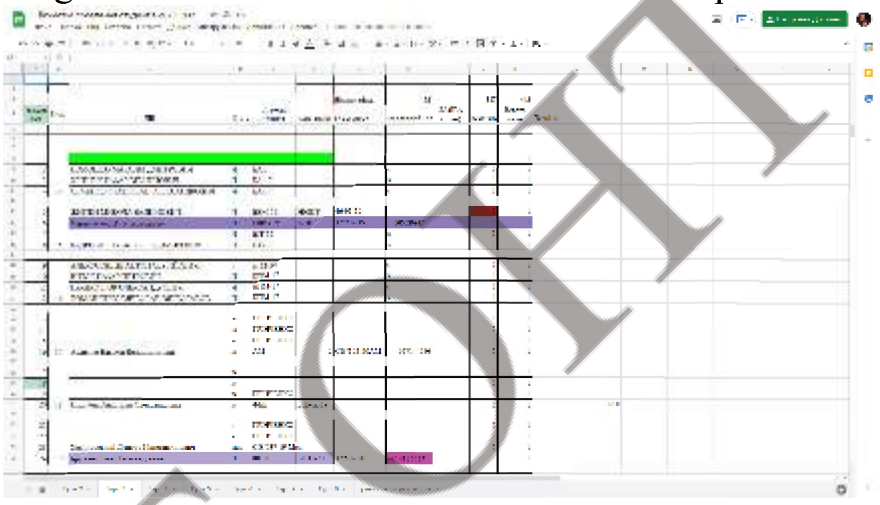

Figure 5. Google Excel as a document for settled students.

– A contract is created in Google Docs (Fig. 6).

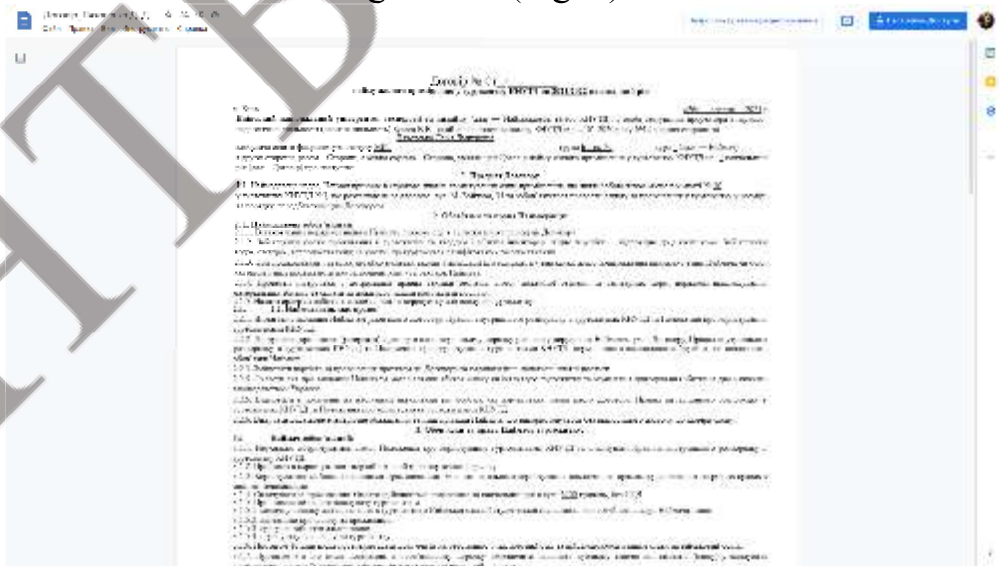

Figure 6. Google Docs Agreement.

– A QR code is created with brief information about the student.

– The contract and QR-code are sent to the mail specified by the student (Fig. 7).

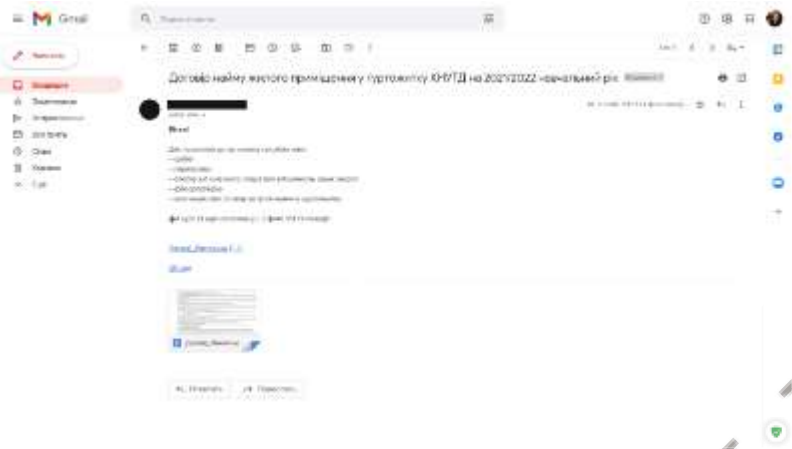

Figure 7. Letter with a document and QR-code.

5. Then the student has to print out and sign the contract.

The generated QR-code will be further used by the student to enter the dormitory.

All this will transfer some processes that exist in the dormitory and in the dean's office, in a mobile device or personal computer, will identify students in the dormitory and will make a modern system of entrance to the dormitory and student accommodation.

Electronic settlement is a part of the task of digitalization of the dormitory, which we have already implemented and is undergoing a testing phase on the example of the dormitory №3.

All the problems that exist in the dormitory are not unfounded, it lasts for years and the creation of our application can be a turning point in relation to the organization of student life.

2. The second module of the dormitory digitalization system - the module of monitoring of indicators of air in the room

To implement the task, the following development components were used:

1. Software (software) development environment for microcontrollers;
2. Processing programming language (based on Java);
3. Program code and subsystem elements.

In the course of solving the problem, microcontrollers such as Arduino UNO, Arduino Nano, MEGA, Espressi were analyzed. Based on the analysis, we chose a wireless microcontroller that can be installed in an intelligent device. A smart device is a device that can be controlled over a Wi-Fi network.

The monitoring module, as a set of sensors, is represented by two sensors: one (digital) for measuring temperature, humidity and atmospheric pressure from Bosch BME280; another sensor is analog for measuring ultraviolet radiation GYL8511, which emits an output signal and further in the code we can operate with the values we need [3].

The ESP8266 microcontroller was chosen to develop the element base, which is currently one of the highly integrated solutions for working with Wi-Fi [4].

A user-friendly interface is required for the full operation of any automated database. TelegramBot was chosen as the interface for storing information system data. The services send the result to the device, and the result itself will be in the bot itself.

The search is conducted in the form of communication in the interface, which specifies what data will be collected. The functions of the Telegram bot have the ability to execute commands in chat. These commands will directly trigger certain actions or request new information.

We chose NodeRED as a programming tool. It allows you to connect hardware devices, APIs and Internet services. The RedBot package for NodeRED was used to write the bot.

Algorithm for testing the main functions of the system.

1. Create wireless access points. The module connects to Wi-Fi with Internet access. An access point is created.

2. At a certain IP address, go to configuration mode. Checking the system to create an access point (Fig. 1). The created access point is password protected to ensure the security of the subsystem settings and to avoid changing the settings by the user who was not granted access.

3. Specify the name and password of the Wi-Fi network to which the monitoring module should be connected

4. Select the server to send data. Indicate the dormitory number and the room to which the module with sensors will be attached.

5. Set the interval of data exchange (Timing of information). In the settings, specify the period of time after which the update will take place, for example 20 minutes. Every 20 minutes it will dump data to the server.

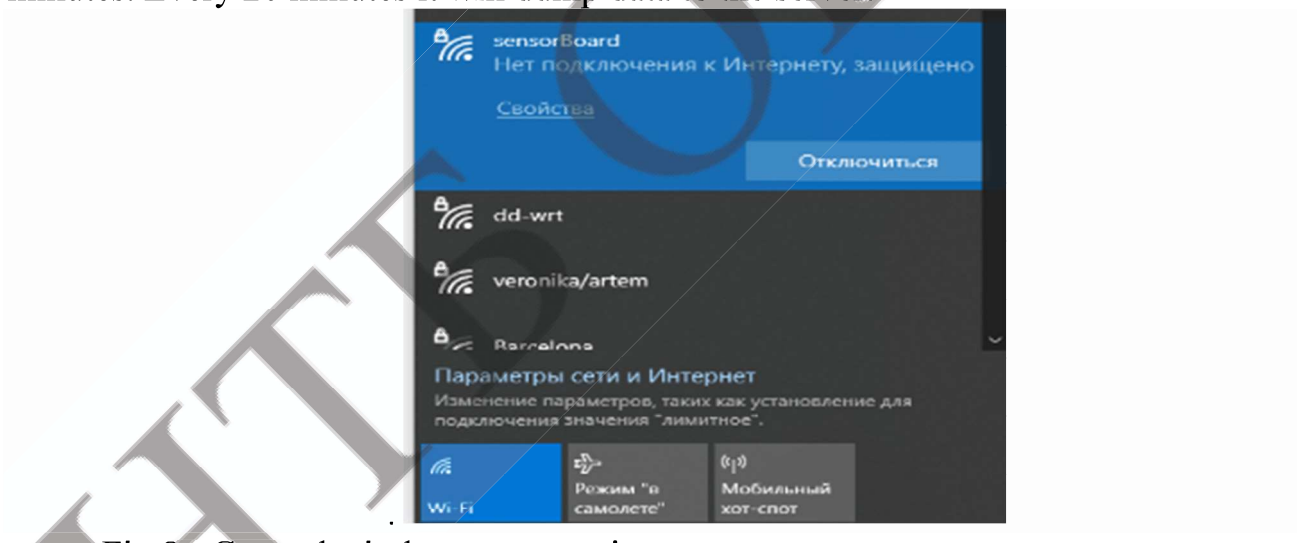

Fig.8 - Created wireless access point

Upon successful connection, all information from the monitoring module, in particular location data and sensor readings, is generated in the data packet and sent to the address specified in the settings. server at a specified interval

On the NodeRED side, HTTP codes and the user code block process this data and store / send notifications to the user.

6. To start communication with the bot, click "start". The user receives a message in which you can actually see what can be useful for this bot (Fig. 9).

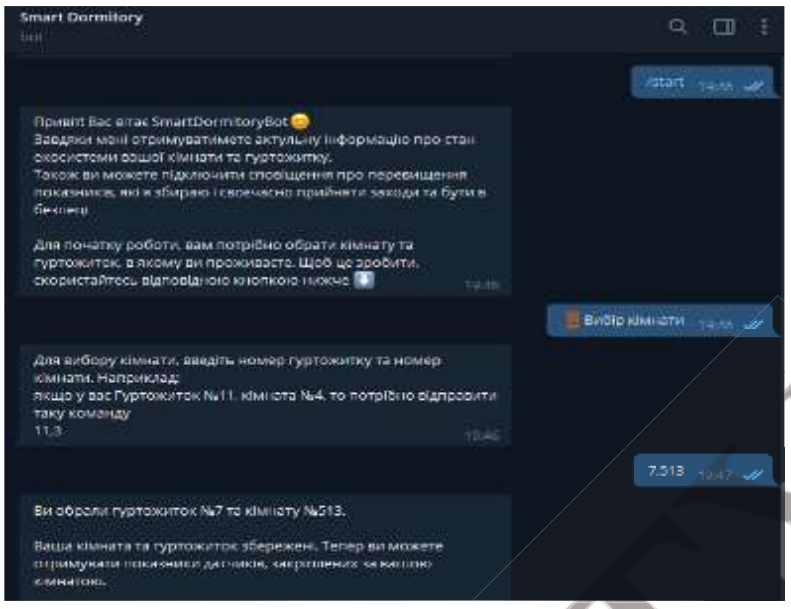

Fig.9. Communication with the bot. Choosing a room

There is a separate custom keyboard with different commands, the variety of which depends on the selected action (Fig. 10). The "Main Menu" and "Back" buttons remain unchanged.

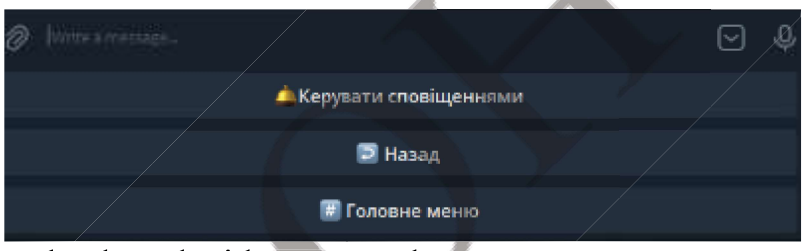

Fig.10. Custom keyboard with commands

7. By clicking on "View indicators", the user will receive all the data on the state of the ecosystem of the room, which are studied: air temperature, humidity level in the room, CO2 level, air quality (Fig. 11).

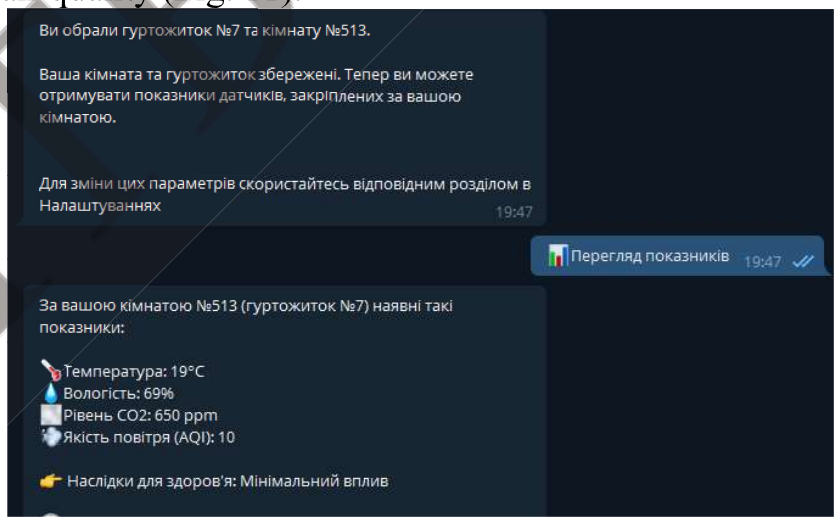

Fig.11. View room ecosystem performance

Example,

1. Indicator of the concentration of CO2, characterizes the accumulation of viruses in the air, which is especially important today during the pandemic of coronavirus infection

2. Changing the temperature in the dormitory rooms will show where there is

unauthorized use of heaters and other devices that can lead to a fire hazardous situation.

To protect your health from the effects of negative factors, you can enable notifications of changes or exceedances of certain indicators. (Fig. 12).

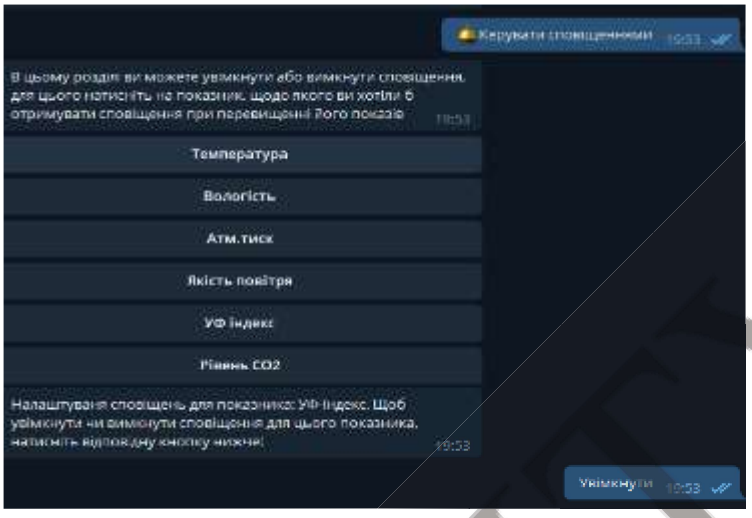

Fig.12 - Enable notifications of changes in indicators

V. CONCLUSIONS

The issues of digitalization of the dormitory on the basis of development of two modules were considered in the work: the module of electronic settlement and the module of monitoring of indicators of air indoors. This is part of the task of digitalization of the dormitory, which has already been implemented by us and is undergoing testing at the dormitory №3 and №7 of the Kyiv National University of Technology and Design in May-September 2021.

The first module - e-settlement module, can be used in any university or other organization that requires automation of the process of settling people in dormitories and accounting for the current state of occupancy of the dormitory in real time. The use of this software product will reduce the time spent by the staff involved in organizing the settlement process, and as a consequence reduce the material costs of the settlement.

The second module - the module of monitoring of indicators of air in the room will give the chance to trace data in a dormitory room, will send notifications on their changes and promptly react to dangerous situations in case of deviations from the standard. The development of the module was considered on the example of a smart dormitory, where one of the components of the system is the technology of the Internet of Things.

All the problems that exist in the dormitory are not unfounded, it lasts for years and the creation of our application can be a turning point in relation to the organization of student life.

The developed models and methods of their application allow to optimize the internal processes of the dormitory and will be able to improve the lives of students in the dormitory and ensure the health of students from the effects of negative factors.

VI. REFERENCES

1. 1.Астістова Т. І.,.Ляховська Д. Д., Розробка системи електронного поселення. *Матеріали V Міжнародної науково-практичної конференції* "Мехатронні системи: інновації та інжиніринг-"MSIE-2021" (*м. Київ., 4 листопада 2021*). Київ, Київський національний університет технологій та дизайну, 2021, С. 150- 152.
2. MVP Explained: A Systematic Mapping Study on the Definitions of Minimal Viable Product″ *(2016). 42th Euromicro Conference on Software Engineering and Advanced Applications (SEAA).p.: 112–119.* http://dx.doi/ DOI:10.1109/SEAA.2016.56
3. Radoff Jon (2010), Minimum Viable Product rant [Radoff's Internet Wonderland] . http://radoff.com/blog/2014/05/04/minimum-viable-product-rant/
4. Бойко В.І,. Гуржій А. М,. Жуйков В. Я. Мікрпроцесори та мікроконтролери: Підручник Київ.: Вищашк., 2014, С.115
5. Astistova T.I., Development of the concept of information system "smart city" / T. I.Astistova, D.M. Kochuk // Information technologies in science, production and entrepreneurship: a collection of scientific works of young scientists, graduate students, masters of the Department of Computer Science and Technology - K .: Education Ukraine, 2021. p. 217-220
6. Middleton P, Kjeldsen P., Tully J., Forecast: The Internet of Things, Worldwide, - Gartner, 2013
7. Astistova T.I, Kochuk D.M..Software development for technology"Internet of things", *матеріали V Міжнародної науково-практичної конференції* "Мехатронні системи: інновації та інжиніринг-"MSIE-2021" (*м. Київ*, 4 листопада 2021.) Київ, Київський національний університет технологій та дизайну. - С.57-58
8. Testing of software used to monitor the ecosystem. [Electronic resource] - Access mode: URL: https://uk.wikipedia.org/wiki/Тестування_програмного_забезпещения - Access date: 08.09.2021.
9. Astistova T.I, Smart house management system, user interface/T.I. Astistova, M.A. Kolva //Тези V Міжнародної науково-практичної конференції «Мехатронні системи: інновації та інжиніринг – «MSIE-2021» К. КНУТД, 4 листопада 2021р. - С.156-157
10. Астістова Т. І., Кочук Д.М, Аналіз та характеристика технології «Internet of things»/ Т.І. Астістова, Д.М. Кочук// Інформаційні технології в науці, виробництві та підприємництві: зб. наук. праць молодих вчених, аспірантів, магістрів кафедри комп'ютерних наук та технологій. – К. : Освіта України, 2021 р. . – С. 224 – 227
11. Internet of Things [Electronic resource] - Access mode URL: https://www.sas.com/ /big-data/internet-of-things.html - Access date: 04.05.2021
12. Amazon Web Services [Electronic resource] - Access mode URL: https://uk.wikipedia.org/wiki/Amazon_Web_Services - Access date: 01.06.2021
13. Internet rzeczy [Electronic resource] - Access mode URL: https://www.copadata.com/ platform-editorial-content / co -jest-iot-oraz-iiot / - Access date: 28.08.2021
14. Types of software testing [Electronic resource] - Access mode: http://qalearning.com.ua/theory/lectures/material/testing-types-functional/ - Access date: 02.08.2021
15. What is smart city? [Electronic resource] - Access mode URL: https://placesjournal.org/article/a-city-is-not-a-computer/?gclid _
16. Keo C, S. Kumar S., Tschofenig H., Securing the internet of things: A standardization perspective," IEEE Internet of Things Journal, Vol. 1, No.3, PP.265-27, 2014. https://doi.org/
17. Тестування програмного забезпечення, яке використовується для моніторингу екосистеми: UR: https://uk.wikipedia.org/wiki/Тестування_програмного_забезпечення