СЕКЦІЯ: STEM-ОСВІТА: ШЛЯХИ ВПРОВАДЖЕННЯ, АКТУАЛЬНІ ПИТАННЯ ТА ПЕРСПЕКТИВИ

EMPOWERING STEM EDUCATION WITH IOT: BENEFITS, CHALLENGES, AND OPPORTUNITIES

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STEM education aims to prepare students for careers in scientific and technological fields. One of such fields is IoT – Internet of things. The Internet of Things describes the network of physical objects – »things» – that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet. These devices range from ordinary household objects to sophisticated industrial tools. With more than 7 billion connected IoT devices today, experts are expecting this number to grow to 22 billion by 2025 [3]. The exponentially growing IoT market presents compelling opportunities for innovators to develop and create meaningful applications affecting everyday life. This puts new demands on educational institutions to prepare students for IoT-relevant skills [1].

Integration of IoT in STEM education has the potential to transform the way we teach and learn STEM subjects.

There are several key benefits of incorporating IoT in STEM education:

1. Promoting interdisciplinary learning: IoT projects require students to integrate knowledge from various STEM fields, including computer science, electrical engineering, data analysis, and more. This helps students see the connections between different STEM fields.

2. Bridging the gap between theory and practice: IoT provides students with real-world applications of the concepts they are learning in the classroom. By working on IoT projects, students can see the practical applications of STEM concepts and gain valuable skills.

3. Enhancing problem-solving skills: IoT projects often require students to identify and solve complex problems. This helps them develop problem-solving skills that can be applied in various areas of their lives.

4. Encouraging innovation and creativity: IoT technology provides endless possibilities for innovation and creativity. By learning about IoT, students can come up with innovative solutions.

5. Improving collaboration and teamwork: IoT projects often involve collaboration between students with different skills and backgrounds. By working together, students can develop teamwork and collaboration skills that are essential for success in their future careers.

To start learning IoT in STEM education, you will definitely need special hardware and software resources, such as microcontrollers, sensors, actuators, and programming tools. At a glance, this may seem challenging. Nevertheless, let analyze it all in details and see it is not that problematic nowadays.

The hardware required for IoT can vary depending on the specific project or application. However, some essential hardware components that are commonly used in IoT projects include:

1. Microcontrollers – small computers that can be programmed to control sensors, switches, motors, and other components of an IoT device. Popular microcontrollers include Arduino, ESP8266, ESP32 and Raspberry Pi.

2. Sensors – devices that can detect changes in the environment, such as temperature, humidity, light, motion, etc.

3. Actuators – devices that can be controlled by a microcontroller to perform specific actions. Popular actuators include motors, relays, and servos.

4. Communication modules – devices that enable IoT devices to communicate with other devices. Common communication modules include Wi-Fi and Bluetooth modules. More advanced ones include ZigBee and LoRa.

The price of most of the components considered above does not exceed a few dollars (fig. 1). The most expensive of them, the Raspberry Pi, costs several tens of dollars, but it may be necessary for more advanced projects and is not required for beginning. Furthermore, many teachers who work in STEM already have Arduino kits with a lot of sensors and actuators, so the only thing they may need to purchase is communication modules.

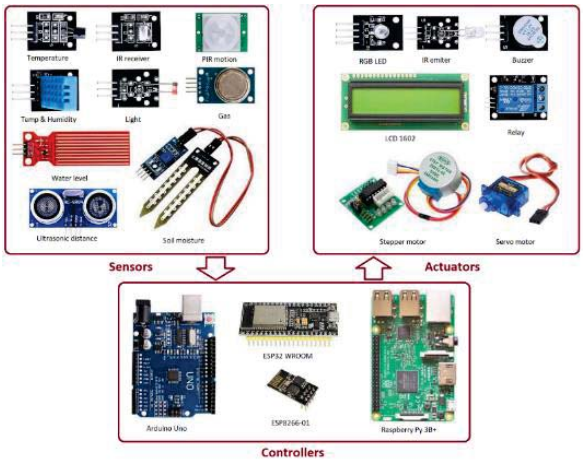

Fig. 1. Popular components for educational IoT projects

Programming tools are essential for writing the software that runs on microcontrollers and processes data from sensors and actuators. Most popular programming languages for IoT include C/C++, Python and JavaScript, and all of them are free and open-source.

As stated above, IoT refers to the network of "things" that exchange data with other devices and systems over the Internet. In fact, real-world IoT applications typically follow a 4-layer architecture that includes cloud-based online services (fig. 2) [4]. Cloud-based services provide storage, processing, and analysis capabilities for IoT data. Examples of popular cloud-based services for IoT include AWS IoT, Google Cloud IoT, and Microsoft Azure IoT.

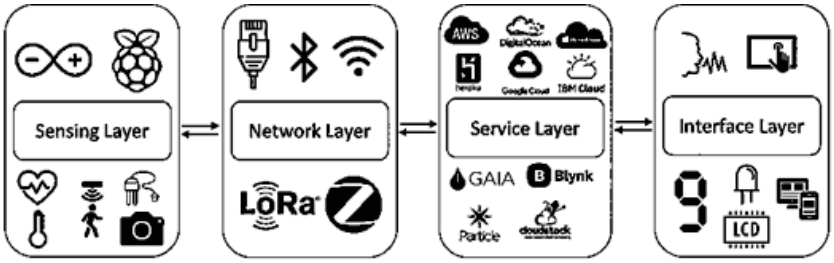

Fig. 2. IoT 4-layer architecture

The services listed above have free plans, but to start, you should consider using other popular cloud-based IoT platforms:

Blynk (https://blynk.io) – provides a drag-and-drop mobile app builder to help users build custom interfaces for controlling and monitoring their hardware projects. The platform offers a range of hardware integration options, including Arduino, Raspberry Pi, ESP8266, ESP32, and more. Blynk also provides data storage, analytics, and notifications services to help users easily collect and analyze data from their projects.

Ubidots (https://ubidots.com) – allows users to easily collect, store, and analyze sensor and device data from a wide range of sources. It provides tools for data visualization, real-time alerts, and data analysis, making it easy for users to gain insights into their IoT systems.

ThingSpeak (https://thingspeak.com) – allows users to act on data from sensors or actuators in real-time. It provides a service that enables the creation of IoT applications with MATLAB analytics, visualization tools and other web-based services. ThingSpeak has a simple user interface and a powerful set of APIs that allow users to easily upload, analyze and share data from their connected devices. It is often used for applications such as environmental monitoring, smart agriculture, and home automation.

There are many areas to start developing IoT projects (fig. 3). For instance, you may consider some of the Top 9 areas for IoT real-world applications in 2023 [2]:

1. Agriculture and Pest Control – can monitor soil moisture, temperature, and other factors to optimize crop yield and reduce water usage.

2. Environment – can monitor environmental factors such as air quality, water quality, and weather patterns to improve public health and safety.

3. Smart Home Applications – can control lighting, temperature, and other home appliances to improve convenience and energy efficiency.

4. Health Care – can monitor vital signs and track patient health, reducing the need for hospitalization and improving patient outcomes.

5. Smart Cities – can monitor traffic flow, air quality, and other factors to improve city planning and resource allocation.

6. Safe Driving – can provide real-time data about the road conditions, traffic flow, and weather conditions.

7. Waste Management – can monitor waste collection bins and dumpsters in real-time, which can help optimize collection routes, reduce fuel consumption, and save costs.

8. Industrial Automation – can monitor and optimize industrial processes, reducing downtime and improving productivity.

9. Supply Chain – can track goods in transit, monitor inventory levels, and optimize supply chain logistics.

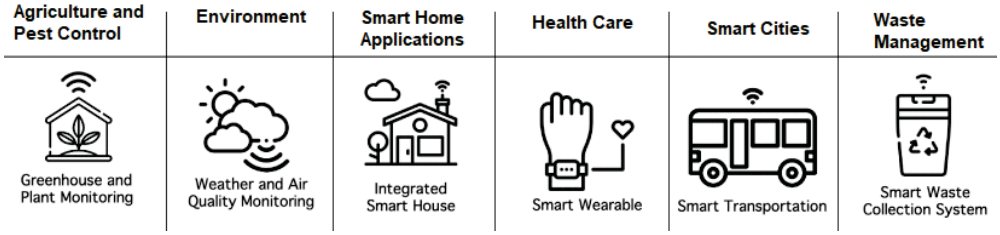

Fig. 3. Popular areas for real-world IoT applications

Overall, learning about IoT in STEM can provide students with a range of benefits. Firstly, they will gain important knowledge necessary to pursue careers in these fields. In addition, as students work on real-world projects that require collaboration and the design of solutions to complex problems, learning about IoT can also foster problem-solving and teamwork skills. These skills are not only important for future careers in STEM fields but also for everyday life.

While there are certainly challenges to implementing IoT projects in STEM education, the benefits of doing so can be significant. By leveraging the power of IoT, students can gain hands-on experience in electronics, programming, and data analysis, and develop skills that are in high demand in today's job market.

References

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