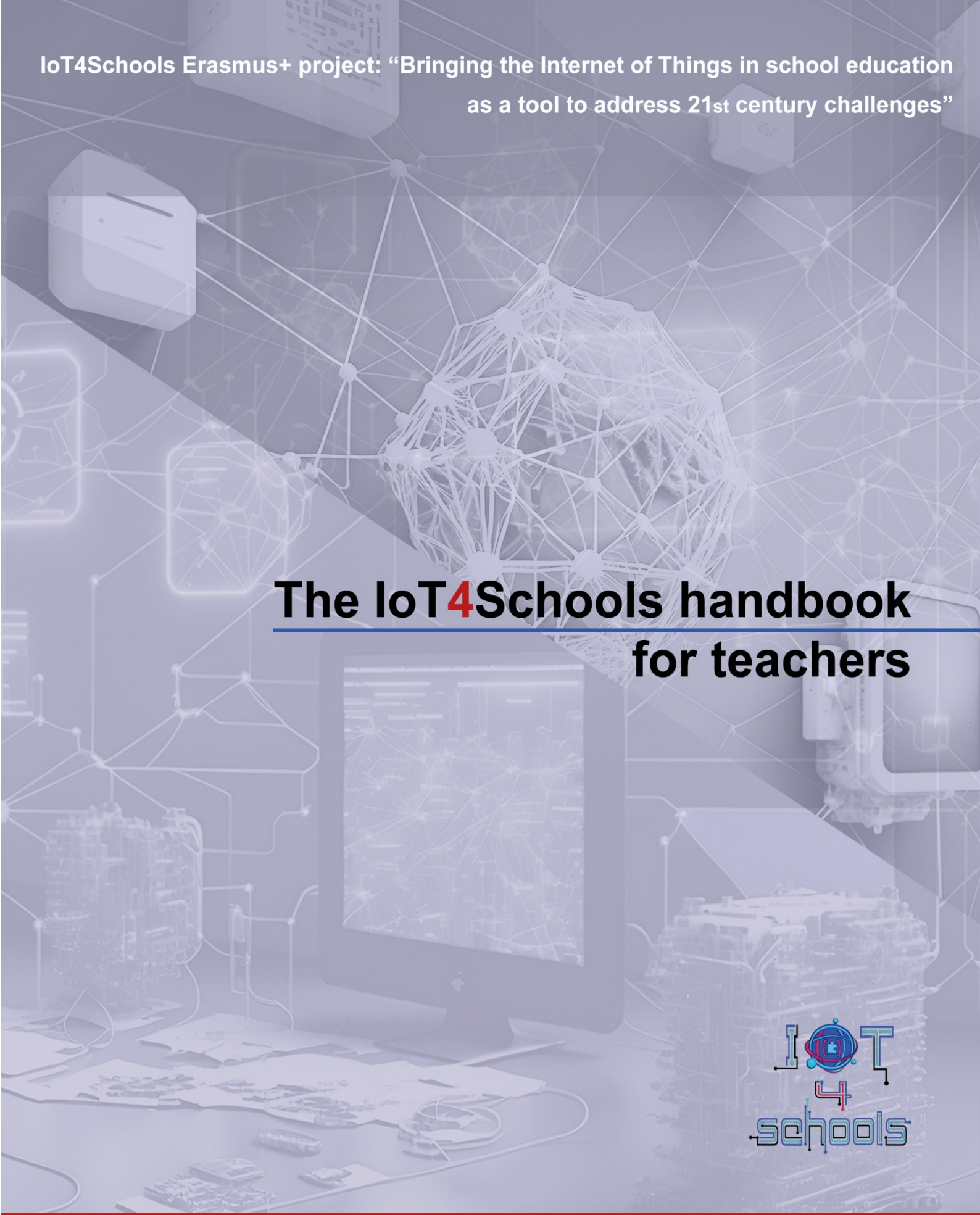
IoT4Schools Erasmus+ project: “Bringing the Internet of Things in school education as a tool to address 21st century challenges”

The IoT4Schools handbook for teachers



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IoT4Schools
"Bringing the Internet of Things in school education as a tool to address 21st century challenges"

- The IoT4Schools handbook for teachers-

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Introduction

What this handbook is about

The present document is the “IoT4Schools handbook for teachers”; a document that is produced in the framework of the IoT4Schools Erasmus+ project with the aim of helping educators to introduce students aged 12 to 18 to the concept of IoT and IoT technologies. The purpose of this handbook is to provide a brief but concise guide to the world of IoT, with information that is easy to understand, while offering ways and methods to familiarize learners with this concept through the lens of real-world challenges and problems and the ways in which they can be solved or mitigated by using IoT applications and technologies. On this basis, the handbook explains why it is important to introduce IoT into school education and suggests possible (but feasible) mechanisms for its proper implementation. To this end, it addresses a range of 21st century challenges and problems, raising awareness of the presence of IoT in our daily lives, as well as a number of good practices of past implementations of IoT in school education, serving as real and inspiring stories from the wider educational community. These form the basis for a number of exemplary learning scenarios which represent learning methods and objectives that encourage collaborative learning, combined with hands-on practices that spark critical thinking, problem solving and creative thinking. The exemplary scenarios aim to motivate students to explore and study different ways and cases in which IoT is present to their everyday lives, interacting with existing IoT applications and devices, while analyzing and reflecting on the different representations of the world through the collected data, leading to decision-driven choices when it comes to design and implementation. The creation of specific IoT projects as solutions to the challenges is beyond the scope of this handbook. However, suggestions on how each scenario can be further developed are included, paving the way for a smooth transition to the development of student-led IoT projects, in the framework of the next work package. In this way, the present handbook not only helps both educators and students to become familiar with the IoT and to explore its inherent concept in depth, but also serves as a learning scaffold for approaching and designing IoT projects that will be appropriate for teaching and learning IoT in secondary education.

Who it is intended for

This handbook is designed for a broad audience involved in education, specifically targeting:

Teachers and Educators: Primary users who will directly implement IoT concepts and technologies in their classrooms. This handbook aims to support teachers and educators in introducing IoT concepts in their classrooms and show them how to smoothly engage later on their students in practical activities using IoT technologies.

STEM Facilitators: Individuals who focus on promoting Science, Technology, Engineering, and Mathematics education. The handbook provides them with IoT-specific content to enhance their STEM programs.

Prospective Teachers: Future educators currently in training who seek to incorporate innovative technologies into their future teaching practices. This handbook can serve as a valuable resource for their professional development.

Teacher Trainers: Professionals responsible for the continuous development of teaching skills and methodologies. The handbook offers insights into bringing IoT in the classroom, enabling them to train and support teachers effectively.

Anyone Interested in IoT in Education: Individuals with interest in integrating IoT into educational settings. This includes educational policymakers, curriculum developers, educational practitioners and technology enthusiasts looking to understand how IoT can be applied in a learning environment.

How the document is structured

The handbook has four main sections: 1) Towards IoT: definition, background, challenges and good practices, 2) Introducing IoT in secondary schools: Learning objectives and learning methodology, 3) Exemplary scenarios for IoT projects addressing selected everyday challenges, and 4) Recommendations for further reading.

Section 1 ("Towards IoT: definition, background, challenges and good practices") aims to provide an overview of the concept of IoT, how it relates to everyday life, and why it is important for education. In particular, subsection 1.1 provides a definition of IoT and a brief historical background of IoT, presenting basic information on the origins of IoT. Subsection 1.2 then briefly introduces the main parts of an IoT system, while subsection 1.3 explains why the IoT4Schools project focuses on IoT and its introduction into secondary education. Subsection 1.4 contains the summary of a research conducted in the field of IoT in order to identify a number of challenges and problems in everyday life that can be solved by IoT. These are 1) Smart Cities, 2) Home automation, 3) Health monitoring and 4) Environmental protection, which are the focal points for the development of the exemplary scenarios. Finally, subsection 1.5 presents a number of good practices regarding the implementation of IoT in various learning setups, which serve as inspirational stories for the development of the exemplary scenarios, as they present how IoT has been meaningfully introduced and implemented in other projects, educational settings and initiatives.

Section 2 ("introducing IoT in secondary schools: Learning objectives and learning methodology") presents the ways in which IoT concepts and technologies can be introduced to students through the lens of the four challenges, combined with project-based learning approaches and pedagogies, as well as the expected learning outcomes from the implementation of the exemplary scenarios. In particular, subsection 2.1 highlights what your students will learn, be able to do and the knowledge they will gain through the implementation of the exemplary scenarios, while subsection 2.2 presents how the methodologies (thoroughly described in the document "Defining learning objectives and learning methodologies for IoT project") are introduced in the context of the exemplary scenarios.

Section 3 ("Exemplary scenarios for IoT projects addressing selected everyday challenges") presents a number of exemplary scenarios that reflect practical and engaging ways to introduce IoT to your students through the lens of hands-on approaches, fostering interdisciplinarity and STEM related approaches, that encourage collaboration, critical thinking and problem solving. The scenarios highlight the role of IoT technology in everyday life, particularly in the domains of Smart city, Housing automation, Health monitoring and Environmental protection. Each scenario follows certain stages, which are a) Group Formation, b) Device/application/technology Integration, c) Data Collection Assignment, d) Analysis and Reflection, and e) Presentation and Discussion. Through each scenario students are encouraged to collaborate, observe, and share their points of view to discover ways in which IoT can help solve or address everyday problems, while recognizing both the benefits and limitations of such technologies, thus preparing them to work on the IoT projects that will be developed at a later stage, and in the context of WP3. The handbook contains a total of 10 different exemplary scenarios: 3 on Smart Cities ("Traffic and data-driven decisions"; "Smart car: how to reduce the number of car accidents"; "Smart waste bins: how to improve waste management in smart cities"); 3 on Home automation ("Towards designing a smart home"; "Smart Gardening"; "School automation: designing a "smart" energy efficient school"), 1 on Health monitoring ("Using smart electronic devices and applications to monitor health-related data"), and 3 on Environmental protection ("Using air quality monitoring application"; "Using IoT devices for water conservation and preservation of school gardens"; "Introduction to IoT-based weather reporting system"). Each scenario includes a description of the activity, indicative questions to help initiating the dialogue, specific learning objectives, tools or/and software required for its implementation and additional suggestions for facilitating its smooth implementation.

Finally, section 4 (“Recommendations for further reading”) includes a number of indicative sources that can provide you with further inspiration on how to introduce IoT in the classroom, as well as available technologies that can support the creation of an IoT project. This provides a link to the next step of the IoT4Schools project, which is the development and implementation of interdisciplinary hands-on IoT projects.

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1 Towards IoT: definition, background, challenges and good practices

1.1 A brief definition and historical background of the IoT

IoT refers to internet-connected devices that collect and transmit large amounts of data over wireless networks, to other (connected) devices to perform specific tasks [1 - 3]. A device (or "thing") can be anything from physical objects (with embedded sensors) to mechanical systems that enable communication between various entities through data transfer [1, 2].

Figure 1: Examples of IoT devices: a. Smart Lock (Retrieved from here); b. Smart garage control (Retrieved from here); c. IoT wireless environmental sensor (Retrieved from here); d. Glucose monitor system (Retrieved from here); e. Smart baby monitor (Retrieved from here); f. Smart Speaker (Retrieved from here)

> *"Essentially, any object, whether natural or man-made, can be assigned an Internet Protocol (IP) address and possess the capability to transmit data over a network." [2]*

The first person to use the term "Internet of Things" was British technology pioneer, Kevin Ashton in 1999 [1, 4]. Ashton's idea for the IoT came about while he was working on Radio-Frequency Identification (RFID), when he realized that it would be very beneficial if computers were able to gather data on their own, rather than relying on data originated and generated by humans [4]. According to him, such an ability would allow computers to capture and communicate much more accurate and interesting information about the world (in the form of data), while allowing humans to focus on monitoring and analyzing larger amounts of data, thus making more valuable decisions about the "things" around them, leading to a reduction in waste, loss and cost [4]. Although the idea of interconnected computers and objects that communicate data can be traced back to the concepts of ubiquitous and pervasive computing [5], Ashton's idea combined with the rapid development of the internet, paved the way for more active discussion and research on this topic [2]. Nowadays, the IoT has become omnipresent due to the combination of wireless technologies, microelectromechanical systems (which are the driving force of automation), microservices and the internet, leading to "a more interconnected and data-driven ecosystem" [2].

1.2 How IoT works

An IoT system consists of a device with built-in sensors and hardware that collect data [6-8]. The collected data are stored in IoT platforms. To do this, the device should be connected to these platforms. IoT platforms have cloud servers and large databases that process and analyze data to extract important information [8]. This information is then transmitted/shared to users through a website or an application, and used to perform specific tasks, according to users' needs [6].

There are 4 main components that describe the concept of an IoT system: 1) sensors/ devices, 2) connectivity, 3) data processing and 4) user interface [7]. Sensors or/and devices (through sensors) sense the physical environment and collect important information in the form of data. Connectivity (Wi-Fi, Bluetooth, etc.) is the medium that allows sensors to send data to IoT platforms and cloud servers. Data processing is about the analysis of data and the speed at which this is done. Finally, user interface is the output of the whole process in a visual and perceptible form for the user, based on the task that needs to be accomplished.

1.3 Why IoT and why IoT4Schools

As mentioned, IoT is omnipresent, offering a host of benefits that improve everyday life, thus transforming the way people interact with technology [2]. The exponential growth of the IoT and the relevant technologies has enabled individuals to make decisions based on input from their smart devices for a variety of reasons, including lifestyle and health management [1,2]. Furthermore, it has facilitated the development of solutions to complex daily, societal and environmental challenges, some of which are briefly mentioned in sub-section 1.4.

The IoT has also begun to be integrated into the education sector, particularly during and after the Covid-19 pandemic [9]. This integration has been driven by the necessity to provide solutions that align with the demands of a new era, which has been shaped by the pandemic as well as the ongoing conflicts. The IoT is rapidly transforming conventional teaching approaches, resulting in significant shifts in the foundational aspects of educational institutions. This shift, which is reflected by the term "Internet of Educational Things" (IoET), aims to enhance educational content, teaching methodologies, and the infrastructure of schools and universities' campuses in light of the Internet of Things (IoT) [10]. In this context, the implementation of IoT technologies, applications and devices is aimed at creating smart classrooms that can facilitate more engaging and personalized learning experiences by helping teachers to monitor the progress of their students, providing insights on how they can improve their teaching practices and adopt new learning approaches [11]. Furthermore, the utilization of IoT technologies and devices (e.g., sensors and cameras) facilitates the enhancement of teaching practices, thereby transforming the learning experience into an interactive and intuitive one [11].

These aspects are highly promising in terms of improving and enhancing teaching methods and learning through the use of interactive and tangible content, turning the entire learning process into a more meaningful experience. As [9] estimated, in the near future, the majority of students will be immersed in a world where IoT technologies are pervasive. In this context, it is not only crucial for students to learn to interact with IoT enhanced environments, but also important to educate them so they can gain an understanding of the world being shaped by IoT and other technologies [12]. It is therefore crucial for students to grasp the fundamental

concepts and methods associated with the IoT and to engage in tangible learning experiences that are rooted in authentic case studies from the real world.

In this context, the objective of IoT4schools is to shift the focus on preparing teachers towards engaging their students in learning practices that introduce them to IoT technologies and the ways in which they can be used to solve challenges and problems in everyday life. This will be achieved through the implementation of exemplary learning scenarios and hands-on projects that are inspired by these challenges as well as by good practices that blend IoT with learning approaches, and which will provide students with the tools and resources that will assist them in developing IoT-based solutions.

1.4 Identified challenges and problems in everyday life: results from "Review on 21st century challenges and IoT solutions for everyday life"

In the context of the IoT4Schools project, a comprehensive literature review was conducted to identify the everyday challenges and problems of the 21st century that can be addressed through the use of IoT (available here). Several topics were highlighted and grouped into four main categories and chapters, namely Smart cities, Home automation, Health monitoring and Environmental protection. Each of the aforementioned categories is accompanied by a description of the main challenge and the manner in which IoT can be employed to address these issues, revealing possible pathways and scenarios for introducing IoT to school education. In particular:

1.4.1 Smart cities:

"Smart cities" is a concept focused on the ways that new technologies and IoT can be employed to address the challenges that arise in large urban areas as a result of urbanization. In this sense, the chapter of "Smart cities" gathers a number of sub-problems and analyzes them through the lens of three main topics: transport and mobility, resource management (including energy, water and sewage and waste management) and telecommunication systems. Each topic addresses the potential for IoT projects or small initiatives revolving around IoT to mitigate or solve the imminent problems. In "transport and mobility" a number of initiatives for improving the efficiency and convenience of daily transport and mobility, are highlighted. Some of these include: 1) the use of IoT services and systems for the monitoring of public transport vehicles and the dissemination of information regarding arrival and departure times, thereby enhancing the efficiency of public transportation and reducing the utilization of passenger cars; 2) IoT services for the tracking of traffic, assisting drivers in the avoidance of congested roadways; 3) the deployment of Intelligent Transportation System (ITS) along with autonomous buses and vehicles to improve road safety; as well as 4) the use of IoT in urban amenities such as smart street lights that also contribute to road and pedestrian safety. In the field of "Resource management", a number of IoT solutions for the efficient management of raw materials such as energy, water and food are presented. Such solutions include the use of IoT systems for the following purposes: 1) monitoring and prudent use of energy supplies, 2) monitoring and repairing damages in facilities used for water distribution, thus reducing the waste of water resources; 3) monitoring the quality of already used water (e.g. for watering plants) and reuse it in different sectors; as well as 4) monitoring the level of wastes, and/or properly sorting the trashes, leading to more efficient strategies of collecting and recycling garbage. With regard to the field of "Telecommunication systems", the integration of IoT technologies can facilitate the optimization of telecommunication network efficiency. This can be achieved by the monitoring and analysis of parameters related to poor internet distribution, enabling the formulation of targeted strategies for the improvement of relevant infrastructures.

1.4.2 Home automation:

Home automation category examines the potential applications of IoT in residential settings, with a particular focus on the development of smart solutions that can enhance energy efficiency and provide safety and comfort benefits. Some of the proposed solutions include the

use of IoT for: 1) monitoring weather conditions and adjusting the use of heating and cooling based on the actual needs of the residents for thermal comfort, thus reducing energy consumption; 2) monitoring daily habits in respect to water use thus adjusting the needs for water consumption, including water heating; 3) adapting lighting based on parameters such as the presence of residents in a room and levels of ambient light; 4) monitoring the air quality in the house and activating devices that can purify air quality, or setting alarms in case of emergency (e.g. smoke or a fire); 5) monitoring the content of a refrigerator and informing the owner about the quantity and the quality of food, thus reducing food waste; 6) monitoring the status of appliances and informing the owner for their maintenance; as well as 7) creating custom home automation solutions that will facilitate the life of senior residents.

1.4.3 Health monitoring:

The “Health monitoring” category concerns the utilization of IoT for the purpose of facilitating the delivery of appropriate medical care to individuals as well as improving the quality of life. In this context, some of the proposed solutions include the utilization of IoT technologies for: 1) monitoring critical parameters for the life of a premature newborn baby including body weight, breathing, heart rate, temperature and saturation; 2) monitoring of the health of older people through parameters such as blood pressure, heart rate, and sugar level, with the data shared with relatives or personal doctor; as well as 3) monitoring of the health condition of people with specific diseases, with the aim of preventing mortality from specific episodes of illness.

1.4.4 Environmental protection:

The category of “Environmental protection” examines the potential applications of IoT technology for the preservation and protection of the environment. The solutions proposed in this category include the use of IoT for the following purposes: 1) monitoring the air quality and use this data to develop strategies for mitigating emissions and pollution; 2) monitoring sea or river levels and warn authorities for possible floods; 3) monitoring endangered species and provide information for their protection; 4) detecting smoke or fires and – along with various sensors and weather condition data – inform authorities of the situation allowing them to respond as quickly as possible while providing valuable insights that help firefighters make better decisions about how to approach a fire , thus preventing the development of an extreme fire; 5) monitoring the condition of the equipment used by emergency services and notifying when maintenance services should be carried out; as well as 6) improving watering systems used in agriculture by reducing water waste, along with strategies for storing and reusing rainwater.

1.5 Good practices and inspiring stories

1.5.1 The Project DISTANCE

According to [12] in the period 2013-2015, a systematic way of introducing the IoT in schools began to emerge. The DISTANCE project [13] was such an initiative. DISTANCE – which involved extensive collaboration with a number of prominent organizations, including ScienceScope (a company known for integrating technology into education), the University of Birmingham, UCL, Xively, Intel and 8 schools across the UK – aimed to integrate IoT into the school curriculum to enhance learning in subjects such as science, technology and geography. The objectives of this project were as follows: a) the development of a curriculum for IoT including lesson plans and worksheets; b) the inspiration of students to explore new applications of sensors and data; c) the development of skills related to IoT. In this context, both teachers and students had the opportunity to interact with various sensors to measure and share data relevant to their school building through an IoT platform, specifically designed for this purpose. The monitored data were subjected to analysis, which resulted in the design and production of applications focusing on the topics of energy, weather, health and transport. These applications were subsequently piloted in the participating schools, leading to refinements of the produced results.

1.5.2 The “WeMakers” project

The WeMakers Erasmus+ project [14] was centred on the design, manufacture and programming of intelligent objects, with the introduction of IoT in the context of school education being a key aspect. In this context, a number of learning scenarios included in the educational IoT manual were developed and proposed. One such scenario was the "fire management system in the forest." The learning scenario involved the creation of a system comprising a number of Arduino-based devices equipped with heat, smoke and IR sensors. The system was designed to detect fire in forests and notify the relevant authorities, thereby enabling prompt action to be taken. The students were divided into teams and tasked with creating a paper model of a forest. In this paper model they added a number of sensors and programmed them to share data when smoke was detected, while firing an alarm to notify emergency services. The students were introduced to robotics and the Internet of Things (IoT) through this real-case scenario, and were able to gain an understanding of how the latter can be implemented towards the protection of the environment. Additionally, the students developed a range of 21st-century skills, including creativity, collaboration, problem-solving, and digital literacy.

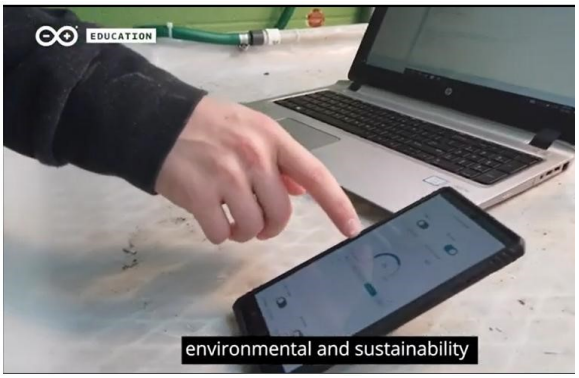
1.5.3 The IoT = Ecology project

The “IoT = Ecology” project [15] was implemented by the IoT Club of the Academic Secondary School of the Białystok University of Technology, and took place in after-school classes from October 2022 to June 2023. The goal of this project was for students to build two IoT devices. One of the devices was about saving energy by automatically turning off the lights or the TV at night, when residents are typically asleep while reading or watching. The sleep phase was detected and monitored through the use of a pulse oximeter integrated into a wristband. Upon detecting a decline in the user’s blood pressure values, the device would instruct the lights or the television to be turned off. The second device was about analyzing the quality of the collected rainwater and determining whether it would be suitable for direct use in a domestic setting (e.g. watering plants) or whether it would first need to undergo reverse osmosis filtration. The students would learn how to use pH and TDS sensors, which would be integrated into the gutters to test the water quality. The data generated by these sensors would be transmitted to a website for monitoring and further evaluation. Through these projects the students would engage in a series of hands-on activities, including circuitry, programming, and 3D design. They would also become familiar with IoT and its potential applications, and ultimately, they would enhance soft skills such as collaboration, creativity, time management and critical thinking.

1.5.4 The AI4STEM project

The AI4STEM project [16] is an Erasmus+ KA2 school project that aims to introduce primary and secondary education students to Artificial Intelligence through a combination of various hands-on IoT projects that combine circuitry, programming, and STEM learning outcomes. Some of the IoT projects that have been developed include a DIY Smart robotic car which collects -among others- data from its surroundings such as temperature and light intensity; an AI vision system which identifies faces or objects based on stored data; and a Smart intruder alarm which transmits distress signals to other microcontrollers. All of the aforementioned projects are accompanied by various resources that facilitate their implementation, including teachers’ guidelines and students’ worksheets. In addition, the project comprises three main teaching components: a) an Educational Framework that presents the methodology underlying the projects, b) an IoT Electronics Kit comprising a BBC micro:bit microcontroller and various electronic components that facilitate the creation of the projects, and c) an online Academy that contains the resources necessary for the implementation of the projects. The projects will be piloted from December 2024 to April 2025. It is expected that through the implementation of the IoT projects the students will develop and enhance 21st century skills such as creativity, critical thinking, and problem solving. The project was featured in the European School Education Platform in April 2024, as one of the most prominent projects to create value to educators and to build AI capacity of schools [17].

1.5.5 Building an Automated Greenhouse using IoT



At White Mountains Regional High School in New Hampshire, US, high school students majoring in computer technology, environmental science and sustainability and mechanics and fabrication, collaborated to build an internet-connected greenhouse [20, 21]. Led by their teachers the students used remote sensing applications to automate lighting, regulate temperature, adjust humidity and monitor the greenhouse from their mobile phones. The students, who would not normally be in the same classrooms, collaborated on this interdisciplinary project and acquired practical skills that they can apply in the future, such as connecting devices, automating manual processes and welding parts. However, this project offered students more than just practical skills. It enhanced their cooperation and communication abilities while also providing them with the opportunity to experience the excitement of learning and witnessing meaningful outcomes. Furthermore, the students had the opportunity to work on a project that was of personal interest to them, as it was inspired by a real-world case scenario and was about suggesting a solution that would help a person in the local community (i.e., help an owner to optimize their Greenhouse), thereby making the entire learning process more engaging.

1.5.6 Cyprus Space Week: Inspiring the Next Generation of Space Scientists

The Cyprus Space Foundation (CSF) collaborated with the Meteorology Department, the Eratosthenis Centre of Excellence (ECoE) at the Cyprus University of Technology, and the Excelsior2020 project to host the fourth annual Cyprus Space Week. The objective of this event was to promote space exploration and astronomy in Cyprus and to foster international collaboration. As part of the program, the Pico microsatellite experiment involved the launch of a microsatellite using a weather balloon [22]. Additionally, 85 educational institutions, participating in the "Plants to Space Program," were involved in this experiment. This initiative integrates STEAM education with space exploration, focusing on the perspective of agriculture. On Friday, 26 May 2023, the robot of PASCAL English School (Larnaka) students, E.L.I.A.S., was launched on a spaceflight reaching an altitude of up to 90.000 meters. The microsatellite was equipped with sensors and cameras that gathered information including speed, altitude, temperature, and moisture. Furthermore, the robot was carrying flower seeds (collected by students from the 85 schools) that were exposed to the conditions of the stratosphere. The robot was subjected to extreme conditions, akin to those encountered in space, including sub-zero temperatures and intense solar radiation, at altitudes reaching up to 90.000 meters. Upon landing, the participating schools received the capsules, and the students cultivated the seeds to observe (based on the data received) the impact of space conditions on seed growth in hydroponic systems.

1.5.7 IoT on Campus – SURF research and education community

SURF [18] is a cooperative of Dutch educational and research institutions that collaborate to enhance digital services and foster knowledge sharing through continuous innovation. This collaboration includes universities, colleges, vocational institutions, UMCs (University Medical Centers), and research institutions. Together, they work to purchase or develop the best digital services. SURF is also exploring the potential of an Internet of Things (IoT) applications ecosystem specifically for the Dutch research and education community. Various research projects and pilots at universities and research institutes across the Netherlands are investigating ways to reuse and share network resources and data platforms for IoT applications. One such initiative is “The Smart Campus in Groningen” [19], which provided students with the opportunity to monitor and analyze a plethora of data received from sensors measuring occupancy, humidity, CO2, sound levels and movements, and use this data to informed decisions regarding the improvement of the quality and flexibility of education and research. Another initiative is “Wireless Leiden IoT in Leiden” [18]. This project involved a number of companies, including SURF, in enhancing the presence of an IoT network in Leiden. This has formed the basis for several pilots and research programs, including smart streetlights, smart agriculture and indoor classroom environment variable measurements.

1.5.8 Summary

The majority of the aforementioned inspiring stories revolve around the utilization of diverse approaches to the application of IoT technology and systems in order to provide solutions to a range of real-world case scenarios and problems. In most of the cases the students were working in teams and interacting with various microcontrollers, sensors and applications to investigate potential ways for addressing the given problems or challenges. The students did not merely observe and interpret the received data, but they were also engaged in hands-on experimentation to propose a tangible and vital solution. As a result of their participation in these learning journeys, students not only gain familiarity with the concepts and methods underlying the IoT, but they also had the opportunity to develop a number of 21st century skills, including creativity, collaboration, problem solving, critical thinking, as well as skills related to digital literacy (using IoT technologies, programming, 3D design etc.).

2 Introducing IoT in secondary schools: Learning objectives and learning methodology

As mentioned, the objective of the IoT4School handbook is to assist educators in introducing students to IoT technologies and engaging them in learning practices that address the aforementioned challenges and problems through the lens of IoT. The following learning objectives and methodology are derived from the aspects and the needs that were identified in the preceding sections, as well as from the analysis of existing examples (working as good practices and inspiring stories) showcasing ways of introducing and implementing IoT in other projects, educational settings and initiatives, combined with project-based learning methods and pedagogies[1].

2.1 Learning objectives

A core objective is to foster **foundational knowledge of IoT** concepts and technologies. This includes understanding how various devices collect, share, and process data to interact with the physical world. By grasping the principles of sensors, networks, and data analytics, students can comprehend how IoT devices contribute to the more efficient operation of a range of systems, including homes, cities, environment, health and transportation systems. Having acquired this knowledge, students can then proceed to examine in greater depth the issues related to the IoT sector.

It is also crucial to **identify** in which **cases IoT systems are used** and the manner in which these systems enhance various sectors of everyday life, ultimately resulting in an improvement in the quality of life for humans. This approach enables students to gain an understanding of the underlying needs of specific sectors and to identify the most suitable IoT technologies based on real-world case studies. Furthermore, this method fosters interdisciplinarity, enabling students to explore a diverse array of cases belonging to different fields and subjects where IoT can be applied.

Another significant learning objective is for students to comprehend the **impact** that **data-driven decisions** can have in multiple real-world cases. It is essential that students are able to identify instances where data-driven decisions are made, as well as the most effective method for utilizing raw data and extracting useful information based on specific parameters, in order to address a given problem, thereby creating a functional IoT system or application.

Furthermore, another core objective is to **cultivate practical skills** in the design and implementation of IoT solutions. This involves hands-on experience with age-appropriate hardware and software, which encourages creativity while also facilitating experimentation. Such practices are also interlinked with the development of **digital literacy**, in particular the acquisition of skills such as the ability to use microcontrollers and electronic components, programming, and designing applications.

Another objective that is fostered is the **collaborative design** and implementation of IoT-enhanced constructions that integrate principles from **multiple disciplines**, including science, technology, engineering, and mathematics (STEM), as well as art and social studies, to solve real-world problems and enhance students' understanding of interconnected subject areas. The aforementioned skills will be predominantly developed through students' engagement in the IoT projects in the context of WP3. Nevertheless, the current learning scenarios will stimulate students' interest in the types of hardware and software that can be employed in the production of IoT devices and systems and will smoothly pave the way for hands-on practices.

[1] Here you can read more about the process of approaching learning objectives and learning methodology.

In addition, an essential objective, which is also relevant to digital literacy, is to instill an understanding of the **ethical**, privacy, and security challenges associated with IoT. As students gain an understanding of the extensive capabilities of IoT technology, it is also important for them to be aware of the responsibilities that accompany the deployment of IoT devices, as well as the potential risks associated with sharing and storing data in the cloud.

In brief, through the proposed IoT4schools exemplary scenarios the students should be able to:

- define what IoT is
- Describe the main concepts underpinning IoT
- Recognize IoT applications
- Give examples of IoT-enhanced application in daily life
- Identify real-world cases where IoT devices and systems are used
- Explain how IoT can give sustainable solutions to everyday challenges and problems
- Discuss the impact of monitoring data on our daily life
- Identify cases that data driven-decisions are made
- Elaborate on how different parameters can lead to different decisions
- identify the advantages, disadvantages and risks of making data-driven decisions

2.2 Learning methodology

The IoT4Schools handbook presents learning methodologies and pedagogical practices designed to introduce the concept of IoT to your students in a meaningful and engaging manner. The ultimate goal is to facilitate a smooth introduction to IoT concepts and technologies, addressing the four aforementioned challenges and problems. This approach lays the groundwork for the implementation of IoT projects that will be developed in the next phase of the IoT4Schools Project.

In this direction, project-based learning is used so that your students can engage in hands-on practices that require them to design, build and troubleshoot their own IoT projects, exploring the complex concepts involved through a blend of practical and theoretical aspects that encourage critical thinking, problem-solving and collaboration, among other skills.

To provide a smooth introduction to the main topic and to help students understand some of the core concepts of IoT, a number of scenarios have been designed. These scenarios are based on real-life cases and challenges that can be addressed using IoT technology. The scenarios are the backbone of an activity that can be organized in the class to introduce students to IoT concepts. Through these activities students are invited to work in teams so as to observe specific phenomena, identify the critical aspects of the inherent challenges, monitor/record a set of parameters that can assist in the solution and search for technologies that can help in this direction. In this way, they can better understand the problem and propose sustainable IoT solutions based on specific requirements.

Each scenario encourages students to share their ideas in plenary, initiating dialogue between their peers and discussing the implications of each idea together, building a shared understanding of the core concepts. With this in mind, each scenario is accompanied by a

series of questions that can be asked to encourage dialogue between your students. These questions can also be used in the previous stages to help students approach the activity.

In general, the aforementioned scenarios follow certain stages which are slightly adapted to meet the specific needs of each scenario. These stages include:

1) Group Formation: Form teams to foster collaboration and incorporate diverse viewpoints
2) Device/application/technology Integration: Assign each team a smart device or an application to use for data collection
3) Data Collection Assignment: Over a period of time students record data
4) Analysis & Reflection: Teams maintain a diary of their observations, noting any trends, anomalies, or patterns
5) Presentation & Discussion: Teams present their findings in a class discussion, highlighting insights and personal experience

3 Exemplary scenarios for IoT projects addressing selected everyday challenges

The following scenarios reflect practical and engaging ways to introduce your students to the IoT through the lens of hands-on approach that encourages critical thinking about technology's role in everyday life and on several domains (i.e. smart city, housing automation, health monitoring and environmental protection)[2].

3.1 Smart Cities

Scenario 1: Traffic and data-driven decisions

Activity overview:

The aim of this scenario is to introduce students to the concept of IoT in the context of smart cities, and through the lens of mobility and transport. Divide your students into teams of 2 and encourage them to use Google maps to monitor the traffic on the routes they take every day. Ask them to record these routes at different times of the day for a week, and keep a diary of their findings. Suggest that they also take a print screen to have a visual representation of the data. Encourage each team to think about how this data could lead to different decisions about the route they would take or the mode of transport they would use. Encourage them to make some maps showing the different routes they would choose based on the different traffic patterns and share their observations in the plenary. Raise a discussion about the impact of location-based data on peoples' daily lives in terms of their mobility and transport choices in the city. Encourage your students to think about the ethical implications of such technology. After this discussion, you could ask your students to think about how an application such as Google maps could be used for a self-driving vehicle.

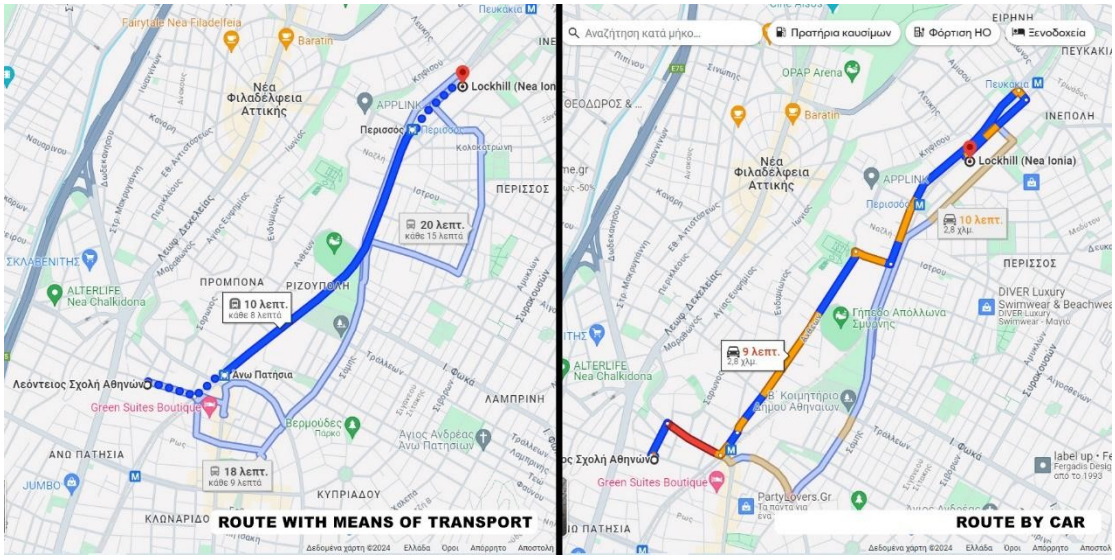


Figure 1: Searching alternative ways to go from one place to an other and comparing the solutions based on the received data (traffic, travel time etc.)

Discussion Points:

To facilitate discussion, you can consider of posing some of the following questions:

- How does Google Maps work?
- Is it important to monitor traffic?

[2] Here you can read more about the process of collecting these learning scenarios.

- How monitoring data affects your daily decisions about mobility and transport
- Is it safe to make mobility and transport decisions based on traffic monitoring data
- Where is the monitoring data stored?
- What are location based services?
- Can you name an (IoT) application that uses Google Maps?
- Can you think of any disadvantages or limitations of using location based services?

Specific Learning Objectives:

Through this scenario, your students will be able to:

- Use Google Maps
- Identify IoT applications that use location-based data
- Explain the importance of making decisions based on location-based data
- Make informed design decisions for their mobility and transport based on data analysis.
- Explain the impact of informed design decisions on the daily life
- Identify the advantages, disadvantages and risks using location-based applications

Required tools/software

- Google maps: https://www.google.gr/maps
- Notebook: For documenting observations, reflections, and insights during the implementation of the scenario

Additional suggestions

- **Expert Talks:** If possible, invite a professional or a technologist to share insights on the convergence of technology and location-based data.

Scenario 2: Smart car: how to reduce the number of car accidents?

Activity overview:

The aim of this scenario is to familiarize students with the issue of road safety. Begin the activity by dividing the students into teams. Ask them to think about where the most car accidents happen and what causes these accidents. Is it excessive speed or perhaps driver error? Look for statistics on the internet and compare your thoughts with them. Then ask each team to think about how they could design a system to prevent two cars from colliding. Discuss the suggested solutions/ideas. Discuss about their advantages, disadvantages and the potential risks (from an ethical point of view), as well as how these solutions could possibly be implemented. Then have each team refine their ideas based on the discussion and consider how such a scenario could be implemented (e.g. by using a microcontroller such as Raspberry Pi Pico or micro:bit and compatible electronics).

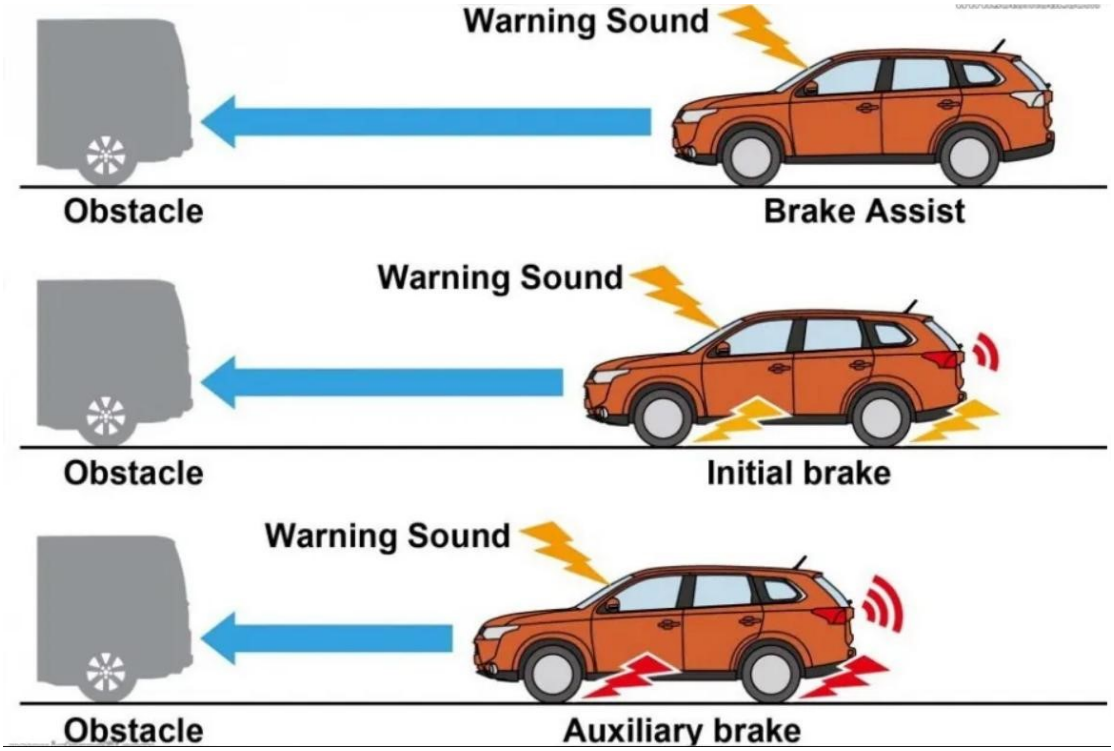


*Figure 2: How collision assistance works; Retrieved from: https://miro.medium.com/v2/resize:fit:1400/format:webp/1*nRxRkYqTTMbZeoSUknzDlg.jpeg*

Discussion points

To facilitate discussion, you can consider of posing some of the following questions:

- Where do car accidents happen most often?
- What is the most common cause of car accidents?
- Is it possible to avoid a collision between two cars?
- Is installing collision avoidance systems in cars a good solution?
- What are the advantages and disadvantages of using IoT technology in cars?

Specific learning objectives:

Through this activity, your students will be able to:

- Identify the causes of car accidents
- Suggest solutions towards preventing car accidents
- Communicate the need to modernize cars with newer systems to prevent car accidents
- Refer to the threats posed by the use of IoT technology in cars

Required tools/software

- A notebook to write down ideas
- Computers with internet access to search for ideas or materials that could be used to carry out a project (e.g. microcontroller to make your own projects, sensors, actuators etc.)

Additional suggestions

- **Expert Talks:** If possible, invite a professional or technologist to give an insight into the technology used in cars to prevent accidents.

Scenario 3: Smart waste bins: how to improve waste management in smart cities?

Interlinked challenge: Environmental protection

Activity overview

The aim of this scenario is to familiarize students with the problem of waste management in the city. Begin the activity by discussing why recycling and efficient waste collection are so important in the city. Consider how the current waste collection system in your city works and list the advantages and disadvantages. Then divide your students into teams, and encourage them to think about how the current waste collection system could be modified to be smarter, e.g. collecting waste only when the bins are full, optimizing the waste collection route, thus reducing fuel consumption, etc. Then discuss the proposed solutions in terms of feasibility. Compare your students' ideas with those available on the Internet and encourage your students to refine their ideas and make a list of components and materials that could be used to implement their idea; a process that could act as a preparatory stage for an IoT project.

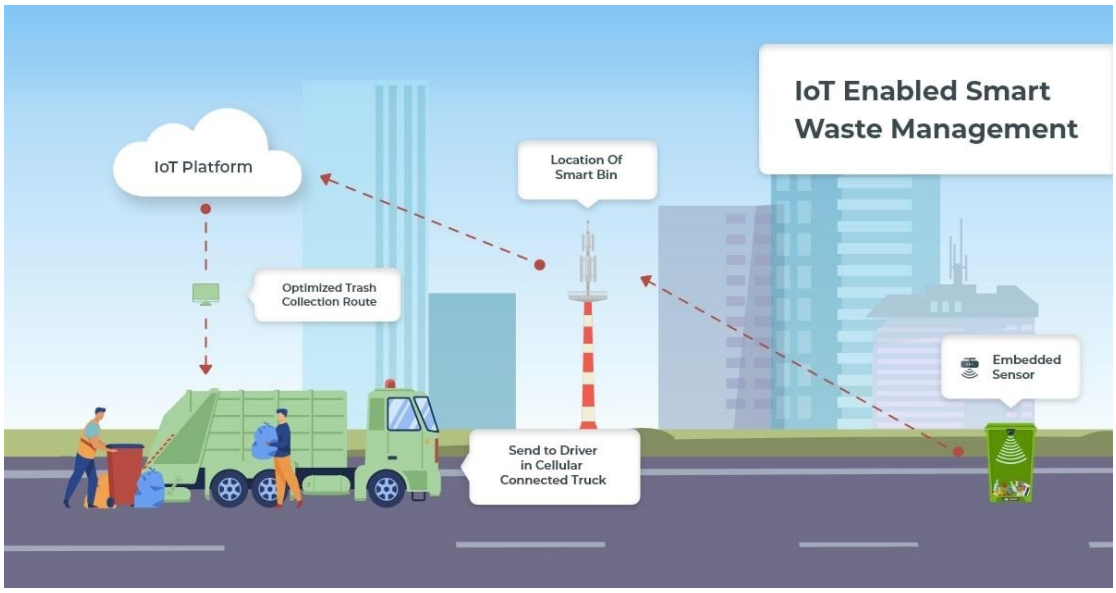


Figure 3: IoT Enabled Smart Waste Management (Retrieved from: https://media.excellentwebworld.com/wp-content/uploads/2021/08/27101104/smart-waste-management-using-internet-of-things.jpg)

Discussion points

To facilitate discussion, you can consider posing some of the following questions:

- What is the current waste collection system in your city? What are its advantages and disadvantages?
- What is recycling? Do you think selective waste collection is important? What can recovered raw materials be used for?
- Is it important to collect only full garbage bins to reduce fuel consumption? What do you think?
- Is it important to optimize the route of the garbage truck? If so, how can this be done? Do you know what the traveling salesman problem is?

Specific learning objectives:

Through this scenario, your students will:

- Reflect upon the problem of waste collection in cities (improving environmental awareness)
- Elaborate on the value of recycling
- Explore the possibilities of IoT technology that can improve the functioning of cities in order to reduce their negative impact on the environment
- Explore solutions to problems using IoT technology and identify the advantages and disadvantages of the proposed solutions

Required tools/software

- A notebook to write down ideas
- Computers with internet access to search for ideas or materials that could be used to carry out a project (e.g. microcontroller to make your own projects, sensors, actuators etc.)

Additional suggestions

- **Expert Talks:** If possible, invite a waste collection professional to discuss with students how waste is currently collected and how technology could optimise the process.

3.2 Home automation

Scenario 1: Towards designing a smart home.

Activity overview:

The aim of this scenario is to introduce students to the concept of IoT in the context of home automation. Divide your students into teams of 2 and encourage them to think of appliances (such as the water boiler) that could be controlled remotely. Encourage them to focus on one example and ask them to think about what kind of data it would be useful to monitor and the benefits of being able to control this appliance remotely. Encourage a discussion about the advantages of such a system in terms of saving energy, as well as the disadvantages or risks of such monitoring could have, especially in terms of data storage and the security of storing data in the cloud.

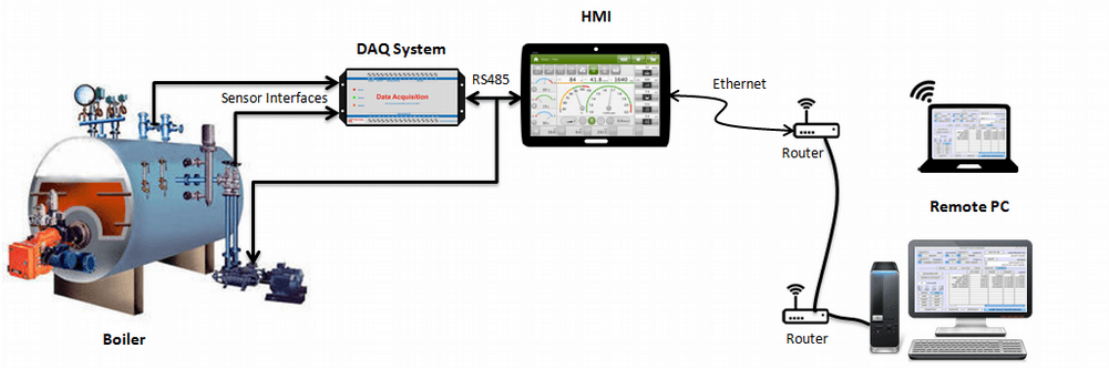


Figure 4: Image retrieved from: https://www.embien.com/case-studies/boiler-monitoring-system

Discussion Points:

To facilitate discussion, you can consider posing some of the following questions:

- What appliances in your home could be controlled remotely?
- What kind of data should be monitored?
- How would you use this data to control the appliance?
- Could this data be integrated into an IoT application?
- What would this application do?
- What would be the benefits of remotely monitoring and controlling an appliance?
- Where would this data be stored?
- Is there any risk of the monitored data being stored in the cloud?
- What are the potential risks associated with data privacy and security in IoT-based smart home systems?

Specific Learning Objectives:

Students will be able to:

- Identify appliances that could be improved through IoT
- Identify data that would be useful to monitor
- Identify methods for monitoring data
- identify IoT applications that can be used to remote control appliances
- Explain the basic of how IoT devices collect, store and use data
- Discuss the impact of monitoring data on energy saving
- Discuss the importance of making informed design decisions for their homes based on data analysis
- Identify the advantages, disadvantages and risks of using IoT for home automation
- understand how IoT can be applied to create smart home systems

Required tools/software

- Notebook: For documenting reflections and insights during the implementation of the scenario
- IoT smart home applications: to explore how such applications work (indicative links: https://www.home-assistant.io/;)
- MIT App Inventor (optional): for a next level, to explore how to design and program an application
- Microcontroller and sensors (optional): for a next level, to create a device that can be remotely controlled by the application

Additional suggestions

- **Expert Talks:** Invite a professional working in the IoT field to share real-world experiences and insights.
- **Future steps:** Encourage students to think about how they could create a smart home ecosystem. Ask them to write down their thoughts and list some sensors that could be used in such a project.
- **Demonstration:** If possible, provide a live demonstration of a smart home device or a simple IoT setup.

Scenario 2: Smart gardening

Interlinked challenge: Environmental protection

Activity overview

The aim of this scenario is to familiarize students with the problems of water use in gardening. Start the activity by dividing the students into teams. Then ask the students to find out what percentage of water is used in horticulture and agriculture. Encourage them to look up water consumption statistics in Europe and compare the consumption across different countries. Then, encourage each team to consider when watering plants in the garden is really necessary and how smart watering could be designed to reduce water consumption. Encourage the teams to share their ideas in the plenary and discuss the advantages and disadvantages of these ideas and whether or not they are feasible. After the discussion, encourage each team to refine their ideas and make a list of the materials and components (e.g. Raspberry Pi Pico, micro:bit, sensors) that should be used to implement this idea in the next stage.

Figure 5: Smart irrigation, Retrieved from: https://www.twl-irrigation.com/wp-content/uploads/2021/11/Smart-irrigation.jpg

Discussion points:

To facilitate discussion, you can consider posing some of the following questions:

- What percentage of water is used for horticultural purposes and how much for agricultural purposes?
- What can be done to minimize water use in the garden?
- Why is water conservation so important?
- What are the optimum growing conditions for plants? When is watering really necessary?

Specific Learning Objectives:

Through this scenario the students will:

- Learn about the problem of water scarcity in Europe and statistics on water consumption in different areas of life
- Reflect upon the need to save water, especially in horticulture and agriculture
- Explore the possibilities of using IoT technology to reduce water consumption
- Design simple IoT systems

Required tools/software

- A notebook to write down ideas
- Computers with internet access to search for ideas or materials that could be used to carry out a project (e.g. microcontroller to make your own projects, sensors, actuators etc.)

Additional suggestions

- **Expert Talks:** Invite an agricultural professional to share real-life experiences and insights into how technology is supporting their profession.
- **Demonstration:** If possible, have a live demonstration of a smart gardening system and a discussion about how it works.

Scenario 3: School automation: designing a “smart”, energy efficient school

Interlinked Challenge: Home/work automation; Environmental protection

Activity overview

Classroom settings require the regulation of the temperature at all times, however in countries such as Cyprus or Greece, there is rarely if at all air conditioning systems installed at schools. As such, at best the temperature, especially during the warm months of the year, that consist of almost 50% of school time, is regulated by manually opening and closing windows and/or fans located on the ceiling or walls. Additionally, in winter months with less light during the day, it is essential to switch on the lights during the classroom and switch them off for energy conservation during the (daily) breaks.

In this sense, the aim of this activity is to encourage students to think about a smart system that can monitor the temperature in the classroom, and automatically switch the fans on and off when needed, and to switch them off at the end of the school day. The same system can be responsible for switching the lights on and off to save energy and avoid leaving them on at weekends or in the afternoons. Divide your students into teams and encourage them to think about how such a system could be created. Ask them to note down the parameters that need to be taken into account and encourage them to think about how they could monitor these parameters and for how long in order to design a working system. Then, ask each team to share their ideas in the plenary and discuss their advantages and disadvantages. Also, raise a discussion about the ethical aspects of monitoring an environment and possibly storing data in the cloud in an environment populated by minors. Based on the discussion, ask each team to refine their ideas and make a list of components that could be used to take this idea to the next level (i.e. the creation of an IoT project).

Figure 6: BBC Micro:bit controlling the environment of the classroom (image created using Bing Creator)

Discussion points

Some questions that will engage students into creative thinking and problem solving can be:

- What are the needs of your classroom during the months of September - November and April - June?
- What are the problems of manually switching on and off the fans and the lights during the school day?
- How can we automate the use of fans and lighting?
- How can we preserve energy with a proposed automated system?

Specific learning objectives

Through the implementation of this scenario, students are expected to:

- Identify the necessities of classroom environments during the warm months of the year
- Identify the barriers (financial, technical) of using air conditioning systems in all classrooms
- Propose solutions to alleviate the problem with a low cost of installation and operation
- Propose a system that will control and monitor the classroom environment, focusing on lighting and temperature control
- Identify the requirements of such a system

Required tools/software

For the implementation of the proposed scenario, it is necessary to use the following equipment:

- A notebook for recording ideas
- A software for monitoring temperature and lighting levels
- Sensors that can measure temperature and light levels

Additional suggestions

- **Interviews with experts:** It is required that students not only research articles and similar solutions on the internet, but broaden their knowledge by interviewing experts in both the fields of home/office/school automation, but also of environmental control.

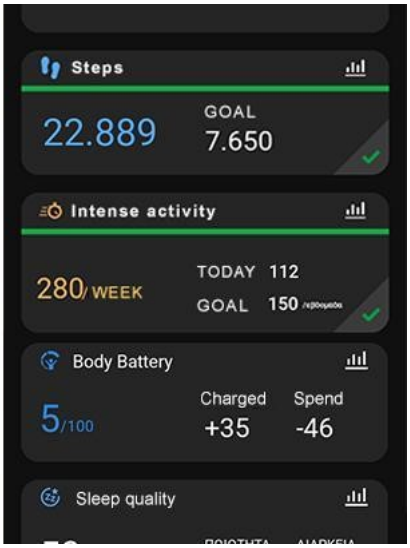
- **Presentation of project to Policy Makers:** Such an activity offers an important solution, even at a theoretical level, for improving working conditions in the classroom. Therefore, it may be important for students to officially present their initial ideas or the project they will produce in WP3.

3.3 Health monitoring

Scenario 1: Using smart electronic devices and applications to monitor health-related data

Activity overview

The aim of this scenario is to introduce students to the concept of IoT in the context of health monitoring. Divide your students in teams of 2 and encourage them to use a smart electronic device, such as a smartwatch or a smart band, along with the corresponding application to monitor health-related data. Ask them to record specific data such as their heartbeat, daily steps, and body battery, three times a day for a week, and keep a diary of their findings. Encourage each team to share their observations in the plenary. Raise discussion on how such data can be important for people with health problems, as well as on the inherent risks of using such devices as an exclusive method for monitoring health. After this discussion, you can ask you students to consider how such an IoT system could be improved to help people with health problems. You can also encourage them to consider ways of building their own smart band to measure one or more health-related parameters including heart rate and steps. Such an activity can be the start of several subsequent hands-on projects, such as designing a pulse oximeter or creating a pedometer.



Discussion points

To facilitate discussion, you can consider posing some of the following questions:

- How is this data gathered and where is it stored?
- Is it important to store data in a secure webspace?
- Based on the monitored data, what decisions can you make about your physical health or daily exercise?
- Can you think of other applications or/and devices that can be used for health monitoring?
- How important is it to have such devices, and how much should we rely on their results?
- Can you think of any disadvantage or limitation of these types of IoT systems?

Specific learning objectives

Through this activity, your students will be able to:

- identify IoT applications that can be used for health monitoring
- explain how IoT devices collect, store and use data

- Discuss the impact of monitoring data on our daily life for making decisions about our health
- Describe how informed health decisions are made, based on data analysis
- identify the advantages, disadvantages and risks using such devices and application for health monitoring

Required tools/software

- Smart Health Devices: Smartwatches or fitness bands for data tracking
- Monitoring App: A compatible application that aggregates and visualizes the collected data
- Notebook: For documenting observations, reflections, and insights during the implementation of the scenario

Additional suggestions

- **Expert Talks:** If possible, invite a healthcare professional or a technologist to share insights on the convergence of technology and health.
- **Privacy Workshop:** Conduct a session on digital privacy, focusing on how personal data can be protected online.
- **Future steps:** Encourage students to think about how they could create an application or IoT system that alerts users by playing a warning sound or automatically sending a message when out-of-range values are detected for some health monitoring data.

3.4 Environmental protection

Scenario 1: Using an air quality monitoring application

Activity overview:

The aim of this scenario is to introduce students to the concept of IoT in the context of both environmental protection and health monitoring. Divide your students into teams of 2 and encourage them to use an application that monitors the air quality. Ask them to record the air quality in different areas, cities or countries three to four times a day for a week, and keep a diary of their findings. Suggest that they also take a print screen to have a visual representation of how the air quality might change during the day. Encourage each team to share their observations in the plenary. Raise discussion on how these data can be important for protecting the environment and peoples' lives. Discuss also the ethical implications of monitoring and storing data in the cloud. After this discussion, you can ask you students to think about how they could create an IoT system that monitors the air quality in their school building, leading to decisions to optimize some operational systems.

Discussion Points:

To facilitate discussion, you can consider posing some of the following questions:

- What are the criteria for monitoring air quality
- How air quality is assessed
- How can the monitored data be relevant to the environment or to people's daily lives?
- Can you think of other applications or/and devices that can be used for monitoring air quality?
- How important is it to have such applications and devices?
- Can you think of any disadvantages or limitations of these types of IoT systems?

Specific Learning Objectives:

Through this scenario students will be able to:

- identify IoT applications that can be used for air quality monitoring
- explain the basis of how IoT devices collect, store and use data
- discuss the impact of monitoring data for protecting our environment
- explain how informed design decisions for our environment are made based on data analysis
- identify the advantages, disadvantages and risks using such devices and application for protecting the environment

Required tools/software

- Air quality applications: applications that are easily accessible from a smart device or a computer (indicative links: https://www.iqair.com/; https://airly.org/)
- Notebook: For documenting observations, reflections, and insights during the implementation of the scenario
- Microcontroller and sensors for creating an air quality monitoring device (as a next level and a possible project)

Additional suggestions

- **Expert Talks:** If possible, invite a professional or a technologist to share insights on the convergence of technology and air quality monitoring.

Scenario 2: Using IoT devices for water conservation and preservation of school gardens

Activity overview:

School gardens can face significant problems during periods when schools are closed for holidays. In Cyprus, for example, there are almost four months when school is closed. Therefore, school gardens tend to be neglected, and plants are exposed to the harsh conditions of the Cypriot summer. The aim of this scenario is to design (and at a next level develop) an IoT-based system that monitors soil moisture, the temperature and air humidity, and provides water to plants in school gardens when needed. Divide your students into teams and encourage them to do short research on the needs and requirements of plants in school gardens in terms of watering based on parameters such as temperature and soil moisture, as well as the problems associated with their maintenance, especially during school holidays. Encourage them to think about the plants that should be chosen to better adapt to the existing conditions (quality of the soil, school timetable etc.) You can also think about inviting expert gardeners, and IoT experts to the class to discuss the topic with the students, in order to deepen and broaden their knowledge and experience. Then ask each team to present their ideas in class and discuss the advantages and disadvantages. After the discussion, you can encourage each team to refine their idea and make a list of the components that would be needed to create a small-scale pilot implementation.

Figure 7: School garden monitored by BBC micro:bit (created using Bing Creator)

Discussion points

Some questions that will enable the students to further research the needs of a (school) garden, and propose solutions are:

- what are the benefits of school gardens?
- what are the limitations of soil found in schools?
- what type of plants can we use in a school garden?
- what are the needs of such plants?
- what are the limitations of having a thriving garden throughout the year, including school holidays?
- how can technology enable us to maintain a school garden, while at the same time conserving resources?

Specific learning objectives

Students are expected to:

- identify the needs and varieties of plants suitable for school gardens
- reflect upon the requirements of plants to sustain them throughout a full school year, including summer holidays
- select equipment for monitoring the moisture in the air and soil, select the equipment for providing water to plants, and reflect upon automating the process
- assess the potential impact of the proposed solution when implemented at a national level

Required Tools/ Software

- A notebook for recording ideas
- A software for monitoring soil moisture, temperature or/and air humidity
- Sensors that can measure soil moisture, temperature and air humidity (optional)

Additional Suggestions

- **Interviews with experts:** It is required that students not only research articles and similar solutions on the internet, but broaden their knowledge by interviewing experts in both the fields of (school) gardens and plants, and also from the field of IoT.
- **Presentation of project to Policy Makers:** Such a project offers a viable solution for the school gardens of schools across the country. As such, it might be important for students, at the end of the project or during the approaching the general concept/idea, to officially present it to Policy Makers.

Scenario 3: Introduction to IoT-based weather reporting system

Activity overview:

This scenario is an activity that can serve as an introduction to the creation of an IoT-based weather reporting system. Students will explore how IoT technologies can improve the efficiency of weather monitoring, leading to more accurate forecasts. Divide your students into teams and encourage them to search for possible IoT devices or/and applications that are used to monitor and report weather data. Encourage them to focus on one such system and study how it works (e.g. what parameters does it record, how does it receive and monitor weather data, what sensors does it use, how does it predict weather etc.). You can also encourage them to check the data for a week and see how accurate the measurements and predictions are compared to the actual data. After a week, invite the teams to present their findings in the classroom and discuss the effectiveness of these systems, as well as issues related to the use of such systems in different areas of everyday life, and the benefits and risks of relying on such systems for critical decisions (e.g. in agriculture for watering scheduling, for disaster management etc.). You can also encourage your students to reflect on the potential privacy and security concerns associated with IoT weather systems, and how these can be mitigated.

Figure 8: Weather reporting system representation (image created using Dall-e)

Discussion Points:

To facilitate discussion, you can consider posing some of the following questions:

- What parameters does a weather monitoring system monitors?
- How does the integration of IoT devices improve the accuracy and efficiency of weather monitoring?
- How does real-time data collection and analysis affect weather forecasting and disaster management?
- How can IoT devices for weather monitoring be beneficial in different sectors (home automation, agriculture etc.)?
- Can you think of any risks or limitations of these types of IoT systems?

Specific Learning Objectives:

Through this scenario students will be able to:

- identify IoT applications that can be used for weather monitoring
- identify the parameters that a weather monitoring system should monitor
- explain the basis of how IoT devices collect, store and use data
- discuss the impact of monitoring weather data for making informed design decisions on different sectors of everyday life (home automation, agriculture etc.)
- identify the advantages, risks and limitations of using such devices and application for weather monitoring

Required Tools/ Software

- A notebook for recording ideas
- A software or device for weather monitoring
- Sensors that can measure temperature, air humidity, barometric pressure and soil moisture (optional)

Additional Suggestions

- **Interviews with experts:** Invite an environmental scientist or IoT expert to discuss the impact of IoT on environmental monitoring.
- **Demonstration:** If possible, show a live demo of a simple IoT setup using weather sensors.

4 Recommendations for further reading

Title	Short description	Link
40 Best IoT Project Ideas & Topics for beginners 2024	Here you can find up to 40 IoT project ideas & topics that you can create with simple electronics and basic to advanced programming skills.	https://www.upgrad.com/blog/iot-project-ideas-topics-for-beginners/
FarmBeats for students	FarmBeats is a project that demonstrates (through a carefully designed curriculum and activities) how students learn about AI, data analysis and IoT by creating a garden monitoring system, using technologies such as micro:bit and raspberry pi.	https://learn.microsoft.com/el-gr/training/educator-center/instructor-materials/farmbeats-for-students
Designing IoT applications in lower secondary schools (paper)	This paper presents a case study where four groups of students of lower secondary school became designers of IoT applications for smart cities in the context of a workshop, using a dedicated inventor toolkit. At the end of the workshop, the students were very satisfied with the knowledge and the skills they had acquired.	https://tinyurl.com/ioterasmus
Using gamification and IoT educational tools towards energy savings-some experiences from two schools in Italy and Greece (paper)	This paper is about "*Green Awareness in Action (GAIA) H2020 research project implemented an IoT-based approach in several European schools for sustainability awareness and energy efficiency, while at the same time increasing students' digital skill. By using gamification, competitions and IoT-based educational activities, GAIA engaged directly with teachers and students in order to realize energy-saving activities in their environment*" (excerpt from the abstract).	https://link.springer.com/article/10.1007/s12652-020-02838-7
Students in the remote area of Timor-Leste learning IoT and 3D printers to devise solutions	An inspiring story about students in Timor-Leste who have developed a number of Arduino-based IoT solutions in the fields of water management, home automation, smart cities, transport and robotics, in the context of a training course.	https://www.undp.org/timor-leste/blog/students-remote-area-timor-leste-learning-iot-and-3d-printers-devise-solutions

IoT in Education: Tech Makes Gains in K-12 schools	This online article provides examples of how to use IoT Ed Tech in the K–12 Classroom in order to change "the way educators teach and, by extension, the ways students learn".	https://edtechmagazine.com/k12/article/2021/12/iot-education-tech-makes-gains-k-12-schools-perfcon
Getting started with Raspberry Pi Pico; Introduction to Raspberry Pi Pico	Introductory IoT projects using Raspberry Pi Pico to get inspiration on how to introduce students to this particular technology and on how to build projects.	https://projects.raspberrypi.org/en/projects/getting-started-with-the-pico; https://projects.raspberrypi.org/en/pathways/pico-intro
Internet of Things Class	A series of Arduino-based projects for intermediate learners to get inspiration for project development.	https://www.instructables.com/Internet-of-Things-Class/

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