

D2.1

**First Version of Best Practice Examples of
Lighthouse Activities**

WP2

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Contact Information

Coordinating Institution: University of Education Freiburg

Coordinator: Prof. Dr. Katja Maaß

Project Manager: Laura Wanckel / Dr. Elena Süß

Authors: Mónica Baptista, Iva Martins, Ana Rita Alves, Nuno Dorotea, Pedro Reis, Teresa Conceição.

Lead partner for this report/WP2: IE-ULISBOA

Website: <https://icse.eu/international-projects/icse-factory/>

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1. Executive Summary

The "First Version of Best Practice Examples of Lighthouse Activities" (D2.1) represents a milestone within the ICSE Science Factory project, documenting the successful implementation of Lighthouse Activities (LHA) across participating countries. This report encapsulates the outcomes of these pilot initiatives, integrating interdisciplinary methodologies to address societal challenges through innovative science education.

Embracing the principles of Design-Based Research (DBR) (Scott et al., 2020), each partner country conducted LHA pilots and collected qualitative data using a semi-structured observation guide. This approach enabled the evaluation and iterative improvement of activities, aligning with the overarching goals of the ICSE Science Factory.

The activities spanned three core topics: Green Deal, Health, and Digitalization. Implementing LHA in various educational settings, the report details how learners engaged with real-life scientific challenges, fostering knowledge, skills, and a positive attitude towards science. Significant partnerships with educational institutions and industry experts underscored the success and real-world relevance of the LHAs.

Key outcomes of the activities include the development of essential competencies such as problem-solving, teamwork, and digital literacy. Moreover, the report emphasizes the importance of engaging and enjoyable educational experiences, as demonstrated by creative activities like "Molecular Kitchen" and "Escape Room for a Sustainable World."

A total of twelve LHAs were successfully implemented, revealing the adaptability of these activities to different age groups and educational contexts. The report acknowledges challenges encountered, highlighting the crucial role of facilitation in overcoming obstacles and ensuring comprehension, especially for learners introduced to new concepts.

This report affirms that the LHA not only significantly advanced science education but also cultivated curiosity and lifelong learning. By bridging education with societal needs, LHAs have established themselves as effective tools for developing informed, thoughtful, and proactive global citizens.

2. Background and Key Information

2.1. Lighthouse Activities

In contemporary discourse, the term “lighthouse” is applied within innovative projects and educational paradigms, serving as a cornerstone for initiatives aimed at addressing societal challenges through collective action. Lighthouse projects, often highlighted in educational contexts, are characterized by their innovative approach in fostering science education.

- Accordingly, the ICSE Science Factory Project aims to use lighthouse activities (LHA) to offer collaborative science learning opportunities at the local level for all citizens. These activities highlight the relevance of science for real-life challenges and contribute to a continuum lifelong learning. Such activities not only enhance science learning among students but also inspire interest in scientific careers, aligning with the project's objectives.

- Following a literature revision (see document Lighthouse activities/ WP2, Task 2.3), we have identified key characteristics that an LHA should comprise authentic contexts, interdisciplinarity, active involvement/learner-centered strategies, and collaborative work. Besides those, the concept of challenge-driven innovation (CDI) was also included, referring to a strategy to promote innovation based on the establishment of well-defined objectives focused on pressing challenges of communities that require the mobilization of a set of partners to solve them (Mazzucato, 2018). Additionally, following the projects’ guidelines, LHA should focus on topics like Green Deal, Digitalization and Health.

LHA are designed as short-term, interdisciplinary events focused on the Green Deal, Digitalization, and Health. Spanning several hours, LHA aim to engage 10-15 participants. This inclusive approach targets a diverse audience, encompassing all age groups and is also tailored to individuals who may be initially skeptical about science, such as senior citizens, girls, and families. The initiation and topic selection for LHA are led by external stakeholders and universities that provide the activity, ensuring the content is both engaging and academically sound. The overarching aim is to instill a sense of fun in the exploration of scientific concepts while simultaneously deepening understanding. These LHA are not standalone events but serve as an initial step towards broader educational engagement. They act as the launching point for Open Schooling activities, stimulating and guiding subsequent projects that follow the thematic threads introduced in the workshops. The dynamic between the LHA and Open Schooling

initiatives is symbiotic, with the former sparking interest and the latter expanding upon that foundation in a more extensive project format.

2.2. Piloting of Lighthouse Activities and Data Collection

The piloting of LHA follows the Design-Based Research (DBR) approach, which consists of four stages: Design, Test, Evaluate, and Reflect (Scott et al., 2020). This methodology ensures that the activities are carefully planned, piloted, assessed, and refined based on feedback, ultimately leading to effective and impactful learning experiences.

Therefore, each partner planned and implemented LHA in their countries, and used a semi-structured observation guide. Specifically, this observation guide (prepared within the scope of WP2, see document Lighthouse activities/ WP2, Task 2.3) is composed of seven evaluation dimensions and aimed to analyze and reflect on the results of all partner countries in the next DBR-phase (Reflect) and, consequently, to improve the activities to be implemented later. Additionally, the collected data is valuable in illustrating international best practices.

The focus of this observation is on both the participants and the activities themselves. Specifically, dimensions A (Conceptual knowledge), B (Skills), and C (Difficulties experienced), described below, are intended to collect data on the conceptual knowledge and skills that participants develop during the implementation of the lighthouse activity. Dimensions D (Relevance), E (Consistency), F (Practicality), and G (Activity effectiveness), on the other hand, aim to gather data on the relevance, consistency, practicality, and effectiveness of the activities.

During this pilot phase, each country had to describe best practices examples concerning the LHA developed and implemented during the pilot phase. For that, best practice examples were prepared by each country with the information collected through the observation guide, that aimed to capture the knowledge/expertise produced during the development and implementation of the lighthouse activities.

As a result of this procedure, each partner country prepared a report, the template of which was prepared and made available by WP2 (see document Lighthouse activities/ WP2, Task 2.3) and which covered the following topics:

1. Description of the activities carried out (their learning objectives, the topics included, their main characteristics, and the possibilities of interdisciplinary integration).

2. Description of the implementation process of the lighthouse activities:
 - a. Context in which it was implemented – information about the participants and partners' collaboration/involvement.
 - b. Location where the activities were implemented and duration.
 - c. The different people involved (partners and their role and level of involvement).
 - d. The role of the learners.
 - e. How they were implemented.
3. The knowledge, skills, and attitudes developed by the learners.
4. The difficulties experienced by the learners and the strategies developed to overcome these difficulties.
5. The key success factors of the lighthouse activities.
6. Our perspectives on the relevance of the lighthouse activities.
7. Overall assessment: final reflective remarks.

All reports produced by partners are presented in the Annex of this document.

3. Overview of the Piloted Lighthouse Activities

A summary of the piloted LHAs is presented in the following table.

Table 1. Summary of the piloted LHA, by country.

Country	Name of the activity	Topic(s)	Interdisciplinarity	Duration	Target age
Croatia	Modern energy in households	Green Deal and Digitalization	Mathematics, Physics, Computing, and Energetics	90 min	13-14
	Mathematics and human body	Health	Mathematics, Biology, and Biomedicine	120 min	16-18
	Teach a robot to dance!	Digitalization	Computer science, and Robotics	90 min	11-14
Cyprus	Measuring particulate matter pollution in the city	Green Deal	Natural Sciences, Mathematics	Not implemented	
Germany	Lesson in the forest/ "Climate impact of forests"	Green Deal	Biology, Earth Science, Environmental Science, Chemistry, Physics, Mathematics	105 min	10th grade
	Molecular Kitchen	Health	Science	90 min	8th grade
Portugal	<i>Olivaria</i> : the olive tree	Green deal	Natural Sciences, Geography, Literature, History, Mathematics	90 min	Families (6-43)
	Sound for the Future: Acoustic Comfort in School	Health and Digitalization	Science, Technology, Engineering, and Mathematics	75 min	10-12
	Invisible world: Discovering air quality	Green Deal	Science	90m min	9-10
Turkey	Air Quality Measurement with Artificial Intelligence Assisted Coding	Digitalization	Science, and Technology	120 min	Families (children 12-14)
	Escape Room for a Sustainable World	Green Deal	Technology. Environment, Ecology, and Biology	90 min	Families (children 11-13)
	The Influence of Exercise on Heart Rate	Health	Biology and Technology	60 min	Families (children primary school)

In total, twelve LHA were implemented. In general terms, the activities had a homogeneous distribution in terms of topics: six activities were carried out under the Green Deal topic, four under the Health topic, and four under the Digitalization topic. In two of the activities, it was possible to explore two topics together: “Modern energy in households” (Croatia) and “Sound for the Future: Acoustic Comfort in School” (Portugal). Regarding the possibilities of interdisciplinarity, practically all LHA allow the articulation of knowledge and/or skills from various subjects, from scientific and technological areas (e.g., mathematics, computing, physics, biology, etc.) to non-scientific areas (e.g., history, literature). In terms of duration, the activities lasted between 60 and 120 minutes and had target audiences of different ages and in different contexts, from primary students to families.

The next section describes in more detail some aspects of piloted LHAs.

4. Results from Country Reports

The description of the implemented LHAs will be made in this section, taking into account the dimensions contained in the report template.

4.1. Description of the activities carried out (their learning objectives, the topics included, their main characteristics, and the possibilities of interdisciplinary integration)

- **Green Deal**

Addressing the urgent environmental issues and the goals of the Green Deal, the partner countries (Croatia, Cyprus, Germany, Portugal, and Turkey) have introduced a range of activities. These initiatives aim to educate participants about sustainable practices and environmental awareness. Each activity, developed with clear learning objectives, incorporates an interdisciplinary approach, bridging the gap between theoretical understanding and practical application. From exploring energy consumption and solar power viability to investigating air quality and the role of forests in climate regulation, these programs equip learners with the necessary skills to navigate and address today's environmental challenges. A more detailed description of each activity is presented next.

The activity called "Modern energy in households", implemented by the Croatia team, aimed to teach participants basic concepts about energy systems, introduce different electricity tariff models in Croatia, and explore the need to balance energy production and consumption. In the DRLab, participants explored the energy consumption of different devices and analyzed the benefits and costs of solar home systems through a web application. The aim was to consider the role of energy in an individual's everyday life and the importance of responsible energy consumption. The activity mainly covered the themes of Green Deal and Digitalization, challenging participants with problems that required calculations and physics concepts (e.g., electricity, voltage, measurement units). In terms of interdisciplinarity, the activity brings together physics and computing.

Although not yet implemented, the activity "Measuring particulate matter pollution in the city", from the Cyprus team, aims to engage students in understanding and measuring particulate matter as a key aspect of air pollution. By doing so, they become acquainted with one of the most pressing environmental issues—air quality. The students are guided to investigate and collect data on particulate matter in their local environment, utilizing scientific methods to

quantify and analyze pollution levels. The activity was designed to engage participants in creating a simple device to collect particulate matter and analyze the data to understand air quality in their local area. The project integrates environmental science with technology and mathematics, allowing students to draw upon diverse fields to investigate a real-world problem. The scientific process of collecting and analyzing data is underscored, promoting a hands-on approach to learning about the environment.

Germany implemented an educational workshop (“Lessons in the forest: Climate impact of forests”) focused on the forest’s role in climate change mitigation. Participants, were given the opportunity to understand the general functions of forests, measure the height and diameter of trees using professional devices, calculate the wood volume and carbon storage, and relate these measurements to carbon emission equivalents. The overarching aim was to foster appreciation for forests in climate regulation and to stimulate proactive thinking regarding environmental conservation. The workshop demonstrated the interdisciplinary nature of environmental education by integrating biology, earth science, environmental science, physics, chemistry, and mathematics. Students were not only exposed to theoretical knowledge about forests but also applied mathematical formulas and scientific principles to understand and quantify the ecological services provided by trees.

As for Portugal, the Portuguese team implemented two activities within the topic of Green Deal: “*Olivaria*: the olive tree” and “Invisible world: Discovering air quality”. Regarding the first one (*Olivaria*: the olive tree), the activity was designed to explore the importance of trees in terrestrial ecosystems, the societal value of trees, detailed knowledge about olive trees—a characteristic tree of Portugal, and the understanding of products and pollutants derived from olives. As such, the activity brings together earth sciences, geography, literature, biology, history, and mathematics. Conducted on a pedagogical farm, families took part in exploratory walks among olive trees, engaging in discussions about sustainable agriculture, olive oil production, and their local context. As for the second activity (“Invisible world: Discovering air quality”), the main goals were to identify the properties of air and its constituents, name the main gases comprising air, produce and identify oxygen and carbon dioxide, learn about anthropogenic activities contributing to air pollution, and engage in experiments to observe, collect data, and draw conclusions. This activity encouraged an inquiry-based learning approach, incorporating elements of science and mathematics.

Finally, the Turkish team implemented an activity (“Escape room for a Sustainable World”) designed to educate participants on the use of artificial intelligence (AI) and coding in the

context of environmental science. Students learn to assemble electronic circuit boards and sensors, and use software to measure air quality, gaining insights into the intersection of technology and environmental monitoring. The aim is to understand how digital tools can be utilized to analyze and address environmental issues, particularly air quality. This activity is inherently interdisciplinary, blending computer science, environmental science, engineering, and data analysis. Students explore how AI can be applied to environmental challenges, thereby fostering skills in both digital literacy and ecological stewardship.

Health

Focusing on health within educational settings, the initiatives from Croatia, Germany, Portugal, and Turkey blend disciplines to enhance health literacy. Mathematics interlocks with human biology in Croatia, illustrating math's role in understanding health. Germany's "Molecular Kitchen" connects chemistry to nutrition, highlighting food science's relevance to health. In Portugal, acoustic science meets technology to examine sound's impact on well-being in educational spaces. Turkey's program integrates biology with technology, focusing on exercise's effects on heart rate. These activities reflect an interdisciplinary strategy to equip students with the knowledge to make informed health decisions and are described in the next paragraphs.

The "Mathematics and Human Body" activity (Croatia) encouraged high school students to apply mathematical concepts to understand various aspects of human physiology. By solving tasks from the lesson sheet, students used mathematical functions (e.g., linear, exponential, and trigonometric function) to examine the relationships between different physiological measurements and health indicators. Combining mathematics with biology and biomedicine, the activity illustrates the significance of mathematical analysis in health sciences.

In the case of Germany, students participated in a workshop ("Molecular Kitchen") that linked chemistry to culinary practices, focusing on the chemical transformations during cooking and the health implications of food additives. The workshop aimed to create a bridge between scientific principles and their application in everyday health and nutrition and merged culinary arts with chemistry, health sciences, and nutrition education, providing students with a comprehensive view of food science and its relevance to health.

In the LHA run by the Portuguese team regarding the "Health" topic ("Sound for the Future - Acoustic Comfort in School"), middle school students were introduced to the concept of sound health and the impact of noise in school environments. This activity utilized technology to

measure noise levels, aiming to foster an understanding of acoustic comfort and its importance for health in educational settings. In this activity, physics, technology, mathematics, and science are combined to provide students with a holistic understanding of how sound and noise levels impact health, emphasizing the need for comfortable acoustic environments for learning.

Finally, in Turkey, students were engaged in a scientific investigation of the physiological effects of exercise on heart rate, when participating in the activity “The Influence of Exercise on Heart Rate”. Using sensors and data loggers, participants explored how physical activity influences cardiovascular health, highlighting the value of regular exercise. In this LHA, biology was integrated with technology, leveraging data collection and analysis to create an engaging learning experience focused on exercise and health.

Digitalization

In addressing the imperative of digitalization, the partner countries have implemented forward-thinking initiatives to incorporate technology into the learning experience. The activities that are described below, aim to foster a deep understanding of digital tools and their applications, encouraging students to explore the practical use of digital technologies in various contexts. These programs exemplify an interdisciplinary approach, preparing students to become adept in navigating and leveraging digital resources in their future academic and professional endeavors.

"Teach a robot to dance!" (Croatia) likely encompasses programming and robotics, engaging students in coding to animate robots, blending technology with creative arts, and demonstrating the intersection of computational thinking with physical expression.

The "Air Quality Measurement with Artificial Intelligence Assisted Coding" (Turkey) initiative focuses on applying AI in environmental science. Students would engage in coding with AI to analyze air quality data, merging technology with science, and equipping students with skills to address real-world environmental challenges through digital solutions.

Additionally, Portugal and Croatia also implemented activities the activities “Modern energy in households” and “Sound for the Future - Acoustic Comfort in School” respectively that, although not exclusively focused on “Digitalization”, also included this topic, and were previously described.

4.2. Description of the implementation process of the lighthouse activities

Context in which it was implemented – information about the participants and partners' collaboration/involvement

The LHA were implemented in educational settings, engaging students, and families to solve real-life environmental and technological challenges. Partnerships were formed with educational institutions, environmental organizations, and in some cases, private sector collaborators who provided expertise and resources. This collaboration ensured an enriching experience that bridged theoretical learning with practical application. For instance, the LHA "Teach a robot to dance!" (Croatia) had 27 participants (elementary school students in age range from 13 to 14 years old, accompanied with one 16 years old high school student, and two teachers) collaborating with members of Institute for Electronic Systems and Information Processing of Faculty of Electrical engineering and computing and a member of the PMF, to understand robotics in the context of programming and creative expression. The "Lesson in the forest" LHA (Germany) involved a collaboration between ALU Freiburg and a 10th-grade biology course at a bilingual school. This activity brought biology to life by taking students into the forest, where they learned about the environment and its protection through practical activities.

Location where the activities were implemented and duration

Activities took place in diverse settings such as schools, laboratories, pedagogical farms, and outdoor environments like forests. The duration varied, typically ranging from 60 to 120 minutes, allowing for in-depth exploration of the topics.

In Portugal, for instance, the LHA "*Olivaria: the olive tree*" took place at the Pedagogical Farm of Olivais in Lisbon, lasting 90 minutes, and giving families an opportunity to explore, among other issues, sustainable agriculture through the context of olive trees. In the case of the activity implemented by the Turkish team, "Air Quality Measurement with Artificial Intelligence Assisted Coding", the LHA took place in a school computer lab, where students used AI and Arduino boards to measure air quality and it last 120 minutes.

The different people involved (partners and their role and level of involvement)

Partners involved ranged from teachers and university faculty to industry professionals and community members. Their roles spanned from conceptualizing and leading activities to providing logistical support. The level of involvement varied, with some partners participating in the planning and execution stages, while others assisted with specific aspects of the activities.

As an example, the LHA “Molecular Kitchen” (Germany) was led by the ICSE and conducted in collaboration with schools: the activity was implemented in a school environment with ICSE members leading the workshop and a chemistry teacher's presence to provide additional support. Other example is the “Air Quality Measurement with Artificial Intelligence Assisted Coding” (Turkey) that was conducted by Hacettepe University. The collaborative effort includes university experts facilitating the workshop and offering direct support to students.

The role of the learners

The role of learners across different LHAs from Croatia, Cyprus, Germany, Portugal, and Turkey demonstrates a dynamic shift from traditional classroom settings to more engaged, inquiry-based learning environments. These activities offer a glimpse into how diverse and hands-on experiences can foster deeper understanding, critical thinking, and real-world application of knowledge.

The Croatia's "Modern energy in households," LHA highlights how learners transition from passive recipients to active investigators, applying mathematical and scientific concepts to understand and influence their environment positively. In Germany's "Lesson in the Forest" learners are not just acquiring knowledge but are actively participating in scientific inquiry, connecting deeply with environmental topics. In Portugal, activities like "*Olivaria*: the olive tree" and "Sound for the Future: Acoustic Comfort in School" illustrate a learner-centered approach that blends science, technology, engineering, and mathematics with cultural and environmental awareness. Students engage in exploratory walks, discussions, and technology use, demonstrating the effectiveness of experiential learning in enhancing engagement and comprehension. In Turkey's activities, such as the "Air Quality Measurement with Artificial Intelligence Assisted Coding" learners assume the role of researchers and developers, employing artificial intelligence to address real-world issues.

How they were implemented

The implementation of LHA involved a blend of direct instruction, experiential learning, and the use of digital tools. Inquiry-based approaches were common, encouraging students to conduct experiments, analyze data, and engage in critical thinking. The use of technology varied from simple data collection devices to sophisticated tools like Arduino boards for coding, demonstrating a commitment to fostering digital literacy alongside subject-specific knowledge.

For example, the activity “Teach a robot to dance” (Croatia), involved pairing up participants, with each pair receiving a Lego Education Spike set and a laptop connected to the robot. Participants learned about basic robot components including the processor, input sensors, and output motors. They then constructed dancing robots using a template and proceeded to solve pre-prepared problems using block-based coding. Encouraged to ask questions and collaborate, participants overcame initial challenges and engaged actively in the learning process. This hands-on approach provided an interactive and educational experience, allowing participants to explore robotics and programming effectively. Regarding the “Escape room for a Sustainable World” activity (Turkey), before the activity, escape room setups were placed on laboratory tables for group work. Participants were given the initial task of unlocking the key above the house and proceeded to solve tasks corresponding to door colors on paper. Successful completion of all tasks led participants to a greeting message in the final room. The aim was for participants to engage in sustainability-themed tasks, utilizing skills and expanding knowledge in fields such as environment, ecology, and biology, with digitalization incorporated. This popular activity format attracted individuals of all ages, providing an opportunity to open locks by solving sustainability-themed tasks within the house model.

Knowledge, skills, and attitudes developed by the learners

Engaging in LHA extends beyond traditional learning; it's a dynamic process that fosters a robust set of knowledge, skills, and attitudes which are crucial in today's interconnected world.

For example, in the LHA “Lessons in the Forest” (Germany), participants measured trees, calculated their wood volume, and connected this to carbon storage, which broadened their understanding of the ecological importance of forests. They developed practical skills in using scientific equipment and mathematical applications, along with an appreciation of environmental conservation. In the activity “The Influence of Exercise on Heart Rate” (Turkey) an inquiry-based approach engaged learners in understanding the impact of exercise on physiological functions. It developed their ability to conduct experiments, interpret data, and gain insights into science and health. Also, in the LHA “Invisible World: Discovering Air Quality” (Portugal) learners conducted experiments to identify air constituents and understand anthropogenic contributions to air pollution. They developed critical thinking and problem-solving skills in a scientific context.

Difficulties experienced by the learners and the strategies developed to overcome these difficulties

The following examples reflect a common theme: effective facilitation and support are critical for overcoming difficulties in learner-centered activities. Tailoring the instructional approach to the learners' needs and providing hands-on assistance were key strategies in enhancing the educational experience and ensuring that learners could fully engage with the material despite initial challenges.

Turkey's Air Quality Measurement activity revealed a gap in experience with Arduino and coding among participants. To bridge this, the workshop featured aides who worked alongside the facilitator, offering targeted support, ensuring that even novices could engage with and learn from the activity. Technical issues arose in the Sound for the Future project (Portugal), where learners found it difficult to troubleshoot micro:bits and sound sensors. Here, the facilitators' proactive support was instrumental in navigating these challenges, providing additional guidance to bridge the gap between learners and the technology in use. In Croatia, the "Modern energy in households" activity engaged learners in topics of power systems and responsible electricity consumption. They encountered concepts possibly new to them, as power systems are typically part of an older student curriculum. Younger participants, being introduced to these concepts for the first time, faced difficulties grasping them. This challenge was addressed by the activity leader adjusting the approach to suit their level of understanding and by fostering teamwork among participants, allowing them to discuss and work through problems collectively.

4.3. Key success factors of the lighthouse activities

The LHA from the partners share several key success factors that collectively contributed to their success:

- Integration of Practical Experiences: Across all activities, the incorporation of hands-on, practical experiences like cooking in a molecular kitchen, measuring trees, or programming robots was a fundamental element that not only enhanced understanding but also retention of knowledge.
- Interdisciplinary Approaches: These activities showcased the power of interdisciplinary learning, connecting various subjects like green deal, health, and digitalization, which allowed students to see the interconnectedness of different fields of knowledge.
- Adaptability and Tailored Instruction: Whether it was adjusting the complexity of content to match students' understanding or modifying lesson plans to suit different learning

paces, the ability of facilitators to adapt was crucial for accommodating diverse learning needs.

- Active Engagement and Student Autonomy: Each activity was designed to encourage questions, problem-solving, and independent thinking. By prompting students to take charge of their learning, the activities fostered a deeper level of engagement and a sense of empowerment.
- Use of Current and Relatable Contexts: By focusing on topics that have direct relevance to students' lives, such as sustainable energy use or the responsible consumption of electricity, the activities established a clear connection between classroom learning and real-world issues.
- Collaborative Learning Environment: The success of these activities also hinged on fostering a collaborative learning environment where students were encouraged to work together, discuss, and help each other, thus developing their communication and teamwork skills.
- Enthusiastic and Knowledgeable Leadership: Effective guidance from passionate facilitators who were knowledgeable about their subject matter provided students with a reliable source of information and inspiration, making the learning process more enjoyable and effective.
- Incorporation of Technology: Utilizing digital tools and platforms such as online calculators, coding interfaces, and educational software enriched the learning experiences, making complex concepts more accessible and engaging for digital natives.
- Reflective Practices: Activities often concluded with reflective components, encouraging students to consider the implications of what they learned and how it applies to broader societal and environmental contexts.

4.4. Perspectives on the relevance of the lighthouse activities

The LHA demonstrate significant relevance through their innovative approaches to learning. These initiatives address critical areas of development that align closely with current global challenges.

- Relevance to Environmental and Digital Literacy: In Germany, activities like the "Molecular Kitchen" and "Lessons in the Forest" underscore the importance of environmental awareness. These programs encourage learners to think critically about their impact on the environment and the significance of sustainable practices.

- Connecting Classroom Learning to Real-world Applications: The "*Olivaria*" project in Portugal and the "Modern energy in households" activity in Croatia make abstract concepts tangible by linking them with real-life scenarios, such as energy consumption and responsible use of resources. By examining practical examples, learners gain a deeper appreciation for the themes covered and its direct implications on daily life.
- Strengthening Interdisciplinary Knowledge: The LHA highlight the interconnectedness of disciplines. From the Turkish projects focusing on air quality measurement with AI to Croatia's exploration of robotics with Lego sets, students experience firsthand how different fields of knowledge such as mathematics, science, technology, etc., can integrate seamlessly to solve complex problems.
- Fostering 21st Century Skills: Across all activities, there is a clear emphasis on developing skills essential for success in the 21st century. Critical thinking, problem-solving, collaboration, and technological fluency are consistently cultivated, preparing learners to navigate and contribute effectively to an increasingly complex world.
- Encouraging Inquisitiveness and Lifelong Learning: By engaging learners with intriguing and challenging tasks, such as programming a robot to dance or analyzing the financial return of solar investments, these activities foster a love of learning and an inquisitive mindset that extends beyond the classroom.
- Supporting STEM Education: Each activity serves to bolster STEM education, providing hands-on experiences that help demystify STEM concepts and illustrate the excitement and applicability of STEM fields. This is particularly evident in the "Mathematics and human body" activity from Croatia, which merges mathematical theory with biomedicine, showcasing how mathematics is crucial in health sciences.
- Promoting Health and Well-being: Some activities, including "Mathematics and human body" and the health-oriented tasks in Turkey, emphasize the importance of understanding and maintaining personal health. These activities contribute to a holistic educational approach, where learners are not only academically engaged but also informed about maintaining their well-being.
- Cultivating Environmental Responsibility: With a global focus on sustainability, activities that educate on power consumption and renewable energy resources are particularly relevant. They equip learners with the knowledge to make informed decisions about energy use, echoing the global urgency to address climate change and energy sustainability.
- Preparing for Future Challenges: As the world becomes more technologically advanced, the significance of digital literacy cannot be overstated. The digitalization-themed

activities from Croatia and Turkey help students become adept at coding, programming, and understanding the interface between technology and everyday life.

- Nurturing Global Citizens: By drawing attention to global issues like sustainability, health, and digitalization, the LHA cultivate global citizens who are aware of and engaged with the world around them. This global perspective is critical for learners who will enter a workforce that is increasingly diverse and interconnected.

5. What Worked Well: Best Practices Examples

- This section highlights the effective strategies and outcomes derived from the implementation of LHA across various partner countries within the ICSE Science Factory project. These best practices serve as exemplars for future educational initiatives and underscore the potential for LHAs to impact science learning positively.
 - **Interdisciplinary Learning:**
Each LHA integrated multiple subjects, demonstrating the value of combining subjects like science, mathematics, and technology with areas such as literature and history. This approach enabled a holistic understanding of complex topics like the Green Deal, Health, and Digitalization. For example, activities like "Modern Energy in Households" and "Sound for the Future: Acoustic Comfort in School" showcased how technological solutions could be applied to environmental and health-related challenges.
 - **Inquiry-Based Approach:**
The LHAs fostered an environment of inquiry and exploration. Activities encouraged students to engage in experiments, data analysis, and critical thinking. This method was notably effective in activities such as "Invisible World: Discovering Air Quality" and "The Influence of Exercise on Heart Rate," where learners developed a hands-on understanding of air properties and the human body's response to exercise.
 - **Collaborative Learning:**
Partnerships between educational institutions, industry professionals, and the community were key to the LHAs' success. These collaborations provided a rich learning environment and opportunities for real-world application, as seen in "Teach a Robot to Dance!" where students could delve into robotics and programming with the support of university experts.
 - **Engagement and Fun:**

The success of LHAs was also attributed to their engaging and enjoyable nature. For instance, the "Molecular Kitchen" combined culinary arts with chemistry, intriguing students and stimulating their interest in the science behind cooking. Similarly, the "Escape Room for a Sustainable World" utilized an interactive format to educate participants on sustainability.

- Technology Integration:

Digital tools were employed to enrich learning experiences, as evident in "Air Quality Measurement with Artificial Intelligence Assisted Coding." By integrating AI and coding, the activity prepared students to tackle environmental issues with modern technological solutions.

- Reflective and Critical Thinking:

LHAs were designed to culminate in reflective discussions, enabling learners to connect the activities with broader societal and environmental concerns. This reflective practice was significant in fostering an understanding of the relevance and impact of science in real life.

- Outcomes and Skills Development:

Participants in LHAs not only gained new knowledge but also developed essential skills such as problem-solving, teamwork, and digital literacy. Activities like the "Mathematics and Human Body" highlighted the applicability of mathematical analysis in health sciences.

- Challenges and Resolutions:

Effective facilitation played a pivotal role in overcoming challenges faced during LHAs. Tailoring instruction to student needs and providing guidance ensured engagement and comprehension, especially in activities where new concepts were introduced, such as the "Modern Energy in Households."

The successful practices identified in the LHA not only advanced science education but also stimulated a sense of curiosity and lifelong learning among participants. By creating meaningful connections between education and societal needs, LHAs proved to be powerful tools in developing informed, thoughtful, and proactive global citizens.

This outline for "What Worked Well: Best Practices Examples" integrates the successful elements from the piloted LHAs, providing an overview of the impactful strategies, outcomes, and the overall significance of the activities in fostering an engaging and meaningful learning experience.

6. References

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7. Annex



Country Report
Croatia

Lighthouse activity best practice example

Modern energy in households

Basic information:

- Name of the Lighthouse activity: Modern energy in households
- Topic: Environment/Green deal and Digitalization
- Interdisciplinarity: mathematics, physics, computing, and energetics
- Duration: 90 minutes
- Target age of participants: 13 and 14 years old
- Partners involved in the activity: Croatian mathematics society (HMD) and Faculty of Electrical Engineering and Computing Zagreb (FER)

Description of the activity:

The main aim of “Modern energy in households” Lighthouse activity is for participants to:

- Learn (or revise their knowledge) about basic concepts about power systems.
- Get introduced to different electricity tariff model existing in Croatia, and to consider benefits of those models for a household.
- Learn about the necessity to balance power production and consumption.
- In DRLAB (energy demand response laboratory) explore power consumption of different devices.
- Explore the benefits and costs of household solar system through solar calculator web application developed by FER.
- Consider the role of energy for everyday life of an individual, and importance of responsible power consumption.

The activity covers primarily topics of environment/green deal, but also includes topic of digitalization. Participants were challenged with different problems requiring computation and basic concepts from physics.

The course of the activity: participants first go through a short introduction of DRLab, the purpose of the lab, and how can they use it.

DRLab is a room with a great number of kitchen and other household devices (e.g., oven, microwave oven, coffee machine, water heater, washing machine, dryer, Hoover, light system, floor heating system), it also contains a display on which the electricity consumption of each individual device is recorded. After the introduction, participants are familiarized with (or repeat their knowledge about) basic concepts regarding power and power systems (e.g., electricity, voltage, appropriate measurement units, existing tariff models). Next, participants are engaged in problem solving of the first three tasks from the lesson sheet (Appendix 1).



Problems are being solved independently, or in cooperation with other participants, and if necessary, the help can be requested from the activity leader. After checking the accuracy of solutions, activity continues with the Task 4 (Appendix 1), i.e., consumption analysis of live measured electrical devices from DRLab. In this activity different devices are being switched on, while their consumption has been monitored on the display. Before each experiment participants are asked to try and estimate the consumption for each device. With a real data obtained, participants are calculating total electricity consumption and the cost of electricity (e.g., for baking a strudel). The Lighthouse activity ends with the Task 5 (Appendix 1), i.e., with solar calculator demonstration. The web application (<https://fnelektrane.pythonanywhere.com/>) for calculations linked to solar power plants within the self-supply model, is demonstrated to the participants. The participants research the potential consumption or production of solar energy for a household located, e.g., in the Split-Dalmatia County, monitor the costs and discover at what point the investment would be returned. The experiment is repeated with different settings and the results are compared.

Description of the implementation process:

This activity was collaboratively designed between the Department of Energy and Power Systems of Faculty of Electrical Engineering and Computing, and Croatian Mathematics Society. The

activity was conducted in the DRLab located in the building of the Faculty of Electrical Engineering and Computing, in duration of 90 minutes.

The main leader of the activity was M. Eng. Luka Budin, a member of Department of Energy and Power Systems. His role was to introduce participants with DRLab and coordinate their activities in process of solving the lesson sheet. Additional help with organization, coordination, logistics, some help with baking a strudel, and with motivating participants to active collaboration, was provided by Petra Vidovic (HMD), Renata Svedrec (HMD) and Matea Dvorščak (PMF).



There were 32 active participants of the Lighthouse activity. Most of the participants were 13- or 14-years old, accompanied with one physics teacher. The participants had an active role in the activity. They were encouraged to pose questions, and many questions were posed, e.g., “what is the definition of direct current?”, “how can we know what the system voltage is?”, “will a larger investment (solar panels) give a faster return on investment?”. Since activity was organized in a series of heuristic conversations, with prompting questions such as: “what is the

relationship between electricity consumption and its original price?”, “which we need to calculate the consumption and cost of electricity?”, “why using kJ is not convenient for displaying electricity consumption, why do we use kWh?”, “what do you think, when will the air conditioner have a higher consumption? If we heat in winter or summer? If we cool in winter or summer?”, participants are stimulated to be active and use their reasoning and justifying skills.

Outcomes:

In the course of the activity students will:

- learn (or revise) about electricity, voltage, appropriate measurement units, existing tariff models;

- practice calculations of consumed electricity, the cost of electricity, and determining current flows;
- consider the use of appropriate measurement units;
- practice their graph reading and interpretation skills;
- reflect upon a responsible consumption of electricity in a household;
- reflect upon strengths and weaknesses of different energy sources;
- develop a positive attitude regarding the importance of reflection about the responsible consumption of electricity;
- develop positive attitudes regarding renewable energy sources (solar energy);

Relevance, success factors and difficulties:

From our perspective this activity is very relevant since it covers an important topic regarding a responsible consumption of electricity. It prompts participants to learn key concepts related to power systems, to consider tariff models they are using in their households, and to reflect upon their own usage of electricity.

There were several factors responsible for the success of the lighthouse activity:

- well prepared leader, and the lesson plan which included a good ratio of heuristic talk, problem solving and experimentation;
- topic interesting for participants, which prompted them to ask a lot of questions;
- possibility for participants to explore on their own;
- baking of a strudel and the eating it afterwards;

There were some difficulties which could be observed:

- A part of participants were 13 years old students of 7th grade of elementary school. Power systems are part of 8th grade curriculum. Therefore, some participants had difficulties with understanding all concepts (they were completely new for them). The difficulty was overcome with leader adjustment of approach and the teamwork between participants.
- Some problems arose from solving problems in tasks 1 to 3. Participants had difficulties with understanding or applying concepts necessary to solve problems. One of the strategies for overcoming this difficulty was to consider the difficulty with their colleagues participating in the activity, discuss the issue together and try to reach a solution. The other strategy was to reach to the leader of activity for help. In this cases leader would either activate some other participants who managed to solve problems to help, or he would help participants to discover the solution. For example, to solve Task 1.c participants had to know what the power system voltage is. Although some participants knew that the right answer is 230 V, a leader decided to let participants discover it. He presented to them a voltmeter, explained how this device works, and let participants to discover the voltage by connecting a voltmeter to the circuit.

Final remarks:

The paradigm of the power system is changing in the last decade. It is no longer sustainable to have consumers using electricity without any restrictions. Therefore, consumers are expected to use electricity responsibly, meaning that they have to be able to shift or suspend their load at some times (demand response). It has become very important to educate citizens, and especially young people to be responsible consumers. It is especially important to get young people to think about how they use electricity and how electricity is used in their household, and what they can do to make the use of electricity more responsible and, ultimately, more financially profitable. From our point of view, the lighthouse activity: Modern energy in households, is valuable effort in achieving this aim.

Cooperation between two institutions designing the activity (HMD and FER) was very pleasant and fruitful. Members of Department of Energy and Power Systems did an excellent job, proposing course of the activity, and excepting all proposals from the partners.

There are several actions that could be done to improve this lighthouse activity. For starters, it would be wise to organize it in a smaller group (approximately 20 participants), because this would be the optimal number if the size of the room in which DRLab is considered. For the future attempts it would also be wise to prolong the duration of the activity. Not only that the students had a lot of questions, but it would also allow the time to finalize the activity with a discussion. Although the responsible use of electricity was discussed during all the specific tasks that were carried out, the whole activity would have been rounded off nicely with a final discussion on that topic. Therefore, ensure that participants leave the activity reflecting on important aspects of the topic.

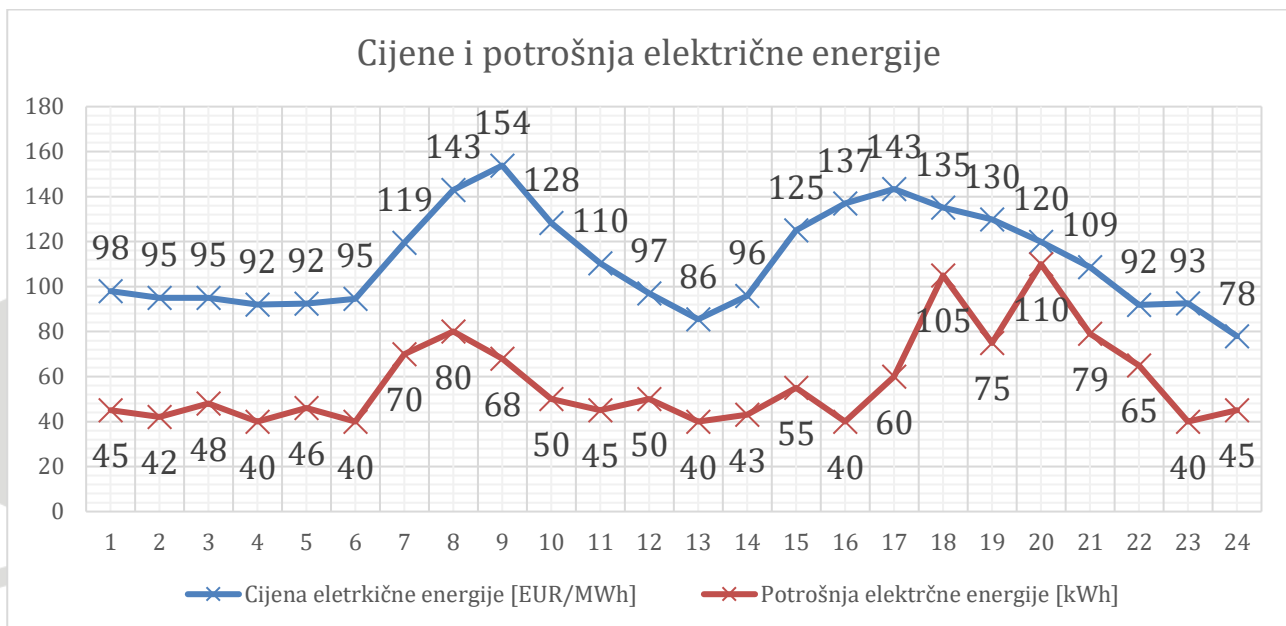
From our perspective, this is interesting, important and well-designed activity, and we believe it is definitely worth repeating.

Appendix 1. Tasks from the lesson sheet

1. How much electricity was consumed, if an electric heater of rated power 2kW was used all day?
 - a. Express the energy in kWh?
 - b. Express the energy in kJ?
 - c. How much electric current flows through a heater that is loaded with a power of 2 kW?
2. Using the electric heater from the previous task, whose electricity bill will be lower that day: Ivan, who is in the two-tariff model, or Petra, who is in the one-tariff model?

Something to think about: If Ivan could control the power of his electrical device, and at the same time consume the same amount of energy in a day that he would consume at a constant power of 2 kW throughout the day, could he further reduce his electricity bill? Is the same true for Petra?
3. Let's imagine that Ana's building is neither in the single-tariff nor in the two-tariff model but has a different price for electricity in every hour of the day. We get the price for each hour

from the electricity market and the prices are shown on the graph (blue curve). The hourly electricity consumption of Ana's building is also shown on the graph (orange curve). Which three hours of the day are the most energy-demanding (in which the most energy is consumed)? Why do you think consumption increased during those hours? What is the cost of electricity in each of the mentioned three hours? Is the hour in which the highest cost of electricity equals the hour in which the most electricity was consumed? Justify your answer.



4. Analysis of consumption of live measured electrical devices from DRLab.
 - a. Measurement of air conditioner consumption over time with different loads. Calculation of total electricity consumption in kJ and kWh. Calculation of the cost of electricity.
 - b. Measurement of electricity consumption of different electrical consumers (measurement from the electrical socket).
 - c. Measurement of electricity consumption of lighting fixtures. Calculation of electricity costs on an annual basis if the lights were to work 8 hours a day during high currents.
5. Demonstration of solar calculator created at FER.
 - a. Selection of input data about the household (location, roof orientation, roof slope, tariff model). Selection of the proposed power of the solar power plant and analysis of the obtained results.
 - b. Selection of other power plants in relation to the proposed one and comparison of the obtained results in relation to the proposed power of the solar power plant.

Lighthouse activity best practice example

Mathematics and human body

Basic information:

- Name of the Lighthouse activity: Mathematics and human body
- Topic: Health
- Interdisciplinarity: mathematics, biology, biomedicine
- Duration: 120 minutes
- Target age of participants: 16 - 18 years old
- Partners involved in the activity: Faculty of Science University of Zagreb (PMF) and Croatian mathematics society (HMD)

Description of the activity:

The main aim of “Mathematics and human body” Lighthouse activity is for participants to:

- revise their school acquired knowledge about concepts of functions (exponential and trigonometric) and sequences;
- get an impression of the prevalence and importance of mathematics in real life;
- get introduced to a relevance of mathematics in a scientific context (different than physics application – an existing preconception that mathematics is modelled only in context of problems related to physics);
- explore the role of mathematics in medicine, biology, and pharmacy, and reflect upon it;
- determine mathematical modelling procedures and apply them to real-life problems;

The activity covers a topic of health. It is important for participants to have a basic understanding of concept of functions, and to be familiar with some specific types of functions, e.g., linear, exponential, and trigonometric function.

The course of the activity: The activity starts with the motivation: modelling of stents using differential equations. In this example higher education mathematics is used, not appropriate for high school level. Nevertheless, it is a great example of relevance of mathematics in real life and science (medicine), and it brings us to the notion of biomedical mathematics. Next, participants are engaged in problem solving of the tasks from the lesson sheet (Appendix 2). Tasks are being solved in pairs, and if necessary, with the help of activity leaders. The tasks are designed so that the participants notice the role of mathematics in medicine, biology, and pharmacy. Participants use calculation skills as well as basic knowledge of functions (e.g., exponential function for



modelling a drug concentration in blood), and consider, discuss, and justify possible relationships between different measurements of the human body using mathematics. Participants interpret the obtained results in a real context and make recommendations related to human health. Each task is discussed with the activity leaders. The aim of the discussion isn't only to check the accuracy of solutions, but to move from a specific problem presented in a task, to the modelling procedures that were used to solve the problem. The activity continues

with problems of drawing conclusions from graphs. This is a group activity in which participating students are enrolled in heuristic dialog. Participants are examining and drawing conclusions upon given graphs (representing e.g., vessel diameter, average blood pressure or graphical representation of relationship between height and age). In this activity participants are considering different characteristics of models (being discrete or causal), discussing e.g., the difference between linearity, correlation and causality, etc.

Description of the implementation process:

This activity was designed by members of Faculty of Science, University of Zagreb and it was conducted in one of the lecturing halls of the faculty, in duration of 120 minutes.

The main leaders of the activity were prof.dr.sc. Zeljka Milin Sipus and doc.dr.sc. Matija Bašić, both members of Department of Mathematics of Faculty of Science. Their role was to introduce participants into the topic, to coordinate their activities in process of solving the lesson sheet, and to lead them through the heuristic discussions following the task solving process. Additional help with organization, coordination, and logistics was provided by Petra Vidovic (HMD), and Renata Svedrec (HMD).

There were 11 active participants of the Lighthouse activity. Most of the participants were 17- years old (age range between 16 and 18), accompanied with one



mathematics teacher. The participants had an active role in the activity. They were encouraged to pose questions, and many questions were posed, e.g., “Is it possible to analyze geometry of a stent? How? How does that as a professional?”, “How to get an algebraic expression to model a drug concentration? How about using many different drugs? Which professions analyze such problems?”. Since activity was organized in a series of heuristic conversations, with prompting questions such as: “how does the increase in the concentration of the drug in the blood behave (type of dependency)?”, “what is the meaning of a mathematical model? What is a meaning of linear model? What is a difference between linearity, correlation and causality?”, participants are stimulated to be active and use their reasoning and justifying skills. Participants were using different strategies for problem solving. The most interesting was the evolution of their reasoning. Given that the tasks are placed in context, at first, they seem like biology problems. Therefore, the participants initially relied on their knowledge of biology (e.g., about capillaries, arteries). When activity leaders started to pose the sub-questions, it was possible to see how their reasoning moved from biology to the area of mathematics.

Outcomes:

In the course of the activity students will:

- - model phenomena and processes in medicine, biology, and pharmacy using high school mathematics tools (sequences, and exponential and trigonometric functions);
 - observe and model periodic phenomena;
 - analyze data using linear regression;
 - communicate about the obtained results using mathematical language;
 - consider and justify the relationship between different measurements of the human body;
 - practice their graph reading and interpretation skills;
 - reflect upon and make recommendations based on mathematically obtained data regarding human health;
 - form a connection between mathematical content learned in classroom, and very specific situations important for human health;
 - develop a positive attitude regarding the role of mathematics in real life and other sciences;
 - develop positive attitudes about their own abilities to model real life situations using mathematics;

Relevance, success factors and difficulties:

From our perspective this activity is very relevant for several reasons. It covers an important topic regarding a human health, and the participants are offered with the opportunity to consider and make conclusions on topics such as a responsible use of a medication. In addition, this activity

promotes interdisciplinary teaching, i.e., it shifts the paradigm, from moving from targeted knowledge, common in everyday classes, to moving from problems and questions.

There were several factors responsible for the success of the lighthouse activity:

- well prepared leaders, and the lesson plan which included a good ratio of heuristic talk, problem solving and experimentation;
- topic interesting for participants, which motivated them to engage actively and to ask a lot of questions;
- participants were students attending high school with a mathematical orientation, with a specific affiliation to mathematics and sciences (belonging to a math-science group);

There were some difficulties which could be observed:

- the topic of modelling in biomedicine is very complex, therefore it was necessary to adjust the models (simplify them) in order to be appropriate for a lighthouse activity which presupposes students' active role. Such simplification can leave the impression that the situation participants are modelling isn't completely realistic and authentic;
- new way of working with students (not as in school);
- "transfer" of students' mathematical knowledge to new, not-met-before contexts;
- linking of mathematical knowledge from different mathematical areas and mathematics communication.

Final remarks:

The human health has always been an important topic. The importance of responsible behavior towards health, and the ability to interpret medical information that is being represented to us, has become quite clear in the recent period. For instance, there is more and more talk about the irresponsible use of medication (e.g., antibiotics) and the consequences it brings. Mathematics is often perceived as a set of pure formulas that we manipulate with no apparent purpose. That's why this example of interdisciplinarity is very important for creating a more complete picture of mathematics and for seeing the relevance of what students learn in mathematics classroom in everyday life.

Although it was mentioned that such a complex topic requires simplification, and can be perceived as "artificial", we find that such a situation brings opportunities for further discussion and considerations. It allows us to discuss reasons why it is not possible to conduct such a problem solving in a classroom setting, without simplification of a model. For example, when considering a concentration of a drug in human bloodstream, it is a simplification to state that on average 25% of the drug is excreted from the body during the day. But it is also a good opportunity to reflect on what would we need to be able to use an exact data (e.g., a laboratory, a test subject for blood draw, etc.) and to discuss about conclusions which pharmacists bring, since not all human bodies are the same, and the number of factors that can influence the process of a drug breakdown (e.g., gender, weight, nutrition, etc.).

With a more time available, it would be possible to address the topic of "drug concentration in the blood" as a more open activity that would require students to "study sources (literature, internet, ...) and to do the modelling by themselves. It might also be possible for students to come up with different models and compare them, but still analyze other properties of the models such as asymptotic behavior and drug interactions. Furthermore, some simple use of technology would also be desirable.

From our perspective, this is interesting, important and well-designed activity, and we believe it is definitely worth repeating.

Appendix 2. Tasks from the lesson sheet

6. A patient is sick. A doctor prescribes him medicine and advises him to take a daily dose of 1500 mg. After taking a dose, on average 25% of the drug is excreted from the body during the day. The remaining amount of the drug remains in the patient's bloodstream.

- How many mg of the drug remain in the patient's bloodstream after the first day?
- After the first day, the patient takes the medicine again and the process is repeated. How much drug is in the patient's bloodstream after the second day?
- Fill in the table!
- Investigate by calculating how the amount of medicine (in mg) changes if someone starts taking the medicine in a daily dose of 1500 mg, for example, with the dynamics of 500 mg three times a day.
- Are the consequences quite as dramatic if you skip a day and/or take a double dose of a drug?
- Can any amount of drug in the bloodstream be achieved? Explain your answer.
- How many mg of the drug remains in the patient's bloodstream after one day? Complete the table.

mg OF THE DRUG IN BLOODSTREAM
0
1125

DURING A DAY	mg OF THE DRUG IN BLOODSTREAM
0	1500
1h after	
2h after	
...24h after	1125

7. Further questions for discussion:

- Can you estimate a person's height from their walk?
- Can you estimate a person's height based on the length of their femur/the length of their head?
- What is the nature of relationship between a person's height and their arm span? Are there differences for girls and boys?
- What is the nature of relationship between a person's length of the forearm and the length of the outstretched arm (hand and fingers)?
- In the first year of life, the child's weight triples. Is it the same with height?

8. The following data is part of the data that doctors used to determine the recommended maximum heart rate during exercise depending on the age of a patient.
- Describe the dependence of the given data.
 - How would you formulate a recommendation that doctors could offer to their patients?

years	max. heart rate in a minute
20	198
30	189
40	182
50	171
60	162

Lighthouse activity best practice example

Teach a robot to dance!

Basic information:

- Name of the Lighthouse activity: Teach a robot to dance!
- Topic: Digitalization
- Interdisciplinarity: computer science, robotics
- Duration: 90 minutes
- Target age of participants: 11-14 years old
- Partners involved in the activity: Faculty of Electrical Engineering and Computing Zagreb (FER)

Description of the activity:

“Teach a robot to dance!” is a lighthouse activity from the topic of digitalization, which aims for participants to:

- learn about basic concepts within robotics (the basic components of the robot, which is necessary for us to be able to call an object a robot, etc.);
- get introduced to the basics of programming and to learn basic procedures of block coding;
- to explore the possibilities of using well know children manipulation toy (Lego cubes) for building a functional robot;
- to explore the possibilities of using a Lego robot, and programming it to perform simple tasks (move arms and legs, dance, etc.);
- create a positive attitude towards computing by connecting robotics and programming with the well-known activity of assembling Lego figures;

The course of the activity: participants are divided into pairs. Each pair is introduced to their working material: a box of Lego Education Spike set (Figure 1), and a laptop to which a robot (once it is built) will be connected and activated through <https://spike.legoeducation.com/prime/> website. Participants are introduced to basic components of a robot: robots’ brain, a processor, used for programming of a robot, input components of the robot (sensor for distance, for



Figure 1 Lego Education Spike set

colour, sound or touch) and output components of the robot (motors that respond to sensory stimulation). Participants continue with assembling a robot dancer, with the help of a template, but with independent selection of the external appearance of the robot and access to the connection of input and output components.

After successfully building the robot and connecting it to the computer, the participants of the activity start solving pre-prepared problems (Appendix 3). Problem solving part of the activity is designed as a guided introduction to basic concepts and tasks through a solved example (e.g., tasks 1 and 4), which is followed by a constructivism phase (participants independently solve given problems). The tasks led the students to program the robot to perform simple tasks, using block-based coding. Block-based coding is a simplified mean of programming, where instead of writing the lines of code in a coding language, a word blocks are presented, and coding is performed by “drag and drop” process (Figure 2). Tasks are being solved in pairs, or in cooperation with other pairs of participants, and if necessary, with the help from the activity leader.

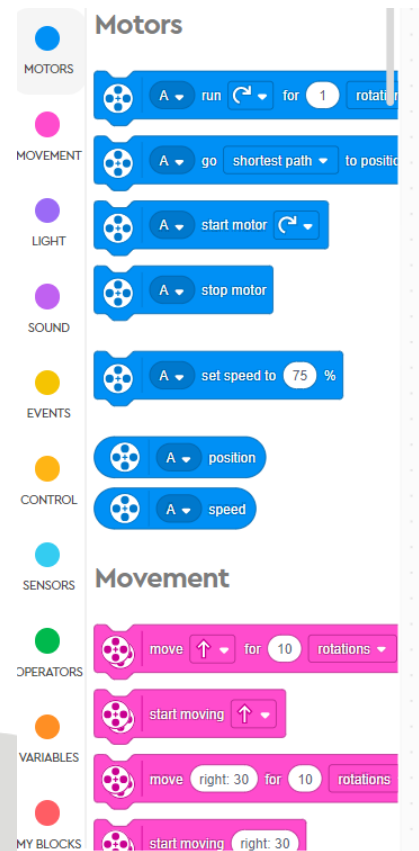


Figure 2 Word blocks in Lego Spike Prime

Description of the implementation process:



This activity was designed by members of Faculty of Electrical engineering and computing, University of Zagreb and it was conducted in one of the lecturing halls of the faculty, in duration of 90 minutes.

The main leaders of the activity were prof.dr.sc. Ana Sovic Krzic and Liljana Puskar, both members of Institute for Electronic Systems and Information Processing of Faculty of Electrical engineering and computing. Their role was to introduce participants to Lego Prime Spike set, and the basics of robotics and programming and to coordinate their activities in process of solving tasks with the robots. Additional help with organization, coordination, logistics, and with motivating participants to active collaboration, was provided by Matea Dvorscak (PMF).

There were 27 active participants of the

Lighthouse activity. Most of the participants were elementary school students in age range from 13 to 14 years old, accompanied with one 16 years old high school student, and two teachers. The participants had an active role in the activity. They were encouraged to pose questions. Participates' questions were usually restricted to additional instructions for assembling input and output components of a robot, help with the search of a corresponding component, or additional clarification regarding the way in which a certain component works. In addition to posing questions, after initial familiarization with the basics of programming and solving the provided tasks, participants were allowed and encouraged to get involved in the process of independently discovering of different possibilities that they can program the robot to do. For example, that the robot reacts to sound, or to movement (depending on which sensor they have connected or activated). The participants discovered that the robot can dance to certain given music, and found this discovery to be very entertaining.

There were several problems observed. Some of the participants found assembling of the robot to be problematic. The problems varied from excessively following the instructions (e.g. the robot on the template has yellow legs, so some participants considered it problematic that they did not have a Lego component of the appropriate color in their set), to problems with the correct assembly of the necessary components for the functioning of the robot (input and output components, connected to the processor), to problems in performing coding independently. At



the beginning of the activity, when facing a difficulty, participants would ask for help from the activity leader or teachers present at the workshop. As the activity progressed, participants were getting more and more relaxed, and started to ask for help other participants, and later engaged into process of independent investigation.

Outcomes:

In the course of the activity students will:

- - get to know the basics of robotics;
 - get to know the basics of programming;
 - practice basic block coding procedures and apply them to similar but new tasks;
 - develop a positive attitude towards robotics and programming;

Relevance, success factors and difficulties:

From our perspective this activity is very relevant because it affects students' interest in programming. During the activity, the participants were able to see that programming is not difficult and complicated, as it is often perceived, but that it can also be fun. Moreover, some participants said that they would be happy to enroll in Faculty of Electrical engineering and computing, if everything was this fun at the study.

There were several factors responsible for the success of the lighthouse activity:

- - well prepared leader, and the lesson plan which included a good ratio of heuristic talk, guided introduction to new concepts, independent problem solving and experimentation;
 - capitalization on existing love for well know children manipulation toy (Lego);
 - topic interesting for participants;
 - possibility for participants to express themselves creatively;
 - possibility for participants to explore on their own;

There were some difficulties which could be observed:

- - some participants demonstrated a lack of understanding which components are important for the function of the robot and which are "unimportant" (affecting only the appearance of the robot), e.g., they could not find a "cube" of the same color as the one on the given template and felt that because of this they could not build robot;
 - some participants demonstrated reluctance to investigate the problem when encountered with a technical difficulty, instead they would immediately ask for help stating: "it doesn't work for me", e.g., the instructions say which letter they should connect the processor to, they don't follow the instructions and immediately give up when something doesn't work;

- pairs of participants had different paces of solving tasks, so the faster ones usually waited for the slower ones to progress on the next task;

Final remarks:

Knowing the basics of programming is an important element of developed digital skills valuable for active participation in the modern world, while problem-solving skills and algorithmic thinking, which are the basis of programming, are skills that we apply in everyday life. Therefore, this activity, aiming on building positive attitudes towards programming and introducing participants to basic concepts of programming and robotics, is perceived to be as relevant.

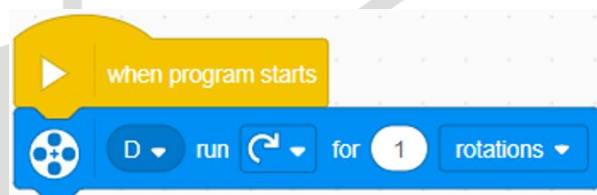
To improve this lighthouse activity, it would be recommended to give an access to the list of tasks on the computer to each individual pair, so that they could work at their own pace.

This activity is easily adaptable to younger and older participants. For example, primary school students could carry out activities with the help of the Lego Essential set, a higher level of guidance and more simple tasks. While high school students could have tasks that include more complex work with sensors, and tasks that include more variables.

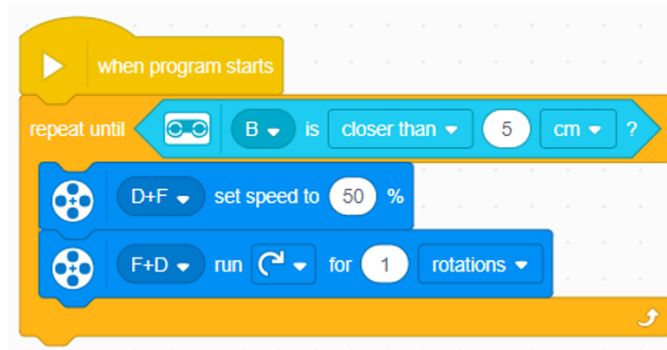
From our perspective, this is interesting, important and well-designed activity, and we believe it is definitely worth repeating.

Appendix 3. Tasks from the PowerPoint Presentation

1. How does the robot move its legs? Copy the program from the image. Make sure that the motor that is connected to the legs is connected to the same letter that you use in the program!



2. Write a program that makes it possible to move both arms and legs.
3. Write a program with which the robot would move its legs 375 degrees at a speed of 30%, and move its arms for 5 seconds at a speed of 50%.
4. The robot is a bit shy, so every time someone approaches it, it stops dancing. Copy the program from the picture to see how you can program it.



- 5. Now we have the opposite situation. Make the robot dance for 3 minutes every time it sees your hand closer than 5 cm. Write a program that would make this possible.



Country Report
Cyprus

1. Description of the activities

At the time of writing this report, no LHA have been carried out in Cyprus, but work is underway to design them. The following is a description of the activity designed and intended to be implemented by the end of March.

Topic

The survey on community needs carried out in Cyprus showed that four of the six main concerns of respondents were related to environmental and health issues, which were: Health, well-being and quality of life (64%), Climate change (53%)

Sustainability of planet's resources (47%) and Renewable energy and energy efficiency (36%).

Based on these results, and in connection with one of the environmental problems of greatest concern today, atmospheric pollution, an activity has been designed that focuses on the measurement of fine particulate matter (European Environment Agency, 2022). The activity was based on an experience carried out with a group of preservice early childhood teachers at the University of Malaga (Spain) led by a member of the Cyprus team, which produced very good results.

Main characteristics

The title of the LHA is: "Measuring particulate matter pollution in the city". The activity begins by posing the following question to the participants: Can we measure particulate matter pollution in the city? The aim of this question is to open a dialogue in which students can express their knowledge about air pollution and whether they know what particulate matter pollution is. After this, students will be asked to carry out a small search for information that will allow them to clarify their doubts about what exactly particulate matter is, with the intention of obtaining a general definition of the term that will allow them to tackle the next phase of the activity.

Once they have defined what particulate matter is, participants will be asked again the following question: Can we measure particulate matter pollution in the city? The idea is that participants

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will come up with their own ideas on how particulate matter could be measured and will be allowed to carry out a further search for information. Again, the aim is for participants to discuss their own ideas about how to detect, collect and measure this type of pollution. The search for information will be guided by the teacher and will be directed towards the development of a feasible experimental design. The teacher will have a previously elaborated experimental design that can be reproduced or followed with some modifications (it will depend on the ideas contributed by the participants, who could come up with interesting and viable alternatives). This experimental design consists of collecting data by making a simple device out of grease and paper (Fig. 1). This device allows particulate matter to adhere, allowing it to be counted later. The grid drawn is to facilitate particle counting and can be divided into more squares if necessary due to the density of the particles.



Figure 1. A device made of paper and vaseline to trap particulate matter in the environment.

Once the measurement device has been designed, participants should think of an experimental design that allows them to measure particulate matter pollution in their school/neighbourhood/city (the spatial scope of the study can be adapted according to the specific circumstances of the group). In the context of the experimental design, the participants will decide on the locations of devices placement and the period of exposure, as well. At this point, participants will have to think about the variables to be controlled during the experiments (places with more and less traffic in cities, busiest times of the day, construction sites, etc.).



Figure 2. Example of the setting of the devices in an activity carried out with Spanish preservice early childhood teacher.

After the experiments have been carried out, participants will collect the devices and count the particles trapped in them (Fig. 3).

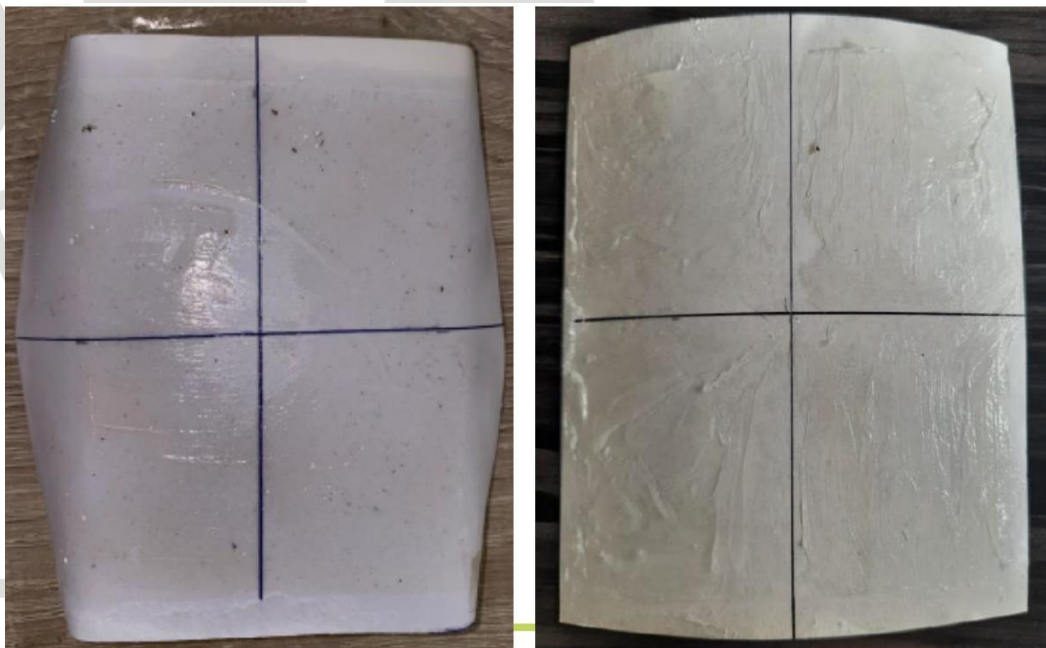


Figure 3. Example of the devices collected by Spanish preservice early childhood teacher.

Once the data have been obtained (Fig. 4), participants will have to analyze them, for example by calculating frequencies (Fig. 5), and finally draw conclusions based on the variables studied (most and least polluted areas of the cities, times of the journey with the most and least pollution, etc.).

RESULTADOS								
Tramo horario	Avenida Carlos Haya	C/ Burguillos (Puerto de la Torre)	Alameda Principal	C/ Antonio de Hilaria (Rincón de la Victoria)				
24 horas (L)	22	21	14	16	22	23	15	1
	24	26	18	22	27	25	8	14
	Total: 93		Total: 70		Total: 97		Total: 38	
13:00-15:00 (M)	10	9	6	8	11	9	7	6
	13	16	3	6	15	14	11	15
	Total: 48		Total: 23		Total: 49		Total: 39	
20:00-22:00 (M)	9	5	3	8	8	4	2	5
	6	5	7	5	10	5	9	8
	Total: 25		Total: 23		Total: 27		Total: 24	
13:00-15:00 (X)	10	9	8	13	9	8	10	12

Figure 4. Example of the data obtained by Spanish preservice early childhood teacher. The second row of the table shows the location (address) information where the devices were placed. The first column shows the time slots when the devices were placed.

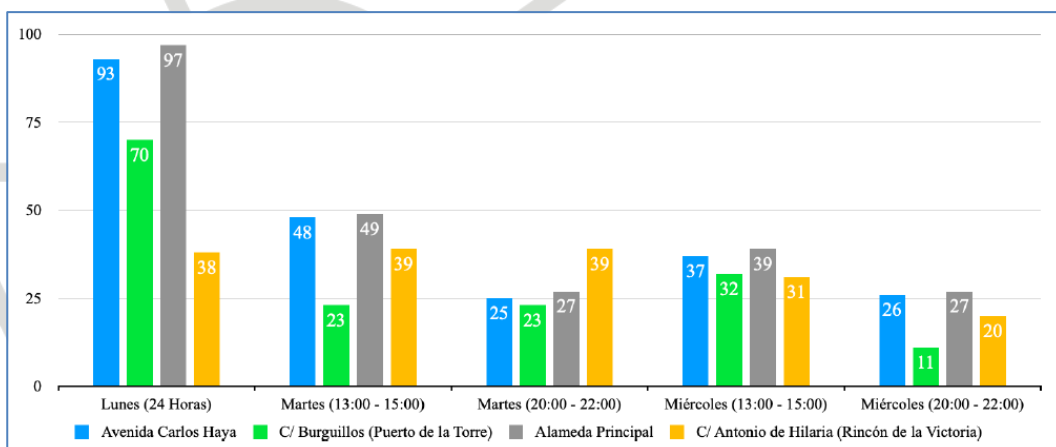


Figure 5. Example of the analysis carried out by Spanish preservice early childhood teacher. Represents the number of particles counted based on the location where the devices were placed and the time slots in which they were placed.

Learning objectives

The activity has two main objectives. On the one hand, it aims to get participants to investigate air quality in their places of residence, so that they address a real, local and community issue, i.e. one that is close to them. On the other hand, it aims to familiarize participants with the way scientists work by carrying out an investigation based on scientific methodology.

Possibilities of interdisciplinary integration

The activity has great potential for an interdisciplinary approach to the problem. It mainly deals with contents related to the natural sciences (specifically with the environment, pollution and its causes and consequences) and others related to mathematics (mainly with obtaining data and their basic descriptive statistical analysis).

2. Description of the implementation process of the lighthouse activities:

a. Context in which it was implemented – information about the participants and partners' collaboration/involvement.

The specific activity will be implemented, as a part of a wider context, in which the teachers who participated in the professional development seminars, offered by UNIC and the Cyprus Pedagogical Institute, will carry out within their classes, a LHA regarding a specific environmental issue (air pollution, noise pollution, marine pollution). The idea is to obtain a holistic image regarding the pollution in Cyprus by the end of the program. The participants are middle school students, who will participate with their parents, to design the experiment and install and collect the devices in their local community (e.g. neighborhood, the district around school etc.). The activity will be led by the teacher but a mathematician or an environmental scientist is possible to participate, to support students during the results analysis and interpretation.

b. Location where the activities were implemented and duration.

The initial phase of the activity will be implemented within the school context. During this phase, teacher will make an introduction in the concept of pollution, where videos and photos will be shown to the students. After the initial phase, the teacher is considering about taking the students for observing the traffic and the general activity in the area close to their school. During this phase, the students will detect possible pollutants and they will discuss for possible variables to take into consideration during the experimental design. After this, the students will have to place the detectors within their local community. The duration of the activity can vary from a few days to a few weeks, depending on the participating group.

c. The different people involved (partners and their role and level of involvement).

As discussed earlier, the main participants are the students and their parents. However, it is possible that external participants will also participate to support students during the analysis and interpretation. Moreover, the teacher has also asked from a peer, specifically a biologist, to talk about the impact of particulate matter pollution on human health.

d. The role of the learners.

The active participation of the learners is the main objective during the activity design and one of the ideas that was emphasized during the teachers' training. After the introduction, which will be held by the teacher, the students will be the ones responsible for every aspect of the LHA. They will design the experimental procedure, develop the detectors, place them, collect, and interpret the data. For each one of these steps, students will work in groups.

e. How they were implemented.

The activity is supposed to be implemented through the following stages:

Phase 1: Raise the problem and concern regarding the impact on human health.

Phase 2: Observing the local community for possible pollutants' identification.

Phase 3: Working in groups to decide on the variables and design the experimental procedure.

Phase 4: Place the devices.

Phase 5: Collect the devices / data analysis.

Phase 6: Data interpretation / results discussion.

Phase 7: Focus on students' agency / planning further acts in the local community to disseminate their results and plan future actions.

3. The knowledge, skills, and attitudes developed by the learners.

Through the implementation of the specific activity, the anticipated behavioral and cognitive impact lies in multiple aspects. Firstly, the main objective is to raise awareness regarding local problems and highlight the role of science and more specifically, the importance of scientific method in addressing these authentic challenges. Secondly, by transferring the active role of learning on the students is the first step to promote both agency and active participation in the local community. Apart from these valuable opportunities, the LHA will be conducted with the students working in groups and enhancing teamwork skills and simultaneously promoting the value of teamwork in real context of scientific community. Students will recognize scientific endeavor as a social activity and not a lonely path. In terms of conceptual content, students are expected to acquire knowledge related to atmospheric pollution, specifically in the form of particulate matter pollution. Moreover, in practice they will develop scientific skills by engaging in hands-on activities (posing research questions and hypotheses, carrying out experimental designs, collecting and analyzing results and drawing conclusions). The analysis and interpretation of data acquired by them from authentic contexts, will enhance their mathematical skills and highlight the connection between science and real life.

4. The difficulties experienced by the learners and the strategies developed to overcome these difficulties.

Students are not very experienced in designing and implementing experiments to address real-life problems. It is expected that difficulties which are adherent to the design and interpretation of the mathematical graphs will emerge. Students might find challenging the procedure of deciding on the

dependent, independent, and controlled variables as well as drawing conclusions from the mathematical form of graphs. To support them and trying to be proactive we are suggesting the participation of a mathematician and a scientist during the final stages.

5. The key success factors of the lighthouse activities.

Since the activity will be implemented in March, the key success factors are not yet revealed. However, the assumption is that students' engagement in a real-life problem and their activation within the actual community context will enhance their interest and confer a dose of fun in the science learning by working in groups.

6. Our perspectives on the relevance of the lighthouse activities.

Each one of us is a member of a wider community which is facing multiple challenges. Middle school students are at an ideal age range to realize their role in the community as active members and being a part of the solution. Particulate matter pollution is affecting citizens' quality of life, entailing a topic of high relevance. Through this LHA they will recognize the problem, reveal its actual size in order to be in a position to take action in the future.

7. Overall assessment: final reflective remarks.

Since the activity will be implemented in March the final reflective remarks will be given at a subsequent time.

References

European Environmental Agency. (2022). Health impacts of air pollution in Europe. <https://www.eea.europa.eu/publications/air-quality-in-europe-2022/health-impacts-of-air-pollution>



**Country Report
ICSE, Germany
Molecular Kitchen**

1. Description of the activities carried out (their learning objectives, the topics included, their main characteristics, and the possibilities of interdisciplinary integration).

Molecular Kitchen is a fun topic, where students create food or drinks that, for example, look special or by the combination of their texture and taste. In order to do so, students need to understand some chemical facts and mechanisms behind the cooking. They also get to know some food additives that are needed to create these special effects which rises the more general question of what food additives are good for (in usual food) and in which way they effect the health of our food. The topic allows to tie the subject chemistry to everyday life experiences like food additives and at the same time experience special effects that stay in mind. The workshops can be used as a starting point for open schooling projects. We plan several projects with schools that have home economics / cooking as a subjects. The projects can for example be about the students making special drinks for their graduation ball or a class experimenting with different gelling mechanisms in the context of food for people with swallowing difficulties.



The Lighthouse Activities consisted of two parts. After a short introduction what molecular kitchen is, part A began by students making themselves by making themselves a cup of blue tea and adding first honey and lemon juice and then dry ice. While the students drank their tea, we discussed the role of blue tea as a pH indicator and the characteristics of frozen CO_2 (and CO_2 as a greenhouse gas).

Next, the topic of food additives was introduced. Students studied the ingredients of several products and we discussed questions like “What roles do additives play in our food?”, “Why are food additives sometimes written as a word and sometimes as an E number?” and “Are food additives unhealthy?”. We discussed three additives in greater detail: First Glutamate, which many people think is harmful but actually turned out to be not problematic, and is specially interesting



because it comes in many different names (yeast extract,...) and because we have a receptor on our tongues just to detect this single molecule. We also discussed riboflavin (also known as vitamin B2) and alginate since they played an important role in part B.



Part B was about spherization – making small spheres filled with liquid, that you can put into drinks. Most students know this from popping boba in bubble tea. The students made spheres filled with non-alcoholic blue curacao and put them into tonic. We showed that tonic fluoresces blue under UV



light, an effect some students know from clubs. We also showed that vitamin B2 fluoresces yellow under UV light.

2. Description of the implementation process of the lighthouse activities:

We tested the workshop in February 2024 with two 8th classes in comprehensive school that is one of our partner schools. The workshop was led by two employees of ICSE. The chemistry teacher was also present. The workshop was carried out in a classroom and lasted 90 minutes. In the first class we divided the class into two halves, who did part A and part B of the workshop separately and then swapped. The second class was smaller and therefore stayed as one group.

3. The knowledge, skills, and attitudes developed by the learners.

Students ...

- ... become more informed consumers regarding food additives: They get a feeling of how food additives are used in general (sometimes needed and completely unproblematic, sometimes not good in big amounts, sometimes used to cover low quality of the food). They have also heard about some specific food additives that are often under discussion.
- ... see that science can be used to create fun things.
- ... notice that science is all around them, let it be in the supermarket, in the kitchen or in the club.

4. The difficulties experienced by the learners and the strategies developed to overcome these difficulties.

Making the spheres was a bit chaotic. Here it is important to give very clear instructions and separate phases of experimentation and instructions so that everyone knows what to do.

5. The key success factors of the lighthouse activities.

The astonishing effects like the color change, the optics of the dry ice in the tea and the glowing drinks created an excited atmosphere and made students wonder how these things work.

6. Our perspectives on the relevance of the lighthouse activities.

We hope that the workshop has a positive effect on students' attitude towards science and has opened a door to thinking about what we eat in a new and deeper way.

7. Overall assessment: final reflective remarks.

We are very satisfied with the covered topics and experiments of the workshop. As we implement it more often, we will try to optimize some details to make it a bit less chaotic. 90 minutes was a bit short for everything we covered, so we will try to adapt the time when possible.

ALU, Germany

**Lesson in the forest
“Climate impact of forests”**

1. Description of the activities carried out (their learning objectives, the topics included, their main characteristics, and the possibilities of interdisciplinary integration).

Climate change is one of the most pressing political and social challenges of our time and it is generally known, that the forest has an important role to play in this context.



This workshop allows students to approach the issue from a practical and active perspective. Moreover, the workshop should motivate them to find solutions and act - in the spirit of Education for Sustainable Development.

Students get to know to the general functions of forests, measure height and diameter of a tree with professional devices, calculate the wood volume and the carbon storage of the measured tree.

To get in touch with the relations, at the end they can calculate how far you can drive by an average car to blow out this amount of carbon. Through this the pupils get to know the importance of the forest for different areas of human life and the environment, they get in touch with the forestall measuring devices and they especially learn about the importance of forests as a carbon storage or carbon sink.

The workshops can be used as a starting point for open schooling projects concerning sustainability and the carbon circle.

The Lighthouse Activity consisted of three parts. Part A was a discussion about the importance of forests. We discussed the different functions forests can fill out at the one hand linked with the nature and the ecosystem (habitat for plants and animals, production of oxygen, storage and filtration of water, storage of carbon) or on the other hand directly linked to human life (improvement of air quality, wood production, protection against noise/avalanches/soil removal, recreational area, balancing the microclimate). Some of these functions are surprising for laymen for example protection against noise.



Part B was the measuring time. After a short introduction in the devices pupils did measure height and diameter of selected trees in little groups. Therefore, they used a tape for diameter and the "Vertex" for height. This is an electrical measuring device which can determine distances and angles. With the help of mathematical laws in right-angled triangles

the device calculates the tree height out of the angle and the distance between measuring point and tree. The aim of these measurements was to calculate the volume of the tree.

Part C was the calculation part, where the pupils worked with their measurements. With given formulas they were able to calculate the wood volume of their tree. Using wood density and values for carbon content per m^3 wood it was possible to find out the carbon content of their measured tree. To get an idea of the size of this carbon amount, we finally calculated the distance you can drive by a average car burning petrol.

Within this project we touch on different subjects such as Biology, Earth Science, Environmental Science, Chemistry, Physics, Mathematics and so we show the interdisciplinary nature of everyday problems.

2. Description of the implementation process of the lighthouse activities:

The implementation phase of the project involved preparing project advertisements and sending them to schools at the beginning of the school year. After receiving positive feedback from the school, the next step was to correspond by e-mail with the teacher, who is interested in the project. We started the implementation of our “lessons in forest” lighthouse activity with a biology course (10th grade) of a bilingual school in December 2023. During the preparation meetings, topics such as project content, project duration, place and time were discussed. At this stage, we modified our concept of the project according to the wishes of the teacher. For example, the teaching language of the project was determined in English instead of German.

In advance of the LHA we developed two different excursion guides: one for the pupils to have all the formulas and necessary information for the measurements and calculations. One for the teacher to have more additional information for preparation for the workshop.

The workshop was carried out in the forest of the city of Freiburg and lasted 105 minutes. The teacher and the students traveled with public transport, so we had to orientate at the bus schedule. The introduction and discussion part we did in one big group. For the measuring and calculation part the group was divided in several smaller groups of 3 or 4 students.

3. The knowledge, skills, and attitudes developed by the learners.

The workshop helped students to:

- ... become more informed about the general functions of our forests
- ... see that physical and chemical laws like atomic weight and density can easily be used to calculate important things.
- ... get to know, that you have to use knowledge from different scientific subjects to get results to relevant questions.
- ... recognize how living or dying forests affect the climate change over their individual carbon content.

Over and beyond the workshop promotes the development of different skills like:

- Know how to mobilize knowledge: By asking basic questions in the introductory part of the project, we tried to change the students' previous knowledge. The students had a good basic knowledge of the topic (environment and forest). However, the information was scattered and inconsistent.
- Hypothesis generation: As the workshop looked at two different types of tree in terms of the amount of carbon they absorb and the amount of oxygen they release, the theory was tested as to which type of tree would be better to plant for future sustainability and environmental benefit.
- Solving the problem using technology appropriately: The car industry has made everyday life easier. On the other hand, modern technology can reduce the negative effects of using different fuels in cars. The workshop looked at how much CO₂ can be produced by burning one liter of petrol/one liter of diesel.

4. The difficulties experienced by the learners and the strategies developed to overcome these difficulties.

Time of the workshop in late December: As the workshop was held outdoors, the cold December weather was a bit of a distraction. From this point of view, it will be more motivating for the students to hold a workshop outdoors in seasons such as spring or summer.

Uncontrollable circumstances leading to the cancellation of the workshop: Part of the challenge of all outdoor activities is the weather. Regardless of the time of year, rain or storm may cause the workshop to be cancelled. The ideal situation is to find a place to hold a workshop that is close to the possibility of finding shelter or a covered area in case of rain or to have at least an alternative date.

Students with a variety of scientific backgrounds in the subject area: From the students' responses to the questions and their participation, it was clear that some students benefited from more up-to-date and accurate knowledge of the subject. It would make things easier for

the group work, when the students are prepared and made aware of the scientific topic of the workshop by the relevant teacher before the workshop. In this case the teachers should do this by using the scientific materials we provide before the workshop starts. If this preparation is not possible or not desired, we could use the better informed students as little experts within the group to help their colleagues.

5. The key success factors of the lighthouse activities.

The key to a successful workshop is to find a way of talking about a topic that awakens the interest of the the students. For this LHA for example the rather abstract topic of CO₂ and climate change becomes much more concrete when we make the link to an everyday action such as driving a car.

6. Our perspectives on the relevance of the lighthouse activities.

We hope that the interdisciplinary workshop on Sustainability has a positive effect on students' attitude towards science and has opened a door to thinking about the importance of forests in general and especially concerning the climate change.

7. Overall assessment: final reflective remarks.

We are very satisfied with the covered topics and experiments of the workshop. As we implement it more often, we will try to optimize some details to make some things a bit easier to understand. 105 minutes was a bit short for everything we covered, so we will try to adapt the time when possible.



**Country Report
Portugal**

Activity #1

Olivaria: the olive tree

- Local: Pedagogical Farm of Olivais
- Topic: Green deal/ Environment
- Interdisciplinarity: Earth Sciences, Geography, Literature, Biology, History, Mathematics
- Participants/age: 12 (6 to 43 y.o.)
- Duration: 90 minutes
- Partners involved: Municipality of Lisbon, Pedagogical Farm of Olivais (CML-QPO)

Objectives of the activity:

The main objectives of this activity were to:

- Explore the importance of trees in terrestrial ecosystems.
- Understand the value of trees in society.
- Know about olive trees, a characteristic tree of Portugal.
- Know about products that come from olives, including pollutants by-products.
- Explore the local context.

Description of the activity:

This activity was carried out on a teaching farm located in the city of Lisbon, in a place called “Olivais” (the Portuguese word for olive grove), which gives this activity a strong connection with a local context. Being a pedagogical farm, open to the public, this activity was carried out by a group of families, during a weekend day, although it was very much aimed at the youngest members. The activity itinerary was largely based on exploring the olive trees on the farm where participants took an exploratory walk, paying special attention to these trees.

By learning about olive trees, students gain a deeper understanding of sustainable agriculture, olive oil production and biodiversity. This knowledge promotes the appreciation of the environment and encourages more sustainable practices, essential to face contemporary

environmental challenges. Furthermore, understanding the history and economic importance of olive trees in Portugal helps to strengthen the sense of national identity and appreciation for local products. As such, during the activity, several aspects were approached and discussed in an inquiry approach.

Considering the approach taken in the activity, it was possible to observe that several subjects can be covered in this activity (e.g., Earth Sciences, Geography, Literature, Biology, History, Mathematics) and, as such, it has an interdisciplinary character.

Description of the implementation process of the activity:

This activity was implemented in February 2024 with 12 participants (6 children and 6 parents), at QPO and was conducted by three monitors from that same farm (from CML) and had the support of two members of IE-ULisboa to collect data (observation and questionnaires). In total, the activity lasted around 90 minutes and was developed in two parts, in which participants played an active role in terms of discussing ideas and exploring the farm.

1st part (Introduction): The activity began in one of the farm's kitchens, where participants had displayed various products derived from olive trees (olives, olive oil, olive paste, olive pomace, etc.), about which were questioned. What would it be? What is your origin? What would they be for? The focus of the activity then moved to the olive trees: generally, the educational farm is visited because of the animals and, as such, this is an activity that also aims to make the visitors see the farm with different eyes. A moment of inquiry followed, in which some materials were provided to the participants (such as a short text and maps of the world and the farm), and participants were asked about where olive trees can be found, about the scientific name of the olive trees (and why to use a Latin



designation), about whether they have seen olive trees and where (link to the real context of the participants). The conclusion that was intended was that olive trees are a common species in Portugal and the Mediterranean and the reasons for this were also pointed out (climate, history, etc.).

2nd part (Exploration of the farm): the exploration of the farm began with an orientation exercise: participants would have to observe the map, orient themselves by the cardinal points to position it in the correct position and find the way to an area of the farm where they could find many olive trees. Next to the trees, several topics were discussed:



- why that area of Lisbon is called Olivais (the Portuguese word for olive grove)
- the historical (and literary) context of that area of Lisbon
- the tree species in the olive family (and what are the differences between them)
- the varieties of olives
- the machines used to harvest olives
- olive oil production (what type of olive oil, olive oil mills, products that derive from olive oil production)
- environmental issues, related to olive pomace, the biggest environmental pollutant in Portugal.
- what can you do with this product? (Fertilizer, energy production/combustion, composting, etc.)



In the final phase, the participants gathered near one of the olive trees and the constitution of a tree was discussed (branches, trunk, etc.) and how one can know the age of an olive tree was discussed (with measurements involving the perimeter of the tree and with the number of rings in a tree). Finally, participants were challenged to search, on the internet, for where the oldest olive tree in Portugal is located.

Knowledge, skills, and attitudes developed by the learners:

At the end of this activity, participants:

- developed scientific knowledge about olive trees in particular and trees in general
- mobilized prior knowledge, much of it related to their daily experiences.
- reflected on issues related to their local and national context
- Developed appropriate and positive attitudes
- became more informed about one of Portugal's main products

Difficulties experienced by the learners and the strategies developed to overcome these difficulties:

In general, this activity was not difficult. Still, due to the fact that it was a very heterogeneous group, with children of different ages and their respective family members, prior knowledge was very diverse. This is also why the concepts covered were not understood by everyone equally. Another difficulty was in getting parents to be more involved: in general, it was the children who participated most, even though they were guided by their respective family members.

In terms of strategies, there was often a need to adapt the language to younger people, so that they could understand, in a simple way, the topics covered.

Key Success Factors of the LHA:

From our perspective, there were several factors that contributed to the success of this LHA. Firstly, the place and environment where the activity took place: a very pleasant place, with animals, and a very relaxed outdoors atmosphere. Without a doubt, the team that led the activity greatly contributed to its success: there was often a need to adapt the language to the different participants and play a little with them. Additionally, the fact that families participated meant that, on many occasions, parents were the ones explaining things to the children and giving examples. Furthermore, the topic covered is relevant to the participants: in addition to being a topic closely linked to the local context, it is, without a doubt, a topic linked to the daily lives of the Portuguese.

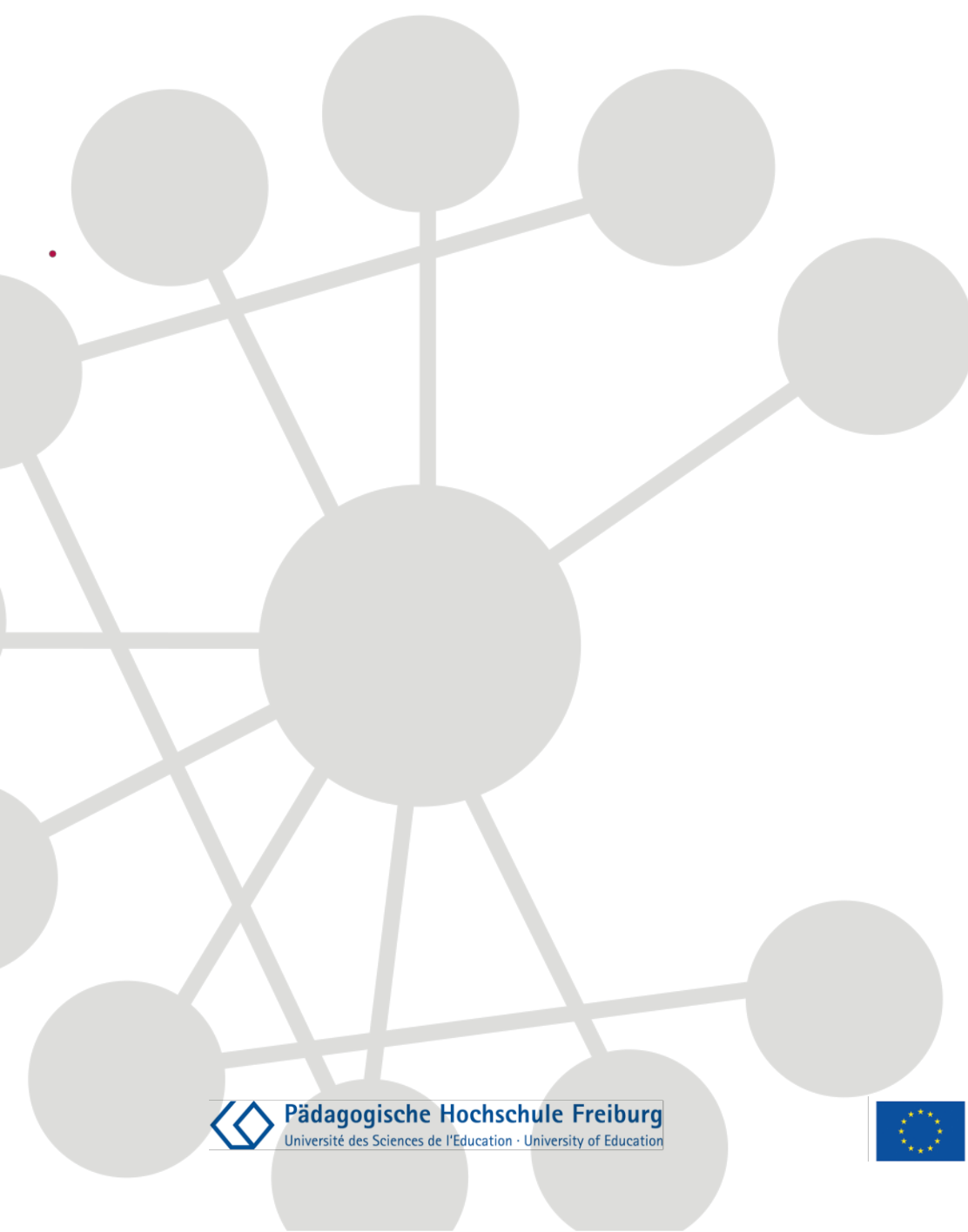
Our perspectives on the relevance of the LHA:

Our general perspective is that this LHA is relevant and suitable for the target audience, which in this case were families. The relevance is justified, in this case, by the local and national context since this activity allows participants to acquire knowledge about the origin and importance of olive trees, so present in the national territory. Likewise, it is an activity that promotes knowledge about the processes and consequences (e.g., polluting products) associated with olive oil production, which in turn encourages reflection on the products we consume.

Overall assessment: final reflective remarks.

The implemented activity has diverse potential. It is a pleasant activity, which can easily be adapted to different audiences as its theme relates to different aspects and areas/disciplines, and therefore has an interdisciplinary character. One of the factors that contributed to the success of the activity was the informal and very friendly environment that was created, as a

result of the vast experience of the QPO (CML) organizers. The perception was that the participants liked it. Although it is well designed, we think it could still be improved through, for example, more targeted challenges that would encourage participants to explore these trees more independently.



Activity #2

Sound for the Future: Acoustic Comfort in School

- Local: Middle school in the Lisbon region
- Topic: Health and Digitalization
- Interdisciplinarity: Science, Technology, Engineering and Mathematics
- Participants/age: 10 students (10-12 y.o.)
- Duration: 75 minutes
- Partners involved: Institute of Education, University of Lisbon (IE-ULisboa)

Objectives of the activity:

This activity aims to:

- Know about sound health and the impact of sound in the school environment.
- Understand scientific concepts about sound, such as sound waves, frequency, amplitude and propagation of sound.
- Explore how noise emissions affect hearing health and acoustic comfort.
- Use technologies such as micro:bits and sound sensors to measure noise levels in different areas of the school.
- Create prototypes of solutions to improve acoustic comfort.
- Research, plan and implement strategies for specific problems related to hearing health.
- Observe and analyze data collected by the sound sensor to understand the relationships between the variables involved.
- Develop technological and digital literacy, as well as computational thinking and problem-solving skills.
- Use micro:bits as a programming platform
- Learn about the components of the micro:bit and how they can interact with the physical world.
- Develop technological skills, such as understanding sensors and the ability to design solutions.

- Design and build solutions using the micro:bit and sound sensor, and iterate to adjust and improve the design.
- Interpret graphs and visualize data to identify patterns and trends.
- Relate sound variables such as frequency, amplitude and others, and express them mathematically.

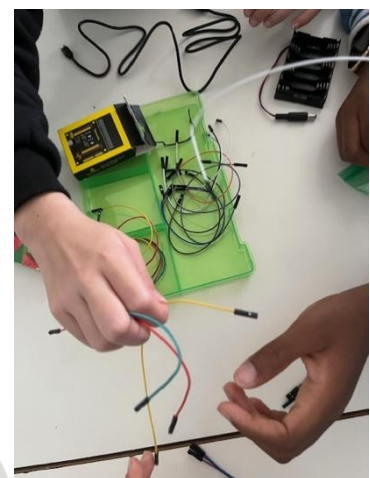
Description of the activity:

The activity was implemented as a school workshop in March 2024, during which the school organized multiple workshops. We were invited by the Parents Association to partake in one of these workshops. It was a day filled with engaging educational activities, and our workshop contributed to the enriching experience offered to the students. This collaborative effort between the school, parents, and external contributors underscores the importance of community involvement in fostering holistic learning opportunities for students. 10 students participated on the activity 9 girls and 1 boy from 10-12 years (5th to 7th grade).

The activities were conducted in various locations within the school, including classrooms and common areas, allowing for dynamic engagement and interaction among participants. The duration of each session was approximately 1 hour and 15 minutes, providing ample time for meaningful exploration and learning experiences.

The learners engaged in hands-on exploration, data collection, and analysis, fostering a deeper understanding of the concepts discussed. Additionally, learners collaborated with peers, shared insights.

The activities were implemented through a combination of structured guidance and open-ended exploration. Learners were introduced to key concepts and tools, followed by practical



application and experimentation. Facilitators provided support and guidance as needed, encouraging autonomy and self-directed learning.

Knowledge, skills, and attitudes developed by the learners:

Learners developed understanding of scientific principles related to sound and health, along with basic skills utilizing technology tools such as micro:bits and sound sensors.

Difficulties experienced by the learners and the strategies developed to overcome these difficulties:

Learners encountered challenges troubleshooting technical issues. To address these difficulties, facilitators provided additional guidance.

Key Success Factors of the LHA:

Key success factors included the hands-on nature of the activities, which facilitated active engagement and deep learning. The integration of technology tools provided a novel and engaging learning experience. Additionally, the support and guidance provided by facilitators and the involvement of the school community contributed to the overall success of the activities.

Our perspectives on the relevance of the LHA:

We believe that the lighthouse activity was relevant in fostering interdisciplinary learning and preparing learners for future challenges in a technology-driven world. By integrating science, technology, engineering, and mathematics (STEM) concepts in a real-world context, the activity empowered learners to become critical thinkers, innovators, and problem-solvers.

Overall assessment: final reflective remarks.

Reflecting on the workshop, it's clear that it was a success, reaching beyond our goals. Students engaged actively with technology, gaining hands-on experience in understanding the impact of sound on health within their school. The use of micro:bits and sound sensors not only introduced them to programming but also to tangible problem-solving as they developed solutions to improve their environment.

Despite the challenges, such as troubleshooting technical issues, the support provided by facilitators allowed students to overcome obstacles, enhancing their critical thinking and resilience. The active, hands-on learning approach proved to be a key success factor, facilitating deep engagement and a memorable educational experience.

The activities resonated particularly well with our diverse group of learners, fostering a collaborative and inclusive space for innovation. This approach to interdisciplinary learning, blending STEM concepts with practical application, is vital in preparing students for a technologically advanced world.

Activity #3

Invisible World: Discovering air quality

- Local: Middle school in a central region of the country
- Topic: Green deal/ Environment
- Interdisciplinarity: Science and Mathematics
- Participants/age: 22 students (9-10 y.o.)
- Duration: 90 minutes
- Partners involved: Institute of Education, University of Lisbon (IE-ULisboa)

Objectives of the activity:

The main objectives of this activity were:

- Identify the properties of air and some of its constituents
- Name the main gases that make up air
- Produce oxygen and carbon dioxide and know how to identify them
- Learn about anthropogenic activities that contribute to air pollution
- Carry out experiments, observe, collect data and draw conclusions.
- Apply critical thinking and problem solving when facing challenges during the activity.

Description of the activity:

This LHA took the form of a workshop and was implemented in a school in the central region of the country in January 2024, during a science week. Twenty-two 3rd grade students took part in the activity, 12 girls and 10 boys. The activity lasted 90 minutes and revolved around a problem centered on air quality.

The LHA followed an inquiry-based learning approach and began with the students exploring the main constituents of air gases. They were then asked to carry out an investigation in which they had to identify the necessary materials and develop a procedure that allow them to



produce two of the gases that make up air - oxygen and carbon dioxide. The students then carried out the activity they had planned and drew conclusions. Finally, they had to identify - using the flame test - the two gases they had produced. The activity ended with a discussion with the group of students about anthropogenic



activities that contribute to air pollution. Facilitators provided support and guidance as needed, encouraging autonomy and self-directed learning.

Knowledge, skills, and attitudes developed by the learners:

Learners developed their knowledge of the properties of air and some of its constituents; the production and identification of two of the gases that make up air - oxygen and dioxide; and the main anthropogenic activities that contribute to air pollution. They also developed skills related to planning and conducting experiments, making observations, collecting data, and drawing conclusions. The LHA also allowed them to solve a problem, make decisions, and work in groups.

Difficulties experienced by the learners and the strategies developed to overcome these difficulties:

Learners had difficulty planning the experiment and drawing conclusions. Oral feedback from the facilitators was important.

Key Success Factors of the LHA:

Key success factors included the implementation of an experimental activity based on an inquiry-based learning approach, which facilitated active engagement and deep learning.

Another important factor was group work. In this workshop, students worked in groups of 4, which allowed for discussion and negotiation of ideas.

Our perspectives on the relevance of the LHA:

This LHA allowed the students to explore, among other things, the components of air and the main anthropogenic activities that contribute to air pollution. This exploration was fundamental for the students to begin to develop their critical attitude towards the role of humans in air pollution. It is hoped that the LHA has made students aware of a global problem and how everyone can contribute to reducing it.

Overall assessment: final reflective remarks.

The LHA was a success and the feedback from the learners was very positive. The LHA helped motivate the learners to learn science and also allowed them to develop various skills. The learners' engagement and enjoyment of the LHA was evident throughout the workshop.

The level of challenge of the LHA associated with IBL was appropriate for the age group of the learners and despite the difficulties in the planning phase, the learners showed learning in terms of developing skills associated with scientific processes. The development of the experiment, when learners produced oxygen and carbon dioxide, was one of the aspects most appreciated by them.

Another very important aspect in the development of the LHA was the possibility for learners to work in groups. The difficulties they experienced were often overcome through group discussion and negotiation of ideas. The oral feedback given by the facilitators was also seen by the learners as a positive aspect that allowed them to develop their learning.



Country Report
Turkey

Air Quality Measurement with Artificial Intelligence Assisted Coding

TOPIC: Digitalization

1. Description of the activities carried out (their learning objectives, the topics included, their main characteristics, and the possibilities of interdisciplinary integration)

Coding with AI is a lighthouse activity that allows participants to make some measurements using an electronic circuit board, circuit elements, sensors and software. The aim of this activity is for the participants to go through the most basic stage of digitalization and experience the process and try to understand the natural world using science and technology. Although the event is basically a digitalization themed event, it is indirectly related to the themes of sustainability and health as it measures the air quality index through the developed system. In the process of the event, the participants are in the role of both understanding the development and working logic of sensors, industry 4.0 technologies, working as an IT specialist developing a technology, a software developer coding using artificial intelligence, as well as data-based scientific research like a scientist. As such, it is interdisciplinary and engages the disciplines of environment, technology, software, and ecology. As a result of the activity process, the participants are expected to understand the contributions of artificial intelligence to the coding process, to have an idea about how the connections are made on the electronic circuit board and to learn the indicators of air quality. However, depending on the participants' past experiences (coding, using Arduino board and software, etc.), possible learning objectives can be revised at the end of the activity.

2. Description of the implementation process of the lighthouse activities:

a. Context in which it was implemented - information about the participants and partners' collaboration/involvement.

This activity was implemented as a family and children's workshop in a computer lab. The participating children were middle school students between the ages of 12-14. Some of these

students had previous experience with Arduino and coding, while others had no experience in this field. The activity was conducted by a practitioner who had worked with software and electronic circuit boards before. In this workshop, which was conducted as a group work, 2 people assisted the workshop leader teacher and helped the groups when they needed support.

b. Location where the activities were implemented and duration.

The activity was carried out in a school computer lab. This is because a table is required for the assembly of electrical circuit boards with connected elements, and an internet connection is required for the connection of the Arduino board to the computer and the use of artificial intelligence. The total duration of the activity is 120 minutes.

c. The different people involved (partners and their role and level of involvement).

This study was planned and conducted by the Hacettepe University team.

d. The role of the learners.

Learners are very active during this activity. Because they need to understand the circuit diagram given to them for the creation of the electronic circuit board, include the appropriate circuit elements in the system, replace the connection points in the coding created with artificial intelligence with the connection points on their own



Arduino cards. At the same time, they should search for the appropriate index range to measure the quality of the air and let the system decide according to the result on the LCD screen.

e. How they were implemented.

The activity of determining air quality by coding with artificial intelligence was presented to the participants in the introduction part.

The activity was started with pre-warm-up questions. These questions were

- What is quality air?
- How are air quality values measured in weather apps on cell phones (such as AccuWeather)?
- Have you controlled them through these apps before?

After the answers to these questions are obtained, the discussions will focus on what is needed to measure air quality and what is not. was brought to the issue of the issue. Then, the participants were given information about the Arduino card, sensors and circuit elements. In this activity, it was mentioned that they would develop a device to measure air quality using these tools and make a coding for the operation of this device, and the participants were given the visual (Figure 1) and materials given below.

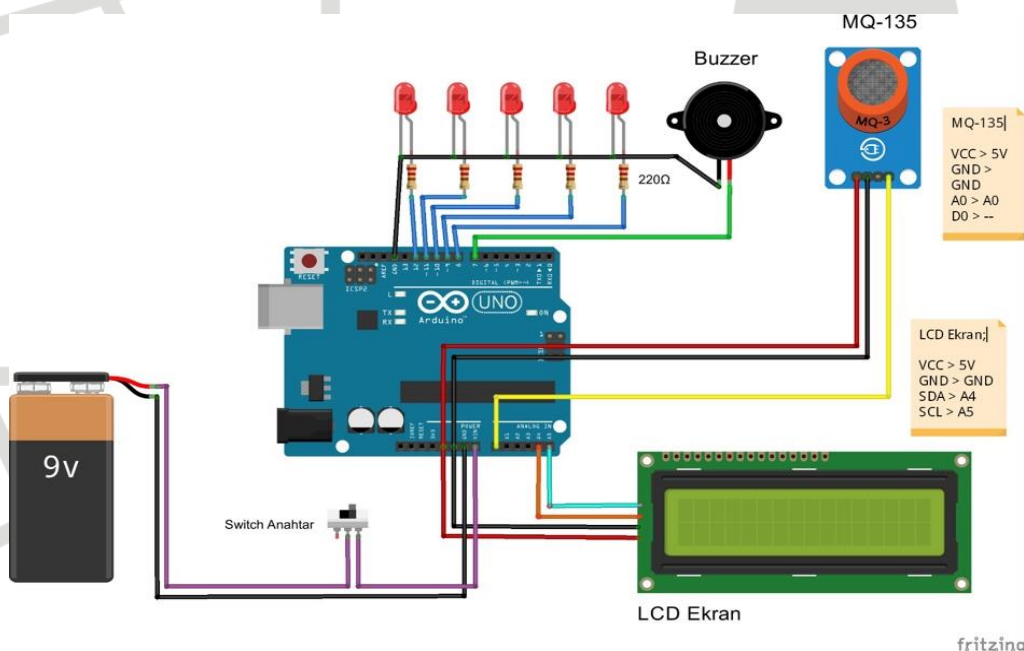


Figure 1. Open schematic drawing of air quality measurement circuit

Participants completed the circuit under the guidance of the workshop leader by making the connections given in Figure 1. Then the Arduino card was connected to the computer using the port connection. After this stage, coding should be done through the Arduino IDE program and the library should be created. However, in this activity phase, the library was presented to the participants by default. After the libraries were imported into the program, the participants were asked to create a code list using Microsoft Bing's Copilot artificial intelligence tool (other artificial intelligence interfaces can also be used). The proposed input to the AI is shown in Figure 2.

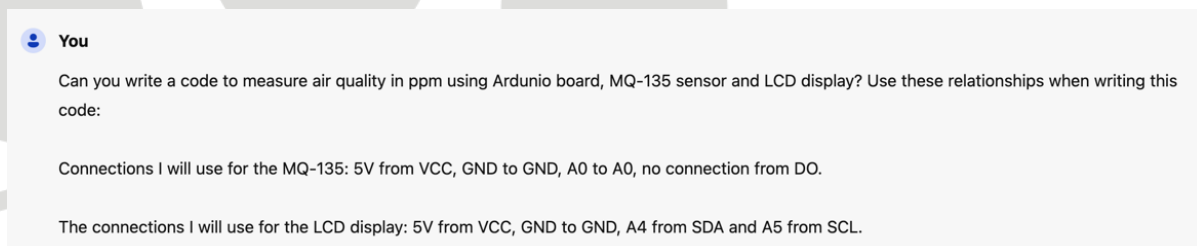
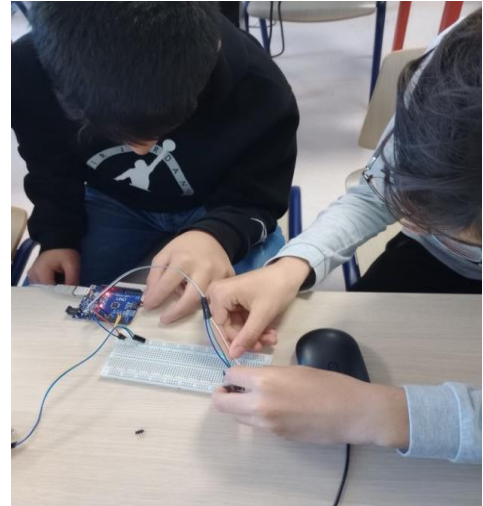



Figure 2. Input generated with Copilot AI

The Copilot AI interface is first described, and the requested connections summarized as shown in Figure 3. This should be checked and evaluated for compatibility with the connection in practice.

 **Copilot**

Certainly! Let's create an Arduino project to measure air quality using the MQ-135 gas sensor and display the results on an LCD display. I'll provide you with the necessary code and connections.

Components Needed:

1. Arduino Uno (or compatible board)
2. MQ-135 Gas Sensor
3. 16x2 LCD Display
4. Breadboard and jumper wires

Wiring Connections:

1. **MQ-135 Sensor:**
 - Connect **VCC** (5V) to **VCC** on the Arduino.
 - Connect **GND** to **GND** on the Arduino.
 - Connect **A0** to **A0** on the Arduino.
 - **DO** (Digital Output) is not used in this project.
2. **LCD Display:**
 - Connect **VCC** (5V) to **VCC** on the Arduino.
 - Connect **GND** to **GND** on the Arduino.
 - Connect **SDA (A4)** to **SDA** on the Arduino.
 - Connect **SCL (A5)** to **SCL** on the Arduino.

Figure 3. Connection summary and code infrastructure requested in Copilot AI interface.

The AI then generated a code list for the Arduino board, considering the connections in Figure 3. This generated code list is given in Figure 4.

Arduino Code for Air Pollution Monitoring:

```
#include <Wire.h>
#include <LiquidCrystal.h>

// Define the pins for the MQ-135 sensor
const int MQ135_PIN = A0;

// Initialize the LCD display
LiquidCrystal lcd(0, 1, 2, 3, 4, 5);

void setup() {
  // Set up the LCD display
  lcd.begin(16, 2);
  lcd.print("Air Quality (PPM)");

  // Preheat the MQ-135 sensor
  delay(20000); // Preheat duration (20 seconds)
}

void loop() {
  // Read analog value from MQ-135 sensor
  int sensorValue = analogRead(MQ135_PIN);

  // Convert analog value to PPM (parts per million)
  float ppm = map(sensorValue, 0, 1023, 0, 1000); // Assuming 0-1000 PPM range

  // Display the result on the LCD
  lcd.setCursor(0, 1);
  lcd.print("PPM: ");
  lcd.print(ppm);

  delay(1000); // Delay for readability (1 second)
}
```

Figure 4. Coding for connection of Arduino board, MO-135 sensor and LED display

The code list was exported to the circuit created through the Arduino IDE program and the created device (Figure 5) started to measure.

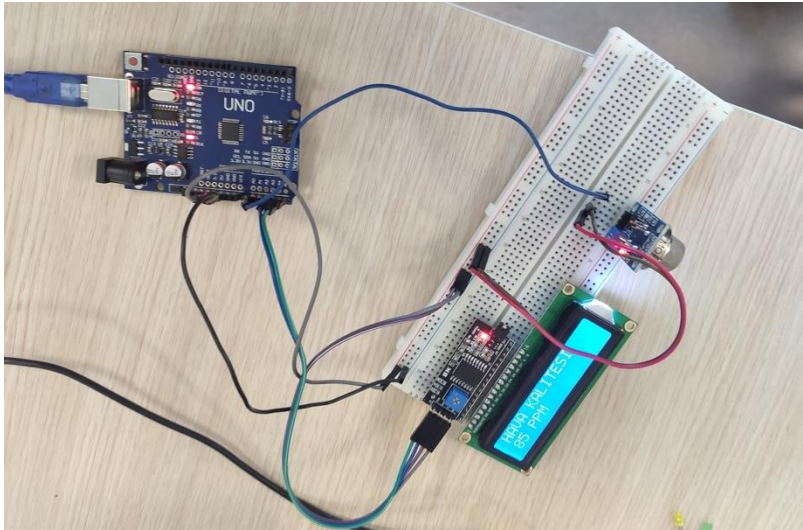


Figure 5. Air quality measurement device latest status

The measurements obtained because of the activity were compared. Some participants added a code to write the phrase "high air quality" or "low air quality" on a certain value instead of the ppm value and made the result appear on the screen.

3. The knowledge, skills, and attitudes developed by the learners.

During this activity, the participants gained experience by using knowledge and skills such as coding, recognizing, and creating circuit elements, creating requests suitable for artificial intelligence and collecting data through sensors. Considering the algorithm in the process of the activity, it is thought that scientists and inventors increase their interest in this field by experiencing the working principles of people who develop technology. The participants' experience of the whole process will also improve their skills such as technology literacy. They had the opportunity to turn their theoretical knowledge such as parallel and serial connection into practice. Especially the excitement of the children and their satisfaction at the end of the process are among the important affective characteristics observed.

4. The difficulties experienced by the learners and the strategies developed to overcome these difficulties.

There were some problems encountered during this activity. One of them was that the participants needed external support due to their lack of previous similar experience. For this, this problem was overcome with the help of auxiliary elements during the activity. It was observed that some of the students had problems in connecting the fittings used in the system as they required fine motor skills. Another problem was that not entering the correct commands at the stage of entering commands to artificial intelligence caused the generated code list to be incorrect. For example, although there was a connection between SDA and A4 in the circuit diagram we gave, if this was not given to the artificial intelligence, it was seen that it established a connection between SDA and A3. This situation prevented the system from working. In these cases, it was shared with the participants that the desired connection information should be entered into the artificial intelligence.

5. The key success factors of the lighthouse activities.

The key success factor of this activity is the variety of actions it includes and the fact that it attracted the interest of children. In the activity, Arduino circuit board, elements, sensors, coding with artificial intelligence, and as a result, the participants get a working device that they have designed and coded completely by themselves. While the participants are engaged in the fun side of science, they also learn a lot of scientific information. In addition to this information, skill acquisition is also provided.

6. Our perspectives on the relevance of the lighthouse activities.

This activity is very suitable for middle school and above. The effectiveness of the activity will increase even more if the participants are experienced. The activity in its implementation promotes collaborative work between participants.

7. Overall assessment: final reflective remarks.

The activity was very successful in terms of achieving the targeted goals. The participants continued and completed the event in a very satisfied manner. They experienced what digitalization means and what kind of process it has from the most basic level.

Escape Room for a Sustainable World

TOPIC: Environment/Green Deal

1. Description of the activities carried out (their learning objectives, the topics included, their main characteristics, and the possibilities of interdisciplinary integration)

The aim of this activity is for the participants to do the tasks given in the context of sustainability. While doing these tasks, they will both put some of their skills to work and increase their knowledge in this field. While bringing together disciplines such as environment, ecology, and biology, it also benefits from digitalization. Escape games are very popular activities and attract the attention of individuals of all ages. They are also used for many different purposes by changing their content. In this activity process, participants open the locks by solving the tasks in the locked eyes of the house model given to them. The questions in the locked eyes consist of 5 tasks created in the context of sustainability.



2. Description of the implementation process of the lighthouse activities:

a. Context in which it was implemented - information about the participants and partners' collaboration/involvement.

The activity was conducted as a workshop with families and children together. There were 5 model houses, and the activity was carried out with the participation of approximately 15 people, with at least 2 people (mother-child or father-child) at the head of each house. The participating students were between the ages of 11-13, studying at different grade levels at

the middle school level. The activity process was planned and implemented by the Hacettepe University team. However, the design and production of the escape houses was done by Dora Toy, who was part of our national convention team. Tasks inside the locked doors during the activity process:

🔍 Task-1: Mr. Nevzat, who bought a new car, wants to travel from Van to Ankara with his family. Nevzat's car burns 7 liters of gasoline per 100 kilometers. How many liters of gasoline will Nevzat Bey spend on the road from Van to Ankara with the least amount of fuel? (Note: You can use Google maps application)

🔍 Task-2: Imagine that the escape room house has the same design as your own house and is 1000 times smaller than your own house. If you were to insulate the exterior of your own house, how much insulation material would you need? (Note: One wall of insulation material measures 500 x 1000 mm).

🔍 Task-3: Examine the preparation given to you through the microscope. Identify what is in the preparation and use it as a password by calculating the total score in the code sequence given to you. (Note: You can use Google Lens to determine which organism is in the microscope image)

🔍 Task-4: Determine the pH and conductivity of the soils allocated for this activity and rank them from the most suitable to the least suitable for a plant growing in alkaline soils with low salt tolerance. Use the code resulting from this ranking as a password.

🔍 Task-5: Ayşe, who took a 1-hour flight from Istanbul to Ankara, traveled from the airport to her home using a diesel car, consuming 10 lt of fuel. During the day, Ayşe consumed 10 kwh of electricity and 5 m³ of natural gas for heating. Calculate the total CO₂ emission of Ayşe because of these actions by using the calculator <https://www.egorman.org.tr/hesaplayicilar/karbon-ayakizi/>. The last 3 digits of the value you obtain will be the combination of the lock.

b. Location where the activities were implemented and duration.

The activity took place in a school science laboratory. Since microscope, pH and conductivity sensor were used in the activity, the laboratory environment was used. However, it can be used in appropriate classrooms where these materials are available. The duration of the activity was 90 minutes. However, the duration varies according to the age group of the participants and their ability to manage in-group dynamics.

c. The different people involved (partners and their role and level of involvement).

The activity process was planned and implemented by the Hacettepe University team. The houses developed for the activity were designed and built by Dora Toy, a company that develops products for educational purposes. As such, it can be said that it was carried out with the support of a higher education representative (HU) and an entrepreneurial company.



d. The role of the learners.

This activity aims for participants to actively solve problems, use digital tools, and collect data. In Task-1, participants are expected to find the shortest way to travel the distance between the given cities with the least amount of fuel through the map application and make a mathematical calculation about it (The most ecological way suggested by Google Map is not taken into account here). In Task-2, participants will determine the dimensions of the escape house and calculate the amount of insulation material to be used. In Task-3, learners will first capture an image using a microscope to find out what the sample in the pre-prepared preparations is and then use their phone to find the name of the sample using Google Lens or similar photo-searching software

and decode it using the alphabetical code list provided. In Task 4, he/she will select the soil suitable for the plant with low salt tolerance and alkaline soil for planting. In Task 5, they will determine the total amount of CO₂ emissions by calculating the carbon footprint. For this they will use an online carbon footprint calculator.



e. How they were implemented.

Before this activity, escape room houses were prepared and placed on the laboratory tables to allow group work. The participants were given the first task clearly and were informed that they opened the key located at the top of the house. Then, the participants performed the tasks to open the locks according to the door color on the paper. Participants who successfully completed all the tasks completed the process by reaching the greeting message in the last lock room.

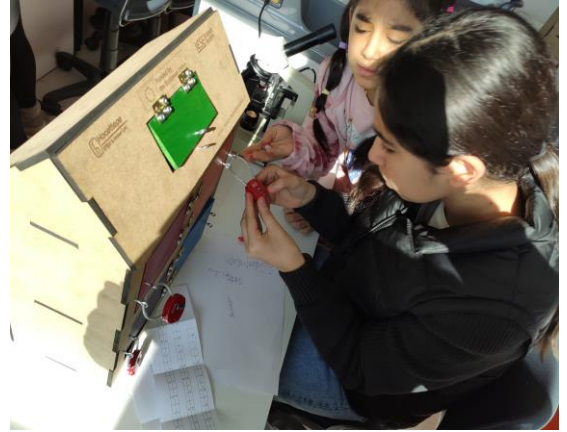
3. The knowledge, skills, and attitudes developed by the learners.

By using mathematical thinking skills, they gained the ability to calculate situations related to sustainability and to include scientific knowledge about these issues in this process. Teamwork is one of the important skills in the activity. It motivates participants to engage in science and to solve given problem situations. At the end of the activity, the participants requested to participate again for the other sessions of the workshop.

4. The difficulties experienced by the learners and the strategies developed to overcome these difficulties.

In general, the activity did not involve any difficulty. However, due to the nature of the activity, the participants were quite excited and impatient in solving the problems and trying to reach the result.

In some of the activity tasks, the younger participants had more difficulties. However, these difficulties were solved by the families who were team members. Families and children worked as a team during the activity.



5. The key success factors of the lighthouse activities.

The success factor of this activity or the aspect that sets it apart from other activities is that it has a gamified process.

It attracts participants of all ages. At the same time, it allows them to think about questions in the context of sustainability and gain knowledge about those issues. Adult participants could work as a team with their children and discover the entertaining side of science with them.

6. Our perspectives on the relevance of the lighthouse activities.

This activity can be done with participants from all age groups and can be used for all areas such as sustainability, digitalization and health by changing the tasks in the key rooms. It includes all the objectives of Lighthouse activities.

7. Overall assessment: final reflective remarks.

Overall, it was a successful lighthouse event. The motivation of the girls was also very high during the activity. The activity intervention has a long-term impact on the participants. The effects last beyond the activity itself.

The Influence of Exercise on Heart Rate

TOPIC: HEALTH

1. Description of the activities carried out (their learning objectives, the topics included, their main characteristics, and the possibilities of interdisciplinary integration).

This activity is an inquiry-based research activity in which the effect of sports on heart rate is investigated. Participants carry out a research process to answer the research question given to them and share the data and results of this research process with other participants. The aim of the research is to answer the effect of variables such as age, regular sports practice (physical fitness) and rest time on heart rate through their studies. This activity can be used especially at primary and lower secondary school level and will guide participants of all age groups in society to make inferences based on data. Although the activity has a biology-based structure, it also includes digitalization in the process through the sensors and software used in it. In particular, the visualization of the data obtained, the ability to read and interpret graphics are also employed in the activity process. At the same time, the fact that there are participants of different age groups in the activity process includes high-level skills such as making comparisons and making predictions for new situations using existing information.



2. Description of the implementation process of the lighthouse activities:

a. Context in which it was implemented - information about the participants and partners' collaboration/involvement.

The activity was conducted in groups of 2 or 3 children and their families. Many of the children are primary school students. The event was carried out by Hacettepe University in collaboration with the STEM Center of Kafkas University. HU was involved in the planning and execution of the activity, while the STEM Center of Kafkas University was involved in finding the participants, arranging the venue, and providing the materials to be used in the activity.

b. Location where the activities were implemented and duration.

The activity was conducted in a STEM laboratory. The activity includes a sensor that measures heart rate from the finger and a data logger that transfers this measurement to the computer. Therefore, the STEM laboratory was used as a suitable environment. The duration of the activity was approximately 60 minutes.

c. The different people involved (partners and their role and level of involvement).

The participants included children, their families, STEM Center staff and the workshop leader. The workshop was led by the workshop leader and the families and children worked as a group. STEM Center staff provided support in the use of data collection tools and data loggers.

d. The role of the learners.

The role of the learners is to carry out the research-based activity by considering the steps in the worksheet given to them during the activity. They are investigating the effect of physical activity on heart rate. To do this;

- First, they measured your heart rate at rest
- They then measured your heart rate immediately after doing physical activity and observed what happened when you cooled down and returned to a resting state


e. How they were implemented.

In the introduction part of the activity, we used preparatory questions to prepare the participants for the process and attract their attention:

- Do you know how to measure your pulse?
- Have you ever thought about what makes your heart "beat"?

After these questions, the participants were told that they would investigate the effect of physical activity on heart rate. The participants were then given a worksheet (Figure 6) and asked to conduct their research.

The Influence of Exercise on Heart Rate



? What Are We Researching?

We will investigate the effect of physical activity on heart rate.

- First you will measure your resting heart rate.
- Next, you will measure your heart rate immediately after doing physical activity and observe what happens when you cool down and return to a resting state.

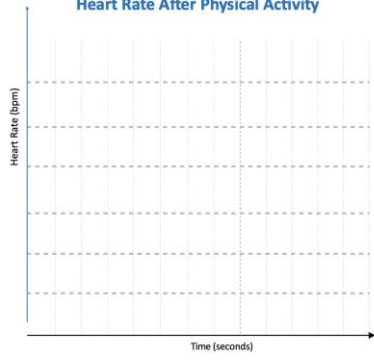
Age	Heart Rate (Pulses per Minute)
Newborn	100-170
Newborn - 2 years	80-130
2-6 years	70-120
6-10 years old	60-110
10-16 years old	60-100
An adult athlete	49-60

1. My resting heart rate is beats per minute (bpm).
2. My heart rate is in the range: typical for my age/for an adult athlete (circle one).
3. Try to explain why an athlete's resting heart rate is low.

⚙️ Before You Start

1. What do you think will happen to your heart rate after doing physical activity?
 - a) Will your heart rate increase, will your heart rate decrease, will it be unaffected?

Heart Rate After Physical Activity



i Compare the results of your research with your prediction of what will happen: My heart rate **increased/decreased/stayed the same** after physical activity.

Record your results in the table below. Use the graphs of the two measurements to help you:

- Tap the graph to bring up a cursor and use it to read your heart rate 5 seconds after the measurement starts. Heart Rate after 5 seconds: _____
- Slide the cursor along the graph and use it to read your heart rate 180 seconds after the measurement started. Heart Rate after 180 seconds: _____

Time	Heart Rate
At rest	_____
Immediately after physical activity (5 s)	_____
Some time after physical activity (180 s)	_____

Select the appropriate conclusions you can draw from your research:

- Physical activity has no effect on your heart rate.
- Physical activity lowers your heart rate.
- Physical activity increases your heart rate.
- When you are physically fit, your heart rate quickly returns to normal.
- When you are physically fit, your heart rate slowly returns to normal.

Figure 6. Worksheet for the activity

Exercise cards were developed for the physical activities to be performed during the research process. Among these exercise cards, one of the mixed cards (Figure 7) was selected and the activity was performed.

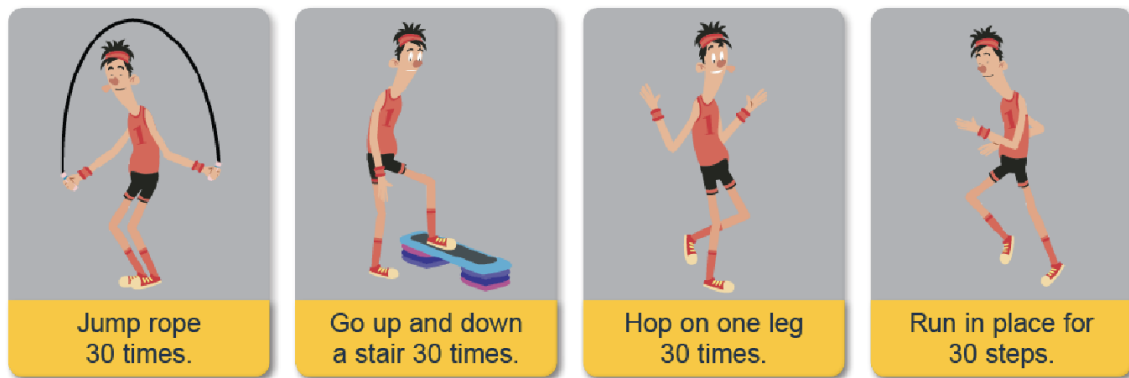
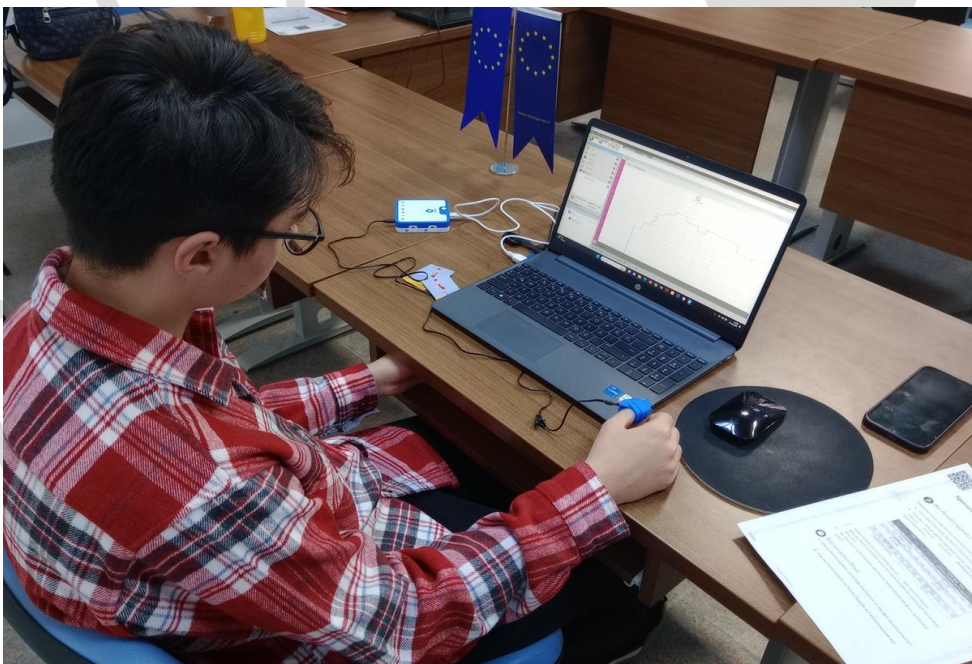


Figure 7. Exercise cards

At the end of the activity, data-based answers to the questions at the bottom of the worksheet were obtained and the participants' inferences were finalized.



3. The knowledge, skills, and attitudes developed by the learners.

During this activity, participants acquire scientific knowledge about the effect of being healthy on heart rate. At the same time, they gain problem solving skills by using appropriate measurement tools. Because during the activity, the participants make measurements with a heart rate sensor and visualize these measurements through computer software (Figure 8).

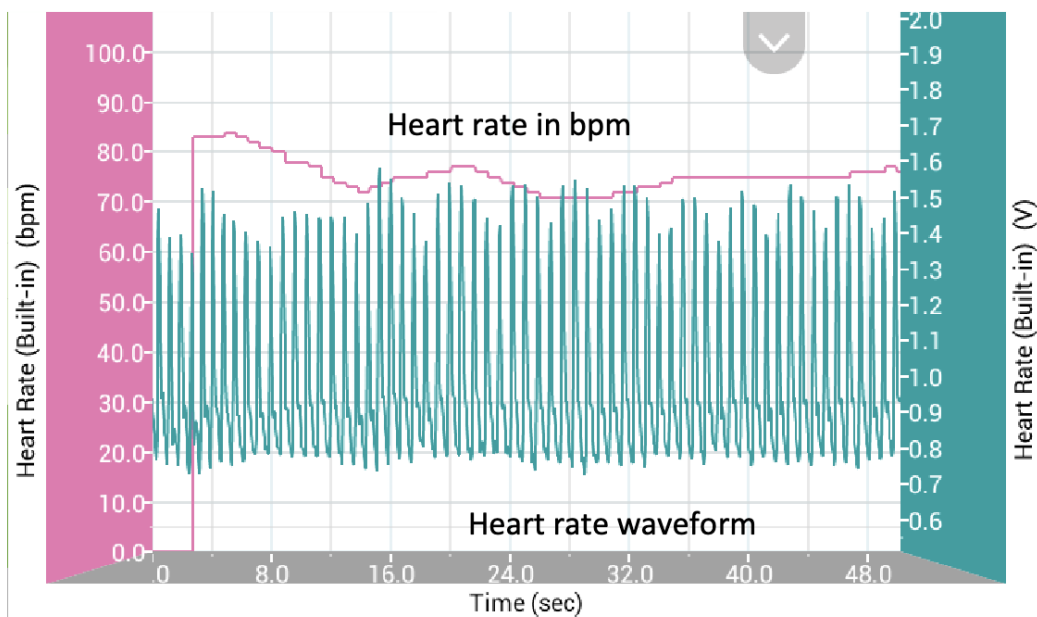


Figure 8. Sample measurement graph

4. The difficulties experienced by the learners and the strategies developed to overcome these difficulties.

During the activity, some problems were encountered in terms of coordination. For example, there were problems such as the sensor getting stuck right after the exercise, but the help of the families was useful in overcoming



these problems. Another problem was that in the graph drawing task, participant families played an important role in solving their children's problems.

5. The key success factors of the lighthouse activities.

The main achievement of this activity was that the young participants were involved in scientific research processes and collected data for the first time through sensors. At the same time, for adults, it is the ability to provide scientific data-based explanations for research questions that they already know or think they know the answer to. In this way, it will contribute to the development of individuals in society as science literate.

6. Our perspectives on the relevance of the lighthouse activities.

It is interesting because it involves the application of real-life problems. Although it has a simple content, it includes all the steps of the inquiry-based learning process. The activity in its implementation promotes collaborative work between participants.

7. Overall assessment: final reflective remarks.

This was a successful activity in which the benefits of being healthy and the benefits of being healthy in terms of heart health were learned using scientific data. When children see their parents jumping rope or jumping on one leg, it is an activity that entertains them and generally pleases the participants.

