

# 2023 年臺灣國際科學展覽會 優勝作品專輯

作品編號 180017

參展科別 地球與環境科學

作品名稱 Air quality monitoring project as an  
educational tool for sustainable  
development

得獎獎項

國家 Ukraine

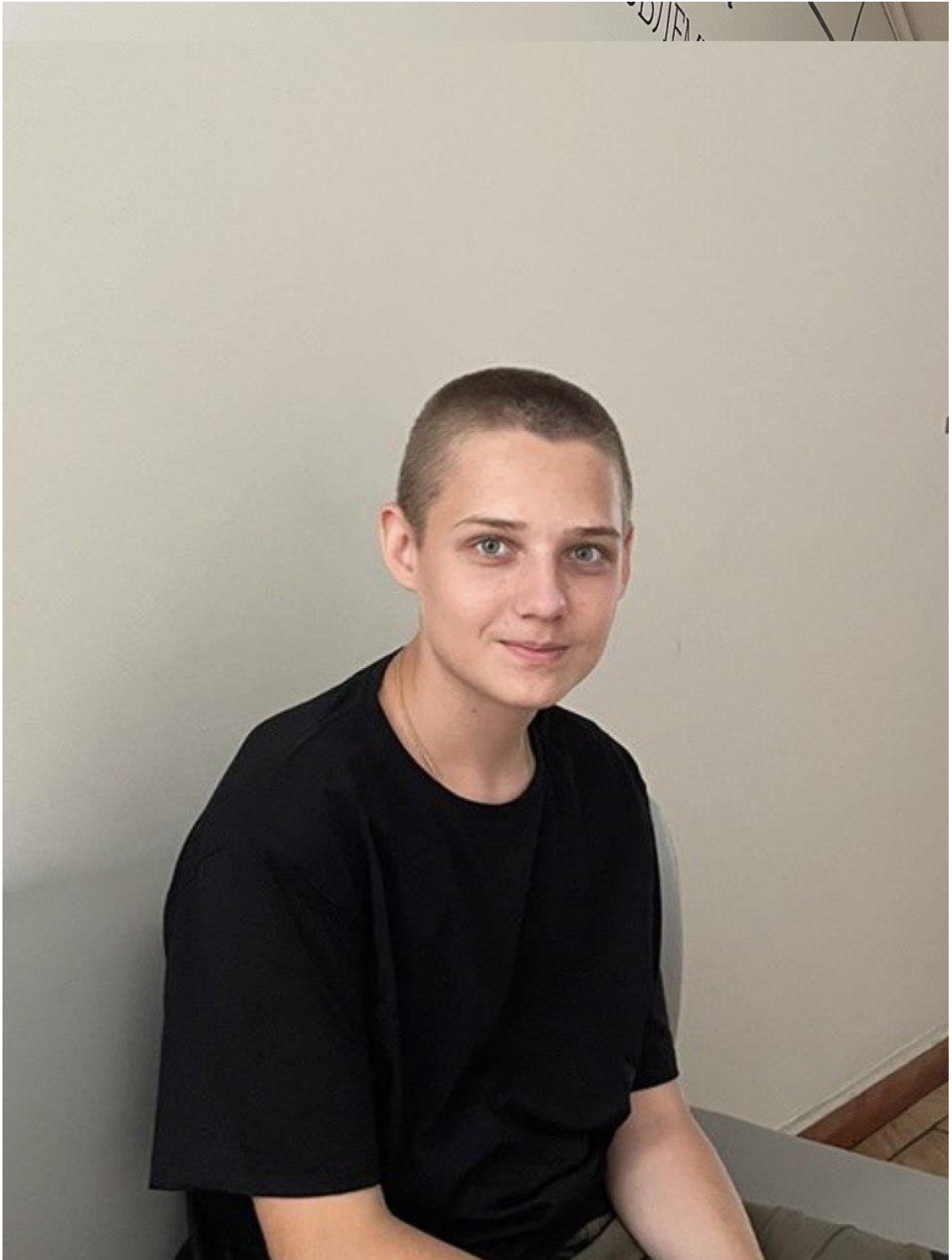
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Sciences of Ukraine" under the auspices of  
UNESCO

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關鍵詞 ecological monitoring、energy saving、  
atmospheric air

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The research project has an extremely relevant topic - the creation of an air quality monitoring system for general secondary education. In the context of the Covid 19 pandemic, proper air sanitation is a determining factor in counteracting the spread of coronavirus infection. Special requirements for the procedure of systematic ventilation of educational premises are set before teachers and technical staff of schools "Sanitary Regulations for General Secondary Education Institutions", which is mandatory for implementation in general secondary education institutions. Together with measures to counter the Covid 19 pandemic, the new health regulations somewhat neglect resource conservation and energy efficiency issues: ventilation during the heating season can lead to wasteful heat losses. Monitoring the quality of air purification is simply necessary if teachers and parents care about creating a safe educational environment for students at school. Requirements for air safety determine and regulate its characteristics such as temperature, humidity, the presence of dust particles of different sizes, the concentration of carbon dioxide (CO<sub>2</sub>), carbon monoxide (CO) and formaldehyde vapors. The level of hazardous substances such as formaldehyde, which can be released from building materials, carbon monoxide and carbon dioxide, should be closely monitored in accordance with the recommendations of sanitary regulations and hygiene requirements of health care facilities. With increased concentrations of carbon dioxide above normal, the human body will experience the negative effects of hypoxia: poor health, drowsiness, decreased cognitive processes, learning becomes less effective.

Carbon monoxide is a poisonous substance that can damage the body, poison hemoglobin and cause constant hypoxia of all organs and systems, long stay indoors with it leads to death. Formaldehyde causes carcinogenic effects, and the excess concentration of dust particles worsens the condition of people with allergies and bronchial asthma, as well as dust promotes bacterial growth and the spread of viral particles, which is especially dangerous in a coronavirus pandemic.

Our solution allows for a transparent permanent monitor of air quality in the school, makes this monitoring completely inclusive - because any user from among the participants in the educational process has access to up-to-date information about the air in the school and can make informed decisions about proper behavior. Our system allows students to become more responsible, independent in terms of sanitary requirements and compliance.

Therefore, the main idea of our project is extremely relevant today - to organize a digitalized system for monitoring the quality of air purification in the school, thus preventing inadequate ventilation with wasteful heat loss and reduced energy efficiency of the school building. The project has signs of sustainability - it is in line with the Sustainable Development Goals – 3 «Good health and well-being», 4 «Quality education», 5 «Gender equality», 11 «Sustainable cities and communities», 12 «Responsible consumption and production» and 13 «Climate action».

### List of abbreviations and acronyms

- SDG – Sustainable Development Goals;
- AP – Atmospheric air quality;

## INTRODUCTION

**Actuality of theme.** Life expectancy and quality depends on the state of the air he breathes. Increasing the level of urbanization leads to increased anthropogenic impact on the environment, which leads to a violation of the ecological balance. A sharp increase in the urban population, the commissioning of new industrial enterprises, an increase in the number of vehicles – these factors cause changes in the gas composition of ambient air and worsen the ecological state of the environment. Atmospheric air quality (AP) is a necessary factor in the safe educational environment of a modern educational institution. In the educational environment of the school, participants in the educational process spend an average of 7-9 hours a day, so air quality is essential for maintaining good health. In the context of the Covid 19 pandemic, proper air sanitation is a determining factor in counteracting the spread of coronavirus infection. Special requirements for the procedure of systematic ventilation of educational premises are set before teachers and technical staff of schools “Sanitary Regulations for General Secondary Education Institutions”, which is mandatory for implementation in general secondary education institutions. Together with measures to counter the Covid 19 pandemic, the new health regulations somewhat neglect resource conservation and energy efficiency issues: ventilation during the heating season can lead to wasteful heat losses. Therefore, the main idea of our project is extremely relevant today – to organize a digitalized system for monitoring the quality of air purification in the school, thus preventing inadequate ventilation with wasteful heat loss and reduced energy efficiency of the school building.

**The purpose and objectives of the study.** The aim of the project is to create a digitalized system for monitoring the air quality of educational facilities of Cherkasy specialized school I-III degrees № 3 and ventilate it to comply with the “Sanitary Regulations for General Secondary Education” from 25.09.2020 and measures to combat the Covid-19 pandemic to control waste heat loss energy and additional carbon dioxide emissions from the school building during the heating season (SDG 13 – Combating Climate Change).

**The subject of research is the process of air purification quality control.**

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**The subject of research** – software and hardware methods and tools for building information and measurement systems for air purification quality monitoring system for educational institution.

**To accomplish the goal we need to perform the following tasks:**

- To equip special rooms of general use of Air Home air quality monitoring devices (10 rooms of the pilot project);
- To create a Telegram bot software to notify the participants of the educational process about the beginning and end of ventilation and continuous transparent monitoring of air quality in the school building;
- To train a team of sanitary energy managers – students of 7-10 grades, who will control and maintain the school system of monitoring air purification and quality;
- To evaluate the effectiveness of the pilot project and develop a roadmap for the implementation of a full-scale monitoring system of air purification and quality in the educational institution;
- To calculate the economic effect of the pilot project and full-scale air purification quality monitoring system as devices “Air Home” and components needed to create control sensors ourselves.

Our research project is of an applied nature, its practical value is that we provide more than a 1000 students and more than 80 teachers and technical staff of the school with a transparent, modern air quality monitoring system, compliance with Covid 19 infection control and reduce heat loss by the school building during the heating season.

The project was tested at the All-Ukrainian and International scientific and technical competitions: the final of «DreamEco» 2021, the 3rd place in the nomination «Ecology and resource conservation» of the exhibition of works «Future of Ukraine», received an honorable mention at the competition «Genius Olympiad Ukraine» 2022, won a bronze award at the International exhibition of works «INTARG» 2022, became a finalist of the competition «I-FEST» 2022, received a silver award at the III stage of the competition-defense of scientific and research works of the National Academy of Sciences and was honored by the Minister of Education and Science of Ukraine.

## Chapter 1.

# OVERVIEW OF EXISTING METHODS AND MEANS FOR ATMOSPHERIC AIR QUALITY CONTROL

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### 1.1. Analysis of the state of the problem of air pollution.

Atmospheric air is one of the most important natural resources without which human life is impossible. Anthropogenic and natural pollutants are released into the atmosphere that cause changes in the concentration of gases. For example, the concentration of gaseous substances such as NO<sub>2</sub> and CO<sub>2</sub> is constantly increasing.

The importance of controlling the level of AP pollution in the environment of anthropogenic impact is justified by the results of theoretical and experimental studies using methods of physical and mathematical modeling. Using this approach allows you to assess the level of quality of AP in a large city or other facility where there are mobile or stationary sources of pollution. Having determined the level of contamination of AP with various harmful substances, and established trends in the distribution of impurity concentrations over time and territory, it is possible to decide on the establishment of stationary posts of 12 observations in the relevant area and schedule them. Such observation points can provide data on the general condition of air masses, control emission sources if they are in their area of influence. The availability of information on the level of pollution of the AP, as well as trends in its change is extremely important to ensure the required cleanliness of air masses. Monitoring the level of AP contamination is the main way to identify relevant patterns.



## 1.2. General characteristics of air quality monitoring systems.

The air quality monitoring system is a system of monitoring, collecting, filtering, processing, storing, transmitting and analyzing information on the level of AP pollution, forecasting its changes and making recommendations to make informed decisions to avoid situations that lead to environmental degradation. The monitoring system will help identify critical situations and sources of negative impact on the environment. In general, the process of monitoring the AP involves monitoring its condition and generating warning reports of critical situations that have, or could have, a dangerous / harmful effect on the health of humans or other living beings. Monitoring the level of air pollution is illustrated by the block diagram shown in (Fig. 1.2.)

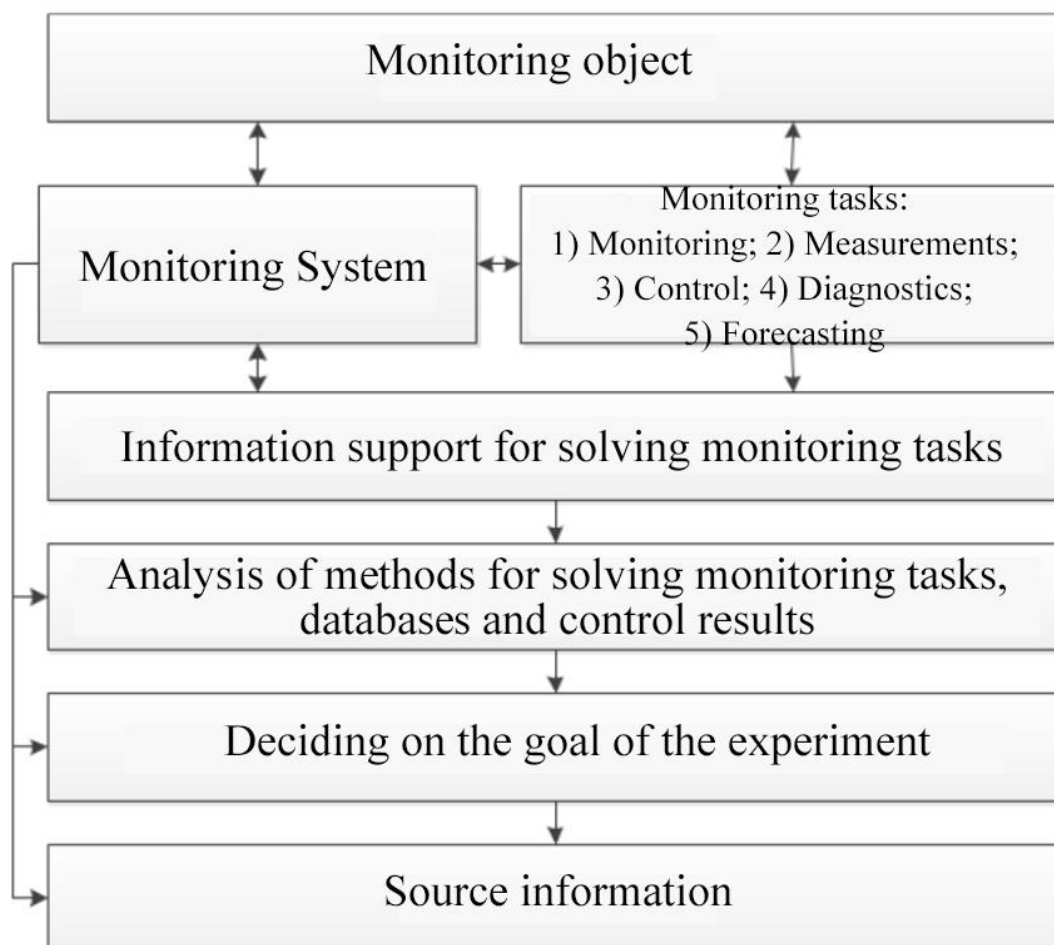


Figure 1.2. Block diagram of the process of air monitoring

Air mass pollution monitoring systems allow solving the following tasks: - monitoring and automated recording of pollutant concentrations; - analysis of the obtained data to determine the actual level of air pollution; - implementation of a set of emergency measures to combat the causes of air pollution; - verification and refinement of analytical calculations for the spread of harmful impurities; - development of recommendations for improving the ecological state of the environment; - obtaining the predicted values of the level of pollution. 14 Automated systems for monitoring the level of AP pollution are used to measure the concentration of the following chemicals: NO, CO, NO<sub>2</sub>, O<sub>3</sub>, SO<sub>2</sub>, NH<sub>3</sub>, H<sub>2</sub>S, CH<sub>4</sub>, C<sub>6</sub>H<sub>5</sub>CH<sub>3</sub>, C<sub>6</sub>H<sub>6</sub>, CH<sub>2</sub>O, C<sub>6</sub>H<sub>5</sub>OH, C<sub>8</sub>H<sub>8</sub>, HNO<sub>2</sub>, C<sub>8</sub>H<sub>10</sub>, C<sub>10</sub>H<sub>8</sub>, CO<sub>2</sub>, O<sub>2</sub>, PM<sub>2.5</sub>, PM<sub>10</sub>. The process of measuring these substances is carried out using a number of specific sensors, including ammetric, electrochemical, piezoquartz, semiconductor, photometric sensors using fiber-optic and indicator tubes, sensors based on surface-active fibers, biosensors, etc.

### 1.2.1. Principles of creating real-time monitoring systems.

The main principle of designing a modern environmental monitoring system of the AP is the principle of real-time data processing. This means that the processing of information should be carried out immediately after its receipt, and the decision taken on this information should control the process of collecting this information. The basis for the creation of real-time monitoring systems is the principle of air condition management, taking into account the analysis of the flow of events. This management process is based on the recording and processing of events, which are constantly analyzed taking into account data on the current state of air pollution. Let's analyze the universal scheme of the information-measuring system for control of a condition of atmospheric air. When determining the structure of the AP monitoring system, the most universal approach is its division into blocks: "Observations", "Assessment of the actual situation", "Forecasting the situation", "Assessment of the forecasted situation".

In addition to monitoring and measuring emission levels, air quality monitoring involves assessing and forecasting the state of the atmosphere. To monitor the state of the environment, an intelligent system of environmental control and monitoring is used, which collects, processes, models, forecasts and evaluates data in order to make management decisions on environmental conservation and rational use of natural resources. Thus, the purpose of the air quality monitoring and control system is not only passive statement of facts, but also their in-depth analysis, environmental justification of prospects, conducting experiments and improving the process of environmental environmental monitoring .

## Chapter 2.

### RESULTS OF DESIGN AND EQUIPMENT OF THE AIR QUALITY MONITORING SYSTEM IN THE SCHOOL

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Digital monitoring in the educational environment is an IDEA we offer.

#### 2.1. Device for monitoring air quality at school.

When analyzing the existing devices, which have all the necessary sensors assembled under one housing, we chose and supported the Ukrainian manufacturer – NGO “Free Arduino”, which speeds became project partners and their device Air Home. This device has all the necessary sensors for use in school, namely:

- pilometers of solid particles PM1, PM2.5, PM10;
- sensor for determining CO2 in the air;
- as well as temperature, relative humidity and atmospheric pressure in the room, which are collected under one building.

Carries out measurements once a minute and displays indicators and devices of students and teachers. Device picture (Figure 2.1)



Figure 2.1. Air quality monitoring sensor, that has been developed by Ukrainian company.

## 2.2. Scheme of organization of air purification quality monitoring system in Cherkasy specialized school of I-III degrees №3.

Implementing the connection between the information from the devices and the participants in the educational process is an integral part of the whole project.

Currently, we are organizing a comfortable connection, ie a system of data transmission from performance sensors to users with a modern Air Quality Monitoring System in the Learning Environment. For convenience and productivity, we chose Telegram Bot as a digital platform. In a simple way to describe the operation of the system can be a scheme.(Fig. 2.2.)

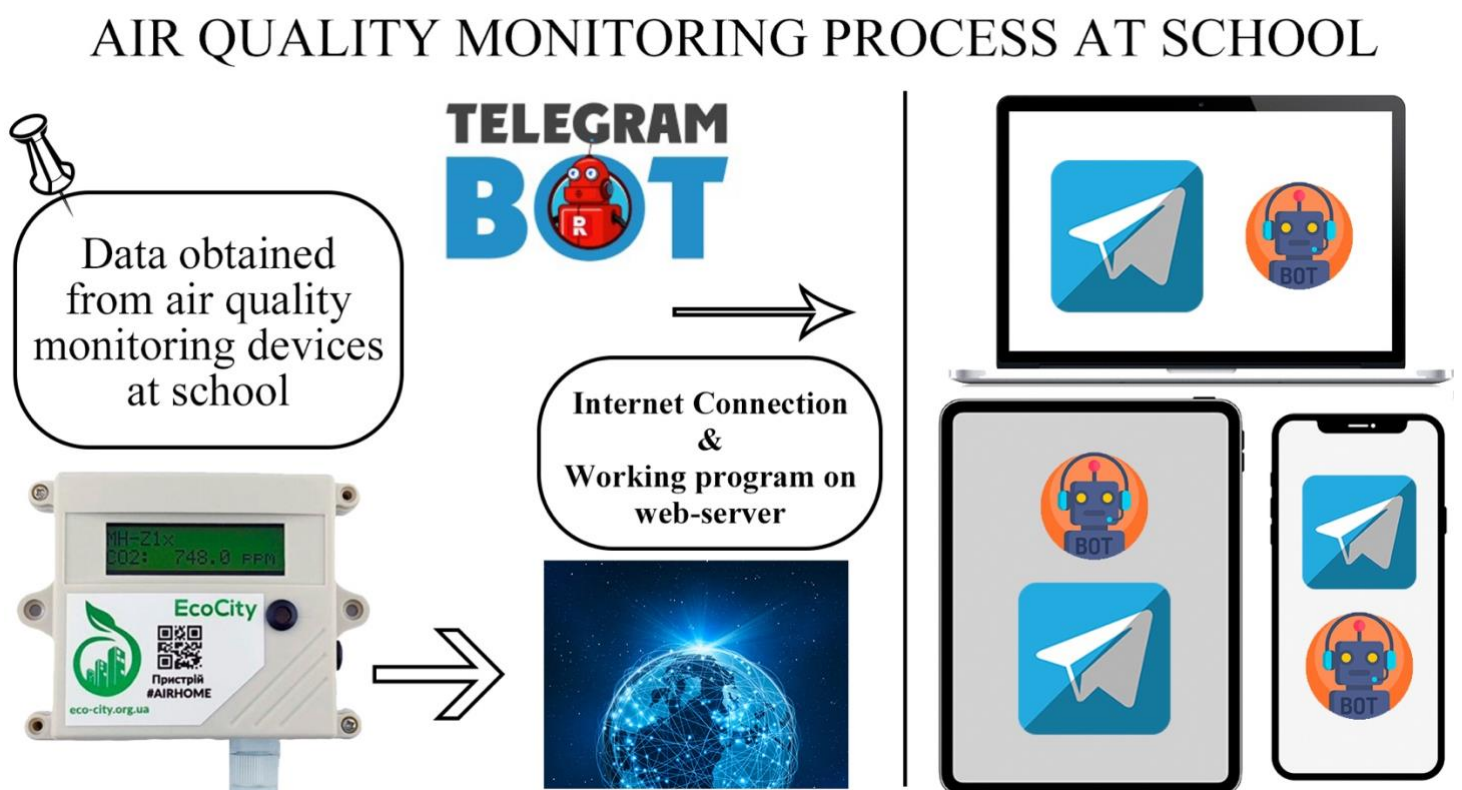


Figure 2.2. Scheme of air quality monitoring process at school.

### 2.3. Telegram Bot software for integrated air condition analysis.

Part of the project is software. After analyzing the most convenient methods for obtaining data by participants in the educational process, we chose the Telegram bot. It is written in the Python programming language and performs all the necessary functions. An example of Telegram Bot is presented below (Fig. 2.3.)

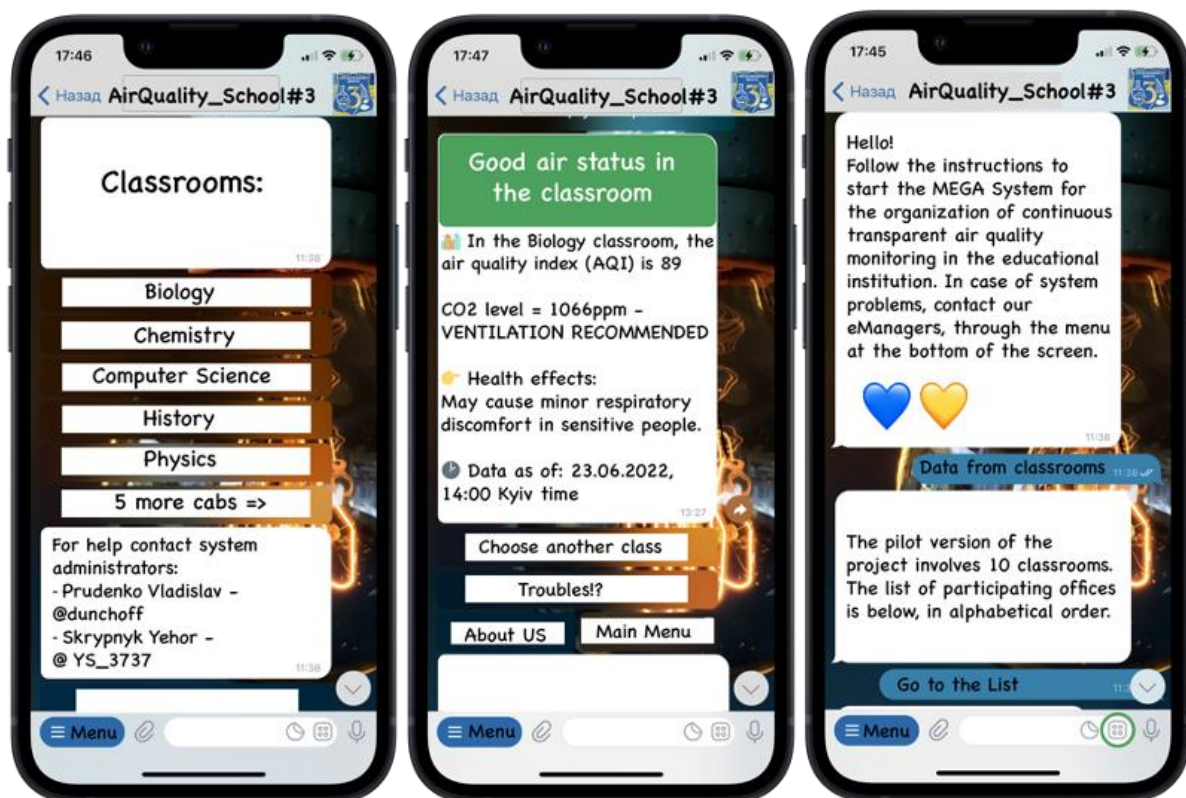


Figure 2.3. Working Telegram Bot example.

A team of energy managers, recruited from students who are interested in implementing and advancing the experiment, will monitor the process of air purification by ventilation. With the help of software, educators will review the state of the air and prevent waste of heat through limited ventilation, ie when ventilating to check the data, which is updated every minute, and immediately when the norm is restored - to end the controlled action.

In addition, such a DIGITAL CONTROL system can be useful for responsible self-government of students who will feel more self-sufficient and responsible !!!

#### 2.4. An alternative for equipping the entire school with air quality monitoring devices.

We have an idea, that can help us use sensors at all school classrooms and economize much money for buying. We`re going to create it by ourselves. The functionality will be the same but they will cost much cheaper. Let's look at the calculations:

- After calculating the components of our own device, its amount will be 1158 UAH  $\approx$  31 USD  $\approx$  31 EUR and the amount of the Ukrainian company developed device is 3511 UAH  $\approx$  95 USD  $\approx$  95 EUR .
- 140,440 UAH  $\approx$  3,800 USD  $\approx$  3,820 EUR will be needed to equip the whole school with air quality monitoring devices with ready-made sensors.
- 46320 UAH  $\approx$  1,250 USD  $\approx$  1,260 EUR will be needed to equip the school with our own devices.

That is, ourselves made sensors is three times cheaper to equip the whole school than ready-made devices.

## 2.5. Sustainable development education role in our research.

Our school has many years of experience in education for sustainable development, which we recognize as part of the mission and strategic plan of our educational institution. The main component of the monitoring system is a team of students and teachers who control the process of airing the premises to restore air quality. When a student systematically monitors the operation of the system at school, he receives personal practical experience in implementing the ideas of sustainable energy and resource consumption, a responsible attitude to his own and public health, accepting that urban communities provide sustainable development through innovation and synergy. All of the above is part of education for sustainable development, namely practical activities in achieving the goals: Good Health and Well-Being (3), Quality Education (4), Gender Equality (5), Sustainable cities and communities (11), Responsible Consumption (12), Combating Climate Change (13).



Figure 2.5. Sustainable Development Goals.



## CONCLUSIONS

1. In order to comply with the requirements of the "Sanitary Regulations for Secondary Schools", it is important to organize the process of ventilation in the heating season, which prevents wasteful heat loss.
2. The best solution for the installation of SMOP in school premises are devices that are equipped with WIFI modules, constantly monitor and send integrated indicators to smartphones via Telegram.
3. Optimization of the air purification quality monitoring system is possible due to the reduction in the cost of construction by manufacturing our own devices and developing our own software.

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## 【評語】 180017

Using commercially available instruments to measure/monitor the air quality for various physical indexes in school classrooms. Simple temperature and air quality detectors were used to monitor classroom air quality and changes in related meteorological elements. Special emphasis is placed on the influence of ventilation or not. The idea is good , but the research objectives and scientific issues discussed should be clearer. Measurements made only for a specific time period without comparisons with , say , other seasons. If there is a comparative analysis of the accuracy of the monitors , it will help the analysis and application of the monitoring data. In addition , if we can analyze the monitoring data for a longer period of time and explain the reasons for the changes , the quality of the work can be improved.