D2.2

Best Practice Examples of Lighthouse Activities

International Centre for STEM Education

ICSE Science Factory

Pädagogische Hochschule Freiburg
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1. Executive Summary

This document reports on lighthouse activities (LHA) implemented across Croatia, Cyprus, Germany, Portugal, and Turkey within the ICSE Science Factory project. These activities brought together universities, schools, enterprises, and communities to address real problems in three topics: Green Deal/Environment, Health, and Digitalization. LHA were piloted, refined through design-based research (DBR), and implemented widely. Fifteen were selected as best practices and analyzed to identify success factors, challenges, and transferable strategies.

Overall, LHA implementation far exceeded targets, reaching over 5600 participants (more than half women) compared to the projected 1500, with 266 activities instead of the planned 135. LHA engaged diverse audiences from 6 to 60 years old, across different educational backgrounds, including students, families, teachers, and people with special needs.

The analysis of these activities revealed a consistent framework with three key components: Inputs (objectives, pedagogical approaches, themes), Implementation Processes (community collaboration, organization, citizens' participation), and Outputs (materials, networks, extension). This framework aims to represent the pedagogical concept of LHA.

Also, four success factors emerged: addressing real community problems with tangible results; using hands-on, flexible methodology; building strategic partnerships combining complementary expertise; and ensuring inclusion through intergenerational participation and accessible materials.

In relation to implementation challenges, results show that four main barriers appeared across contexts: scientific complexity of concepts, technological difficulties with equipment, participant heterogeneity, and multi-institutional coordination. However, effective strategies overcame these obstacles: using familiar analogies and visual demonstrations before theoretical explanations addressed scientific complexity; pre-configured templates and just-in-time support resolved technological issues; differentiated tasks and intergenerational learning turned diversity into strength; and clear protocols with regular meetings facilitated coordination.

These outcomes show that scientific excellence and accessibility can coexist. LHA ensured high-quality while using simple, affordable materials. University-level concepts reached primary students through appropriate pedagogical approaches. Success does not require special resources: what matters is collaboration, authentic problems, hands-on methods, and local adaptation.

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LHA that were most successful shared key characteristics: producing functional prototypes participants took home; connecting concepts to daily life; involving multiple partners; creating reusable materials.

Three elements contributed to sustainability: documentation through practical materials enable replication; networks create ongoing support; teacher capacity development ensure continuation without permanent external support.

The framework and recommendations provide actionable guidance for universities, schools, enterprises, authorities, and civil society organizations.

2. Introduction and context

2.1. Objectives of Work Package 2 - Lighthouse Activities and Open Schooling

Work Package 2 (WP2) on "Lighthouse activities and Open Schooling" serves as a keystone of the ICSE Science Factory project, addressing the first objective of providing collaborative science real-life learning opportunities for all citizens.

WP2 encompasses four primary objectives:

- To offer communities members real-problem solving opportunities, contributing to lifelong learning: This objective recognizes the need to engage citizens of all ages in meaningful scientific activities that demonstrate the practical applications of science in addressing real-world challenges.
- To run lighthouse activities: These activities represent collaborative, interdisciplinary workshops where local consortium members and enterprises work together on real-life problems for community members, thereby contributing to a lifelong learning continuum for all.
- To encourage schools to run open schooling activities: This involves supporting schools in implementing open schooling activities within their communities, supported by mentors and guidelines provided by project partners.
- To continuously optimize activities in the sense of design research: This ensures that all activities are refined through iterative cycles of design, piloting, evaluation, and optimization to maximize their effectiveness and quality.

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2.2. Lighthouse Activity Definition: The initial point

WP2 was implemented through a comprehensive educational framework based on European educational concepts underpinning the methodology, incorporating evidence-based pedagogical approaches such as:

- Inquiry-based learning (IBL) that invites participants to work similarly to how scientists and mathematicians approach problems;
- Real-life problem-solving that enables participants to see the relevance and implications of science in practical contexts;
- Socio-scientific issues (SSI) that involve ethical, moral, economic, and cultural dimensions requiring decision-making;
- Challenge-driven innovation (CDI) processes where enterprises and communities collaborate as equal partners to address open challenges.

The real-life challenges were selected from the following thematic areas: Environment/Green Deal, Health, and Digitalization.

Previously, within the scope of WP2 (T2.3), an initial definition of LHA was developed to be used within the project as a starting point. This definition was based on a systematic literature review conducted by the IE-ULISBOA team and described in the document “Lighthouse Activities.

In brief, this initial definition of LHA drew on several already established concepts, which are described below:

- Lighthouse Schools: The term “lighthouse” was already used in the educational context to describe schools that present exemplary science education programs through the involvement, collaboration and continuous professional development of teachers.
- UNFCCC Framework: The United Nations Framework Convention on Climate Change (UNFCCC) perspective defines lighthouse activities as innovative and transformative solutions offered by civil society and business partners that address climate-related economic, social and environmental challenges in a given geographic area (UNFCC, 2017).

Regarding the literature review previously carried out and described in the document “Lighthouse activities”, the analysis of the 25 selected studies revealed some of the key characteristics that should be present in LHA:

- **Interdisciplinarity** (present in 100% of studies). This element became fundamental in the definition of LHA, establishing that activities must integrate multiple areas of knowledge.

- **Students centered pedagogical strategies**. The literature review revealed the effectiveness of active pedagogical approaches in education, highlighting three main methodologies: design-based learning (present in 32% of the analyzed studies e.g., Bartholomew & Strimel, 2018; Dasgupta et al., 2019), inquiry-based learning (present in 24% of the studies, e.g., Chen et al., 2020; Eroğlu & Bektaş, 2023), and problem-based learning (present in 20% of the studies, e.g., Chen et al., 2019; Ng and Chan, 2019). These approaches promote a participatory learning and enable participants to develop competencies for understanding how scientific knowledge is constructed and how decisions on science-based controversial issues are made.
- **Authentic contexts** (present in 12% of the analyzed studies, e.g., Roberts et al., 2018; Kitchen et al., 2018). The importance of real-world contexts led to the requirement that LHAs address genuine community problems.
- **Collaborative work** (present in 25% of the analyzed studies, e.g., Chen et al., 2019). To reflect this finding, the project was designed to foster partnerships and collaborative engagement among participants.

The LHA initial definition was then refined to align with the specific objectives of the ICSE Science Factory project, i.e., to provide opportunities for collaborative science learning at the local level; to engage participants in real-life problem-solving situations; and to contribute to a lifelong learning continuum.

Also, the concept of Challenge-Driven Innovation was integrated into the LHA definition, referring to a strategy to promote innovation based on establishing well-defined goals focused on pressing community challenges that require the mobilization of partners to address them (Mazzucato, 2018).

The definition for LHA thus emerged as a synthesis of these elements. Specifically, LHA are defined as collaborative and interdisciplinary activities that bring together local community members and businesses to address real-life problems, thereby contributing to a lifelong learning continuum for all citizens.

The definition was subsequently validated and refined through a pilot phase involving 12 activities as documented in Deliverable D2.1 (see "D.2.1. First version of best practice examples of lighthouse activities"). Regarding their typology, LHA are designed as short-term events (60-120 minutes) targeting 10-15 participants from diverse age groups, addressing the three thematic areas previously mentioned: Green Deal/Environment, Health, and Digitalization.

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Subsequently, the initial concept was further refined and expanded during the implementation phase through a systematic analysis of the fifteen LHAs selected as best practice examples, resulting in a framework that aims to represent the pedagogical concept of LHA as a whole (see Section 4). Thus, LHA serves a dual function as both standalone educational interventions and inspirational models for subsequent open schooling initiatives.

2.3. Building on Pilot Experiences

This Deliverable D2.2. "Best practice examples of lighthouse activities" represents the final, optimized version of the lighthouse activities within WP2, building upon the foundation established by Deliverable D2.1, delivered in month 15.

The progression from the piloting phase to the implementation phase reflects the project's commitment to Design-Based Research (DBR) methodology (Scott et el., 2020), incorporating four iterative stages: Design, Test, Evaluate, and Reflect. During the pilot phase, initial insights were captured using a seven-dimension observation guide that evaluated both participant outcomes (conceptual knowledge, skills development, and difficulties experienced) and activity quality (relevance, consistency, practicality, and effectiveness). The piloting phase analysis yielded the following success factors, as documented in D2.1:

- Integration of practical, hands-on experiences
- Interdisciplinary approaches connecting multiple knowledge areas
- Adaptability and tailored instruction to diverse learning needs
- Active engagement promoting student autonomy
- Use of current and relatable contexts
- Collaborative learning environments
- Technology integration enhancing accessibility
- Reflective practices connecting learning to broader societal concerns

While D2.1 documented favorable practices from the piloting phase, this deliverable presents activities that have undergone full-scale validation through the process of implementation.

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3. Methodology

3.1. Timeline and Status Quo

The piloting phase of the LHA took place between months 9 and 14 of the project, following a DBR methodology with iterative cycles of design, testing, evaluation, and reflection. During this period, 19 LHA[1] were implemented across the five partner countries, addressing the three main topics: **Green Deal** (ten activities), **Health** (seven activities), and **Digitalization** (six activities). It should be noted that several activities addressed multiple themes simultaneously.

According to the LHA reports prepared by the various partners, the LHA lasted between 60 and 120 minutes and were conducted in diverse contexts, ranging from schools and laboratories to educational farms and outdoor environments. They involved partnerships between educational institutions, environmental organizations, and private sector collaborators, with an average of 10-15 participants per activity. Further details about this piloting phase can be found in Deliverable D2.1 ("First version of best practice examples of lighthouse activities").

Building on the piloting results, the implementation phase was then initiated, scaling up the LHA to achieve the project's target indicators of 135 LHA in total (27 per country) and reaching an estimated 1500 individuals of all ages across Europe.

As shown in the data reported by all partners and summarized in Table 1, these targets were widely exceeded, with 266 activities implemented and over 5500 participants, more than half of whom were female.

A more detailed presentation of the LHAs implemented by each country is provided in Annex A.

Table 1. Number of implemented LHA.

Country	Piloting Phase			Implementation Phase		
	N. º LHA	Total participants	Female participants	N. º LHA	Total participants	Female participants
Croatia	3	67	33	32	551	264
Cyprus	3	72	n.d.	26	542	304
Germany	7	117	62	127	2722	1364
Portugal	3	76	57	32	1014	663
Turkey	3	78	42	49	772	428
TOTAL	19	350	194	266	5601	3023

[1] D2.1 originally documented 12 LHA; however, seven additional activities were subsequently reported.

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For the presentation and definition of good practice examples, the three LHAs from each partner country that best exemplify these practices were selected from the implementation phase. This selection was made taking into account the reports prepared for each of the LHAs.

To systematically document the implementation and outcomes of the LHA, two complementary instruments were developed: an observation guide for data collection and a reporting template for presenting findings.

The **observation template** was developed as a data collection instrument focusing on both the participants and the activities themselves. This template, presented in Annex B, encompasses five key dimensions. Specifically, dimensions A (Conceptual knowledge), B (Skills and attitudes), and C (Experienced difficulties) are intended to collect data on the impact of the LHA on participants during the implementation of the LHA. Dimensions D (Relevance and Effectiveness), and E (Consistency and Practicality), aim to gather data on the assessment of the activity.

Based on the data collected through the observation guide, a reporting template was subsequently created to present findings in a systematic manner and illustrate best practices (Annex B). This reporting template includes several key sections: a description of the activity, a description of the implementation process, an account of the knowledge, skills, attitudes, and beliefs developed by learners, documentation of difficulties experienced along with strategies for overcoming them and key success factors, and an overall assessment with final reflective remarks.

Both documents are updated versions of previous ones and considered the feedback provided by the partners.

3.2. LHA Selection

Three LHA from each partner country were selected as exemplars of best practice through systematic analysis of individual activity reports. The selection criteria included:

- **Alignment with LHA definition**: Integration of active learning strategies (inquiry-based, design-based, and problem-based learning), demonstration of interdisciplinarity, and authentic engagement with real community problems.

- **Participant impact**: Evidence of scientific knowledge development, relevant skills acquisition, positive attitude changes toward science, and effective strategies to overcome learning barriers (observation template dimensions A, B, and C).
- **Activity quality**: Relevance and effectiveness in addressing problems, consistency between objectives, methodology and outcomes, and practicality for implementation and replication in different contexts (observation template dimensions D and E).
- **Thematic representation and diversity**: Balanced coverage of the three project topics (Green Deal/Environment, Health, and Digitalization), diversity of implementation contexts, and variety of partnerships across educational, environmental, and private sectors.
- **Transferability and replicability**: Adaptability to different contexts, clear documentation of processes and resources, and evidence of success factors that facilitate replication by other organizations.

Thus, the selected examples were intended to represent not merely isolated success cases, but replicable models that incorporate best practices.

To analyze these selected activities, an analytical framework was then developed based on three key elements: the observation template dimensions, the LHA definition, and the project objectives (See Section 5).

4. Best Practices Examples

4.1. Overview of the Selected LHA

Table 2 provides an overview of the LHA selected as best practice examples. These activities are very briefly described in the following subsections, with detailed reports for each activity available in Annex C.

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Table 2. Selected best practice examples of LHA, by country.

Country	Name of the LHA	Topic(s)	Duration	Total number of participants	Number of participating females	Age range of the participants	Partners involved	Foundational aspects (IBL, RLP, SSI, CDI)
Croatia	Soft Robotics – Building and Testing a Universal Soft Gripper	Sustainability, Digitalization	90 min	60	20	14-17	Faculty of Electrical Engineering and Computing (FER), local high school educators	IBL, RLP, SSI, CDI
	Human body and measuring	Health	60 min	12	7	14-15	Faculty of Science in Zagreb, Elementary School Petar Lorini from Dugi Otok	RLP
	ICSE Smart Plants - Smart and Sustainable Plant Growing - Light and Plants – Adaptation to Light Conditions and Sensor Use (Week1) - Adaptation to Light Conditions and Sensor Use (Week 2) - Temperature, Humidity, and pH in Plant Growth – Monitoring Environmental Conditions Using Sensors	Green Deal, Digitalization	90 x 3 min	16	12	11-14	Faculty of Electrical Engineering and Computing (FER), local primary school educators	IBL, RLP, SSI, CDI
Cyprus	Ballon Rocket Challenge	Green Deal	45 min	40	25	7-50	CPI	CDI
	3D Printing in Buoyancy and Flotation Teaching	Digitalization	60 min	6	3	35-60	STEAME Festival, CPI, UNIC	CDI
	Learn about antibiotic and medical waste	Green Deal, Health	30 min	40+	n.d.	7-50	Multipliers Project, CP. Foodlab, Unic Medical School	RLP, SSI
Germany	Dendroecology and tree ring study	Sustainability	120 min	26	16	10-11	Staudinger gesamtSchule	SSI
	Upcycling vehicles	Green Deal	180 min	20-30	10-15	8-15	SFZ Tuttlingen, MINT-Netzwerk Donau-Baar-Heuberg, Mechatronics engineers from Aesculap, pensioners who have worked as engineers	IBL, RLP
	Climate change	Green Deal, Digitalization, Health	180 min	20-30	10-15	8-10	SFZ Tuttlingen, MINT-Netzwerk Donau-Baar-Heuberg, Immanuel-Kant-Gymnasium Tuttlingen	IBL, RLP

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Portugal	Virtual Reality and Choices Behind the Screens - Digitalization in School Context	Digitalization	100 min	130	62	14-56	Agrupamento de Escolas Gil Vicente; IE-ULisboa	RLP, SSI
	Sustainability and Technology	Digitalization, Green Deal	100 min	21	11	8-9	E.S. Lumiar, IE-ULisboa	IBL
	Sustainable Development: Increasing the Energy Efficiency of Buildings	Digitalization, Green Deal	180 min	25	10	15-16	ISEL, IE-ULisboa, E.S. Forte da Casa	IBL
Turkey	Determination of Water Quality	Health, Green Deal	60 min	15	8	12-14	HU, Kars STEM Center, Kafkas University	IBL, RLP
	Hidden Power of Fruits	Health	60-90 min	25	16	6-45	HU, Kastamonu University, Kastamonu Technopolis	IBL, RLP
	Sun Tracking Panel: Smart System for Efficient Energy Production	Green Deal	60 min	12	5	11+	HU, Mekano Lab, Dora Toy	

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a) Croatia

- **LHA ICSE Smart Plants (Green Deal/Digitalization)**

This LHA consisted of four interconnected activities that were implemented as a three-week program. The program combined sustainable plant cultivation, light adaptation, and environmental parameter monitoring (temperature, humidity, pH) through sequential workshops combined with daily sensor monitoring.

The results indicated significant development in students' knowledge about plant biology and sustainable agricultural practices. Students demonstrated practical skills in sensor technologies and data interpretation, while exploring how environmental parameters can affect the growth of plants. The program facilitated interdisciplinary connections across biology, chemistry, physics, mathematics, and ICT, while also fostering positive attitudes toward sustainable technology and ethical reflections on experimentation with living organisms.

- **LHA "Human Body and Measuring" (Health)**

This LHA was a 60-minute session about investigating different forms of measurement using personal reference points. The methodology was interactive and had 4 sections: measuring body height, measuring heart rate, evaluating dependencies using graphs, and estimating absorption of medicine.

This LHA helped to promote students' creative thinking. Students were able to recognize linear dependencies between variables, and learn about correlation versus causation, and develop some of their data interpretation skills. The activity also promoted critical thinking and positive attitudes about life sciences, linking abstract ideas to practical applications in everyday life.

- **LHA "Soft Robotics - Building and Testing a Universal Soft Gripper" (Green Deal/Digitalization)**

The LHA "Soft Robotics" was implemented over 90 minutes in a secondary school and involved 45 minutes of interactive presentation and 45 minutes of laboratory practice. The emphasis was on creating an introduction to soft robotics through the production of sustainable robotic grippers with low-cost and easily accessible materials such as balloons, syringes, coffee, rice, and biodegradable 3D print components, based on principles of granular jamming and pneumatic control.

The LHA was very effective in developing knowledge about 'soft robotics' as well as manual competencies associated with mechanical assembly. Students realized how granular materials

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can be utilized to develop adaptive gripping systems. At a more fundamental level, the activity changed the way students viewed the accessibility of robotics by showing that viable systems can be assembled with everyday materials, thus instilling a sense of creativity, confidence, and appreciation for sustainability in engineering.

b) Cyprus

- **LHA "Learn about Antibiotic and Medical Waste" (Health/ Green Deal)**

Focused on medical waste management and antibiotic resistance, this LHA used an interactive board game format at the Mall of Cyprus. In 30-minute sessions, participants experienced a gamified experience, taking on fictional roles to explore different perspectives on pharmaceutical disposal.

The LHA was based on a modular structure with open participation, using scenario cards inspired by real problems and supported by biologists and chemists as scientific mentors. Results showed increased knowledge of antibiotic resistance and proper disposal practices, along with the development of critical thinking, communication skills, and more responsible attitudes toward the environment and science.

- **LHA "3D Printing in Buoyancy and Flotation Teaching" (Digitalization)**

This LHA was implemented at the Cyprus STEAME Festival and was focused on integrating 3D printing into physics teaching over a 60-minute session. The session combined theory about Archimedes' Principle with practice in 3D software and 3D printer, which allowed participants to create and test geometric models to investigate flotation.

Results demonstrated significant deepening of physics knowledge, as well as their digital skills in 3D design and a change in their orientation towards pedagogical technology. The activity particularly enhanced teachers' confidence to implement innovative student-centered practices in their teaching. The hands-on experience successfully integrated technology with fundamental scientific concepts, demonstrating how 3D printing can enhance physics education.

- **LHA Balloon Rocket Challenge (Green Deal)**

This LHA connected engineering principles with environmental sustainability through an intergenerational collaborative activity at the University of Nicosia campus. The approach was a balloon-powered rocket-building contest where participants would construct a rocket using simple materials (balloons, straws, tape, and clips) in a lessons-based competition leading to the final race. The focus was to learn through experimentation in both interdisciplinary and intergenerational teams while making the contest evident and enjoyable.

The LHA demonstrated Newton's third law, introduced fuel-free propulsion concepts and helped students and adults to work in collaboration. Results indicated that participants achieved an understanding of basic physics principles, developed problem-solving and design thinking skills, strengthened family bonds through co-learning experiences, and increased levels of awareness about sustainability and clean technologies. The alignment with the Green Deal theme, emphasizing fuel-free propulsion and sustainable design, added real-world relevance to the learning experience.

c) Germany

- **LHA "Dendroecology and Tree Ring Study" (Green Deal)**

The LHA "Dendroecology and Tree Ring Study" focused on dendrochronology as an environmental monitoring tool. This activity used trees as long-term bio-indicators to investigate and understand past environmental variables, including, but not limited to, temperatures, precipitation, insect outbreaks, fires, and climate change. Participants investigated tree growth by using specialized equipment, microscopes, increment borer, tree discs, thermal chamber, and studied their relation between tree growth and environmental factors.

The activity had both theoretical introductory sessions that complemented the hands-on and detailed look into tree growth, ring formation, and climate information. Participants determined mean ages for the trees, determined years of poor growth, and built conclusions as to what caused this growth, both anthropogenic and non-anthropogenic factors. This activity was able to develop analysis, comparison, inference, and interpretation skills, as well, demonstrate that data on past climate change can be arrived at using methods other than traditional meteorological observations.

- **LHA "Upcycling Vehicles" (Green Deal)**

This LHA was delivered in several primary schools through approximately 180-minute sessions. The program incorporated both theoretical and practical aspects of upcycling, recycling, and reuse through construction of a motorized vehicle. Students learned project management from idea to product, explored sustainability concepts, and studied PET bottle lifecycles and paper recycling. The practical component included building simple electrical

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circuits, followed by choosing between three construction projects: balloon rocket car, motorized car made from PET bottles, or paint rocket made with toilet paper rolls.

The outcomes showed a significant development in social, communication, knowledge of recycling and sustainability, understanding of electrical circuits, and methodological skills (tool use, documentation). The program was successfully able to combine geography, physics, and manual work into one interdisciplinary experience, and extended to engage students' families through take-home items promoting sustainability awareness.

- **LHA "Climate Change – Understanding and Acting" (Green Deal/ Digitalization/ Health)**

This LHA took place in 14 schools in the Tuttlingen area through sessions of about 180 minutes. The activity combined practical experimentation with climate change ideas, starting with brief input to evaluate the class levels. Students conducted experiments independently in groups of four, while they gradually finished their research manual when working on experiments about albedo, polar ice melting, ocean acidification, warming's contribution to sea level rise, and how different surface materials behave toward thermal radiation. The activity concluded with students independently presenting their experimental outcomes and having conversations to identify connections to impact children's living places and identify action options.

The outcomes included several dimensions of students' learning, including social and communication skills that developed through collaboration and presentations, increased knowledge about the topics of the LHA, and increased scientific skills including inquiry practices and critical data evaluation. Students understood Earth as a radiating planet and recognized warming effects and sea level rise impacts, with the activity generating community value through research manuals that created climate change information flow in families.

d) Portugal

- **LHA "Virtual Reality and Choices Behind the Screens - Digitalization in School Context" (Digitalization)**

This LHA focused on Virtual Reality (VR) applications in educational contexts and ethical considerations about digital choices at Escola Secundária Padre Alberto Neto. The LHA combined external expert presentations, interactive discussions, and data collection through questionnaires about digital well-being and VR perceptions in STEM learning.

Utilizing collaborative learning and critical reflection principles, participants took on specific roles as session hosts, managing registration and coordination. The main session included presentations on VR fundamentals, educational applications, and ethical considerations about accessibility, costs, and learning impact, followed by interactive discussions and questionnaires. The LHA successfully introduced educational innovation through cutting-edge technology awareness across the school community, promoting responsible digital citizenship while exposing participants to emerging technologies and their practical applications in educational environments.

- **LHA "Sustainable Development: Increasing the Energy Efficiency of Buildings" (Green Deal/ Digitalization)**

This LHA examined energy efficiency in buildings by measuring thermal conductivity of building construction materials at School of Forte da Casa. The students used Arduino-based data logging systems with thermocouples to characterize thermal properties of samples of building materials and then analyze the data for assessing energy efficiency and CO_2 reduction potential.

The LHA allowed participants to apply thermal capacity and heat conduction, and mass thermal conductivity, to a sustainability-related context. Participants configured the thermal measurement system, conducted outdoor experiments, recorded experimental data using the Arduino digital data-logging tools, and analyzed the information to assess the energy efficiency of various building construction materials. The LHA equipped students with practical knowledge and sustainability-related competencies, empowering them to contribute to local environmental initiatives and promoting greater awareness of their climate change impact through hands-on experimentation with practical relevance to global sustainability objectives.

- **LHA "Technology and Sustainability" (Green Deal/ Digitalization)**

This LHA focused on technology and sustainability through an environmental monitoring experience at School of Lumiar. The 90-minute experience began with an introduction of the concepts of sustainability, measurement units and instruments, and the role of technology in environmental protection, followed by practical experience with Micro:bit devices and environmental sensors to collect environmental data. During this time, students collaborated in small groups to design environmental monitoring devices, collect environmental parameters, program the Micro:bits and analyze the data they collected.

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Findings showed development of technological and digital skills, awareness of sustainability concepts, environmental impact, and programming competences. The LHA also illustrated a successful intersect of science (environmental effects), technology (programming and Micro:bit learning) and mathematics (data collection) into a cohesive interdisciplinary experience. By allowing students to experience innovative tools for learning, this activity fostered technological literacy and stimulated thinking about sustainability concepts in building better awareness of our ecological footprint. The LHA also encourages development of skills associated with 21st century learning including critical thinking, problem-solving, and collaboration.

e) Turkey

- **LHA "Determination of Water Quality" (Health/ Green Deal)**

The LHA aimed to assess water quality through scientific indicators at Kars STEM Center. Participants used pH, conductivity, and turbidity sensors to test the different water samples (spring, tap, contaminated, and artificially contaminated). The activity began with an introduction on water quality and its environmental and health impacts and continued with practical demonstration of sensor usage. Participants recorded systematic observations in structured tables, compared results between different samples, and discussed pollution sources and preventive actions.

The LHA promoted fundamental environmental science concepts through hands-on experience with scientific tools, developing observation, data collection, and interpretation skills. By focusing on real-life problems, the activity increased water pollution awareness, with students sharing knowledge with family members and contributing to broader community understanding of local water quality issues.

- **LHA "Hidden Power of Fruits" (Health)**

The focus of this LHA was the comparative determination of Vitamin C levels in different foods through simple chemical testing at Kastamonu Technopolis. Participants used iodine reactions to compare Vitamin C content in various food samples, including fruits, fruit juices, and supplements.

Starting with warm-up questions to stimulate curiosity about Vitamin C sources in daily nutrition, participants formulated hypotheses about whether fruits, juices, or supplements contain more Vitamin C. The hands-on test involved adding iodine drops to samples and observing color changes, where lighter color indicated higher Vitamin C content due to its reducing effect on iodine. Participants documented observations and established conclusions based on comparative results. The inquiry-based investigation encouraged experimentation and visual analysis while promoting fundamental knowledge about Vitamin C, its chemical properties, and health importance. The activity demonstrated how everyday science can be explored with minimal resources, increasing awareness about nutrition among participants and their families.

- **LHA "Sun Tracking Panel: Smart System for Efficient Energy Production" (Green Deal)**

This LHA focused on designing a mechanical solar tracking system inspired by sunflower behavior at a secondary school. Participants used two LDRs (light-dependent resistors), a simple microcontroller, and motor to create a system that moves solar panels toward the highest luminosity direction.

Grounded in biomimicry principles and inspired by sunflowers that follow the sun, the activity engaged students in tracking system design using simplified electronic configuration ideal for introducing basic electronics and automation concepts. LDRs were mounted on opposite sides of a solar panel-type surface, calibrated so the motor moved the panel toward the direction of greatest solar luminosity. The complete system was demonstrated in outdoor environments, including discussion about energy efficiency and natural design inspirations. The LHA introduced participants to sustainable energy concepts using simple and understandable tools, promoting technology integration with nature-inspired thinking and demonstrating how everyday energy problems can be addressed with creativity and low-cost solutions.

5. The Pedagogical Concept of LHA: A Framework

5.1. LHA Framework

While the initial LHA definition identified four foundational pedagogical aspects (IBL, RLP, SSI, CDI), the systematic analysis of the fifteen LHA selected as best practice examples revealed how these integrate into a coherent pedagogical concept. Through this analysis, three interconnected categories emerged (inputs, implementation processes and outputs), enabling the development of a framework that represents the pedagogical concept of LHA as a whole:

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a) Inputs

The first identified category concerns the elements that constitute the foundations and guidelines for LHA. In other words, it relates to the objectives and principles that guide and direct the implementation of this type of activity.

- **Objectives**

The analysis reveals that, regardless of the context, all LHA converged on a common objective: creating collaborative scientific learning opportunities, demonstrating the relevance of science to real-life challenges and contributing to a lifelong learning continuum.

- **Background**

This convergence is also manifested through a recurrent pedagogical foundation centered on inquiry-based learning, problem-based learning, and socio-scientific issues that emerge across all contexts. The strategies were adapted to different activities, evidenced through hands-on experimentation and technological monitoring in Croatia, gamification and active experimentation in Cyprus, iterative development and controlled experimentation in Germany, inquiry-based learning in Portugal, and accessible tools with visual methods in Turkey.

- **Topics**

Similarly, there is a thematic scope that is distributed evenly across the three priority topics of the project. In the domain of the green deal and sustainability, activities addressed, for example, smart agriculture, waste management, dendroecology, and biomimetic energy. The health theme was explored through body measurements, studies on antibiotics, climate impacts, nutrition, etc. Finally, digitalization was manifested with environmental sensors, 3D printing, measurement systems, virtual reality and Arduino tools, demonstrating how technology can be naturally integrated into scientific learning processes.

b) Implementation Processes

The second identified category concerns the elements that proved to be the constituents of the LHA implementation process.

- **Community Collaboration**

The analysis reveals that all implementations involved the development of similar collaborative structures, consisting of three elements with shared characteristics.

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Who:

- University members from the partner countries: FER Zagreb, UNIC, German universities, University of Lisbon, Hacettepe, etc.
- Teachers from all educational levels.
- Specialized partners such as technology companies, STEM centers, etc.
- Communities composed of students, families and groups with special needs.

Where:

- Formal environments: Classrooms, educational centers, universities, etc.
- Informal environments: Commercial spaces, festivals, outdoor environments, etc.
- Specialized environments: Isolated communities, special education centers, etc.

Why:

- Engagement in relevant social issues
- Scientific and technological literacy
- Social inclusion and democratization of access to science

- **Organization**

In terms of organization, the LHA reported as best practice examples presented the following organizational characteristics:

Duration:

- 30-60 minutes for general public engagement
- 45-90 minutes for thematic deepening
- 90-180 minutes for in-depth scientific work
- >180 minutes for more complex activities

Format:

- Monitoring using Technology
- Gamification and interactive challenges
- Scientific experimentation
- Collaborative physical construction
- Evidence-based discussion

Interdisciplinarity:

- Natural integration of biology, chemistry, physics, mathematics, ICT, engineering, creating curricular bridges adapted to national contexts.

- **Citizens' participation**

The participation of citizens was a very important element in the LHA implementation process, right from the very definition and objective of this type of activity. The following patterns were identified in the reported LHA.

Diverse audiences:

- Broad age ranges (6-60 years)
- Varied educational contexts (regular, special, vocational)
- Diverse socioeconomic levels
- Urban and isolated communities

Multidimensional outcomes:

- Technological skills: Sensors, programming, fabrication, scientific methodology
- Critical thinking: Hypothesis formulation, data analysis, scientific interpretation
- Environmental and social attitudes: Environmental responsibility, scientific interest, educational aspirations

c) Outputs

The third identified category concerns the tangible results and extensions that emerged from the LHA implementation.

- **Materials and Resources**

The analyzed LHA generated materials and resources that are transferable to other contexts. These include detailed technical manuals, mobile applications and practical robotic devices demonstrating advanced technological integration. Interactive games, educational 3D models and prototypes were produced, evidencing game-based and experiential learning strategies. Structured research manuals, take-home materials for family extension and family-friendly instructions were created to promote learning continuity. Additionally, practical protocols and accessible do-it-yourself instructions were developed, enabling activities to be reproduced with everyday materials and simple procedures, thereby ensuring both the accessibility and long-term sustainability of the activities across different contexts.

- **Networking**

It was also evident that partnerships emerged across all contexts, establishing lasting collaborative networks that extend beyond formal implementation periods. These encompass university-school collaborations, industry connections, teacher training networks fostering continuous professional development, and family and community engagement that broadens educational impact beyond traditional school boundaries.

The LHA revealed characteristics that facilitate their expansion and adaptation to other contexts. Ease of replication stands out as one of the main factors: these activities use cheap and readily available materials such as balloons, recycled bottles, or simple sensors, and methods that any teacher can adapt to their own school reality. Another important aspect is that local teachers naturally learn to implement the activities by participating in them. This learning-by-doing means they become capable of continuing them independently, without the need for constant external training or permanent support from university experts.

The developed resources (manuals, worksheets, step-by-step instructions) also proved to be transferable across very different contexts. An activity created in Croatia can be implemented in Portugal or Turkey with minor local adjustments, maintaining its educational effectiveness.

Finally, it is important to note that simplicity does not mean loss of quality. Despite being easy to implement and using accessible materials, these activities maintain scientific rigor.

Building on the categories that emerged from the analysis of the best practice examples of LHA, a framework for implementing LHAs in other contexts was developed and is described below (Figure 1). This framework aims to represent the pedagogical concept of LHA.

Thus, the pedagogical concept of LHA as a whole involves three main elements:

- **Inputs**, which constitute the initial guiding elements, i.e., the objectives and foundations that orient and direct implementation from the start and include:

i) Objectives, i.e., the educational vision that guides the activity;
ii) Pedagogical Background, which refers to the selected teaching strategies; and
iii) Topics, i.e., Green Deal/Environment, Health, and Digitalization

- **Implementation Processes**, consisting of the dynamics and interactions that occur during the implementation of LHA, i.e., how things happen and include:

  i) Community Collaboration, i.e., Who: The stakeholders who actively participate; Where: The physical and social contexts of implementation; Why: The motivations that sustain engagement;
  ii) Organization, i.e., Duration: How time is structured and adapted; Format: The pedagogical strategies and structures used; Interdisciplinarity: How different knowledge areas are integrated; and
  iii) Citizens' Participation, i.e., Who: The diversity of participants involved; Outcomes: The types of learning and competencies developed.

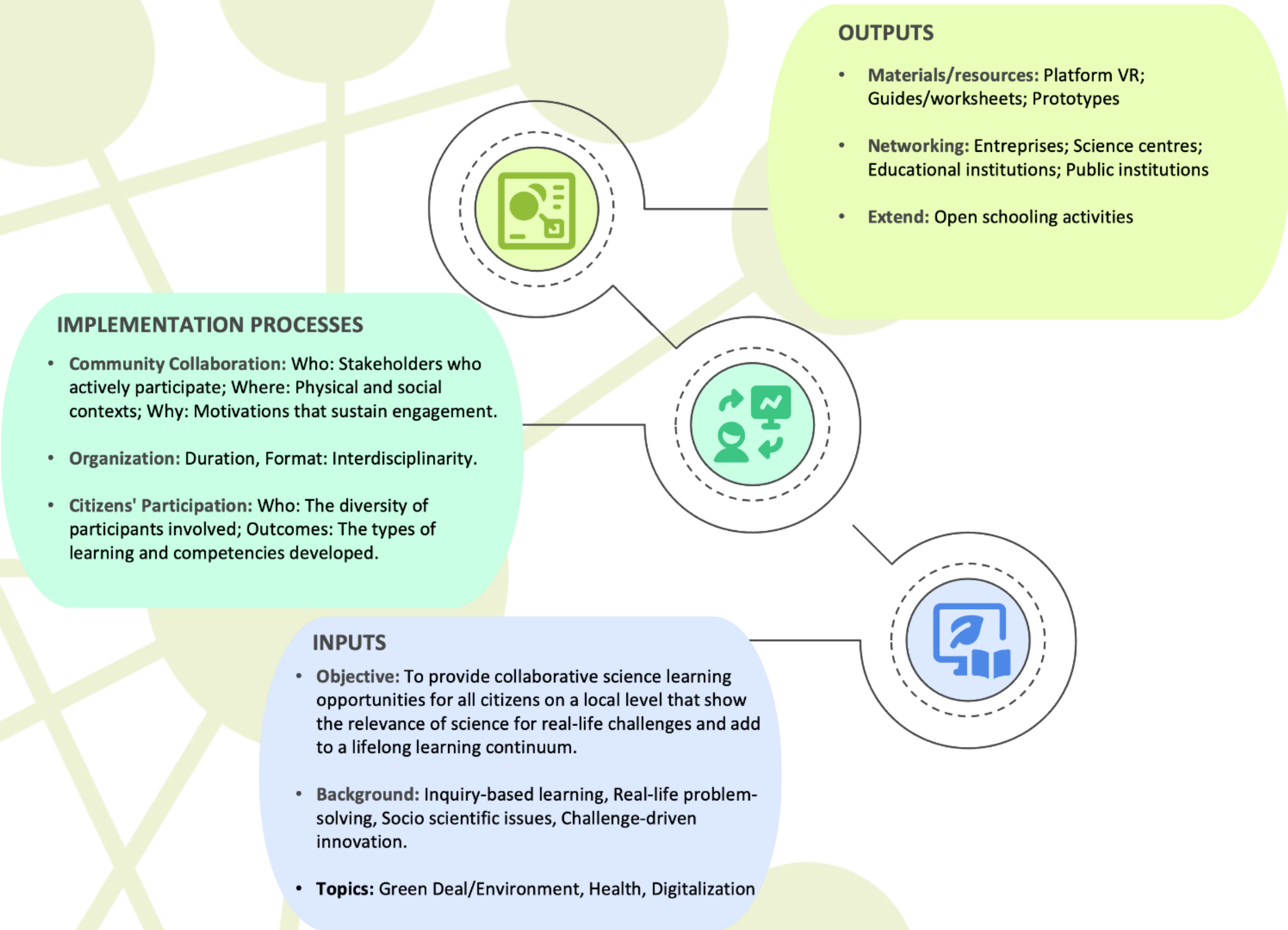

Figure 1. Framework for LHA implementation.

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- **Outputs**, which constitute the tangible results and extensions, i.e., the products, networks, and extensions that result from implementation and extend beyond it:

  i) Materials/Resources, i.e., concrete products that can be reused and transferred, such as manuals, applications, prototypes, etc.;
  ii) Institutional Networking, i.e., partnerships and collaborative networks that are established and persist; and
  iii) Extension to Open Schooling, i.e., capacity for replication and adaptation to other educational contexts.

5.2. Success Factors

Analysis of the fifteen LHA revealed four main factors that determined the success of the implementations.

a) Relevance and Authenticity of LHA

The LHA that demonstrated the greatest engagement were those that addressed real community problems, such as water quality research in Kars, Turkey, and energy efficiency analysis of buildings in Portugal. Another key factor in their success was the fact that participants produced results they took home with them, including functional prototypes like the robotic grippers developed in Croatia, plants monitored in the Smart Plants program, and research manuals created during German activities. The immediate application of the knowledge acquired proved crucial, as demonstrated in the activities on medical waste management in Cyprus and nutritional research in Turkey, where participants were able to directly apply what they learned to their daily lives.

b) Hands-on activities

Hands-on experimentation played a crucial role in achieving success, as seen in the creation of balloon-powered rockets in Cyprus, the electrochemical deposition techniques in Portugal, and the implementation of environmental sensors in Croatia and Turkey. Being adaptable over time was also key, whether it was quick 30-minute sessions focused on medical waste management or longer, multi-week initiatives like Smart Plants LHA. The emphasis on inclusive design allowed for meaningful participation at various levels, highlighted by the German dendroecology LHA, where 10- and 11-year-olds took part in real-world scientific research.

c) Strategic partnerships

Combining complementary expertise has proven crucial, as in the collaboration between FER Zagreb or University of Lisbon and local schools. By sharing resources, STEM equipment has been provided in Turkey and 3D-printing technology in Cyprus. German partnerships with SFZ Tuttlingen and local companies have created replicable models that have established lasting collaboration networks.

d) Inclusion and diversity

Intergenerational participation proved to be very beneficial, especially during the Balloon Rocket Challenge, which brought together families ranging from ages 7 to 50. The Turkish LHA also saw involvement from parents and educators. Materials were easy to access by using everyday items, like creating robotic grippers from household supplies (Croatia) or conducting vitamin C tests with simple resources (Turkey). The German activities showcased how we adapted for special needs, tailoring them for special education centers and participants who had limited proficiency in German.

5.3. Main Challenges and Overcoming Strategies

The analysis of the implemented LHA revealed several barriers to implementing this type of activity. Of these, four main categories stand out, which are described below.

a) Complexity of some scientific concepts

Scientific complexity represented one of the barriers to LHA implementation and was particularly evident in concepts such as climate science and thermal radiation (Germany) and soft robotics (Croatia), which initially intimidated participants. The solutions implemented included conceptual scaffolding through familiar analogies, such as comparing granular jamming to the behavior of compressed coffee, and the use of visual demonstrations before the theoretical presentation of concepts.

b) Technological challenges

Technological challenges constituted another barrier to LHA implementation, manifesting in difficulties with Arduino systems in Portugal, sensors in Turkey, and 3D design software in Cyprus. These limitations were overcome through pre-configured templates that reduced

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the technical burden, peer support that paired experienced participants with beginners, and just-in-time training that provided support at the exact moment of need.

c) Participant heterogeneity

Heterogeneity manifested not only in the participation of mixed-age groups but also in different educational backgrounds in intergenerational activities. This barrier was overcome through innovative strategies such as the Balloon Rocket Challenge, where children taught physics to parents through hands-on experimentation, and German activities where tasks were adjusted to match different skill levels.

d) Coordination across multiple institutions

The final barrier to highlight is multi-institutional coordination, which manifested in the difficulty of synchronizing universities, schools, and companies across all partner countries. Implemented solutions included establishing clear responsibility protocols, implementing regular coordination meetings, and developing flexible schedules with room for adaptation to emerging needs.

6. Recommendations and Guidelines

This section offers practical advice for implementing LHA based on what was learned from analyzing the best practice examples. The purpose is to translate the insights gained from analyzing the best practice examples into actionable guidance for practitioners and institutions interested in developing similar initiatives.

The recommendations are structured according to the LHA framework presented in this document, which represents the pedagogical concept of LHA. For each component, specific guidance is presented for different stakeholder groups, practical implementation steps, and strategies for addressing common challenges. This structure enables the identification of the most relevant recommendations to specific roles and implementation phase while maintaining a comprehensive view of the entire LHA.

6.1. Recommendations for Different Stakeholders

The successful implementation of LHA depends on the active participation and commitment of different stakeholders, as reflected in the Community Collaboration dimension of the framework's Implementation Processes.

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- Universities should provide essential access to laboratories, equipment, and scientific expertise. They need to recognize LHA as part of faculty work (not extra duty), simplify visit arrangements, and involve students as facilitators.
- Schools need to start gradually with one or two LHA per year before expanding. Connecting LHA to the existing curriculum helps demonstrate its educational value and facilitates smoother integration.
- Building partnerships with local universities or companies from the start creates the foundation for sustainable programs.
- Enterprises enrich the learning experience by sharing expertise, materials, or workspace. When employees volunteer as mentors and bring real-world problems for students to explore, learning becomes more authentic.
- Local authorities play a connecting role by including LHA in regional education strategies, funding materials and coordination, and making public spaces available for activities. They also help link schools with potential partners, creating support networks that make implementation easier.

6.2. Fundamental Implementation Steps

a) Phase 1: Defining Inputs

Before the LHA, organizers should carefully consider the framework's Inputs component. This begins with choosing a relevant topic from Green Deal, Health, or Digitalization based on local community needs and available expertise. Facilitators should also clarify their educational objectives, i.e., what participants should learn or be able to do and select appropriate pedagogical foundations such as inquiry-based learning, problem-based learning, or socio-scientific issues approaches. Finding partners such as universities, enterprises, or organizations establishes the foundation for Community Collaboration.

b) Phase 2: Managing the Implementation Processes

During the LHA, focus moves to how things actually happen, i.e., to the framework's Implementation Processes. The organization of the LHA should be carefully managed: facilitators should begin by introducing the topic and connecting it to real-world problems. After providing clear instructions for hands-on work, they should support groups as needed while allowing participants to explore independently, balancing structure with autonomy. The citizens' participation dimension comes alive as diverse participants engage with the

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content, developing technological skills, critical thinking, and positive attitudes. The activity should include participants sharing their results and receiving take-home materials to extend learning to their families, thereby broadening participation beyond the immediate setting.

c) Phase 3: Generating Outputs

After the LHA, focus turns to capturing and extending the outputs. Those involved should document what worked by creating reusable materials - instruction sheets, worksheets, equipment lists, and photos - that others can use to replicate the activity. Reflecting together on successes and challenges builds stronger partnerships through shared learning. When families and the broader community learn about the outcomes, the activity's impact extends beyond school walls, to Open Schooling. This reflection naturally shapes the next activity, creating a cycle of continuous improvement where today's lessons become tomorrow's better practices.

6.3. Lessons from Implementation

Experience across all partner countries revealed several practical principles that support effective implementation of the framework components.

- **Supporting Strong Inputs:** Starting small is essential - beginning with short activities of 60-90 minutes and using simple materials before attempting more complex formats allows facilitators to build confidence in defining clear objectives and selecting appropriate pedagogical approaches. Many successful LHA used everyday materials demonstrating that sophisticated equipment is not necessary for meaningful scientific learning grounded in solid pedagogical foundations.
- **Running the LHA:** Teachers do not need very extensive training before starting. Observing or assisting one LHA prepares them to lead the next independently. This learning-by-doing approach worked across many countries and makes starting easier. Choosing problems that matter locally increases engagement: when participants care about the issue, they participate more actively. LHA work best when participants do things themselves rather than watching demonstrations.
- **Maximizing Outputs:** Flexibility in adapting timing and difficulty to the specific group is crucial for generating valuable materials and resources that can be reused in different contexts. What works well with one group may need adjustment for another. Documentation through photos, notes, and participant feedback creates materials and resources that improve future implementations and allows successful practices to be shared with others, strengthening institutional networking. The manuals, worksheets,

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and instructions created for one LHA can often be reused and adapted by other facilitators in different contexts, demonstrating the extension to Open Schooling potential and multiplying the impact of initial development efforts.

7. Conclusions

This document presents the results from the implementation phase of LHA within the ICSE Science Factory project. Of the 266 activities run in the five partner countries, fifteen were selected as best practices and analyzed to extract lessons for future implementations.

The analysis of the fifteen best practice examples led to the development of framework, which represents the pedagogical concept of LHA and identifies how successful LHA works: through clear inputs (objectives, pedagogical approaches, and themes), effective implementation processes (community collaboration, organization, and citizens' participation), and tangible outputs (materials, networks, and potential for extension).

Four key success factors emerged: activities must address real community problems with tangible results; they work best when hands-on and flexible; strategic partnerships combining complementary expertise are essential; and inclusion across ages and backgrounds enriches the experience.

Experience across partner countries revealed different strategies to successfully engage community members in the LHA implementation process. Key approaches included: presenting LHA as opportunities for participants to work on real problems from their daily lives (such as water quality in their region, energy costs in their homes, or waste management in their community); and emphasizing that LHA use simple, affordable materials and welcome diverse participants regardless of prior knowledge.

Common challenges included scientific complexity, technological limitations, participant diversity, and multi-institutional coordination. However, these were consistently overcome through practical strategies: using familiar analogies, providing support for just-in-time, designing differentiated tasks, and establishing clear protocols.

The recommendations provided offer concrete guidance for universities, schools, companies and local authorities to implement similar activities in their contexts. The three-phase approach (defining inputs, managing processes, generating outputs) provides a simple roadmap that proved effective across very different settings.

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7.1. Contribution to Project Objectives

The LHA contributed to the first major objective of the ICSE Science Factory project: providing collaborative real-world science learning opportunities for all citizens. The quantitative evidence shows that 266 activities reached over 5600 participants, more than half of whom were women, far exceeding the initial targets of 135 activities and 1500 participants.

Beyond numbers, the quality and diversity of engagement achieved matters more. Participants ranged from 6 to 60 years old, came from different educational and socioeconomic backgrounds, and included both urban and rural communities. Activities successfully engaged regular students, vocational learners, families, teachers, and people with special needs.

The contribution to WP2 specific objectives manifested in multiple dimensions. The goal of offering real problem-solving opportunities was achieved through activities addressing authentic challenges in the three topics: Green Deal (sustainable agriculture, energy efficiency, waste management), Health (water quality, nutrition, digital wellbeing), and Digitalization (environmental sensors, 3D printing, smart systems). Additionally, the objective of encouraging open schooling activities received strong support through the materials, networks, and teacher capacity developed during implementation phase of LHA. The take-home materials extended learning beyond classrooms into families, and partnerships established between universities and schools continued beyond the formal project activities.

The objective of continuous optimization through design research was operationalized through the iterative methodology that characterized the entire development process. The evolution from D2.1 to D2.2, i.e., from the piloting phase to the implementation phase, represents not just additional documentation, but systematic refinement based on empirical evidence collected through real implementations of LHA. This approach ensured that the practices documented in this deliverable represent not only theoretically sound concepts but empirically validated and operationally viable strategies.

7.2. Looking Forward

The framework, recommendations, and examples provided in this document offer a foundation for others to build upon. The activities described are not merely success stories to be admired but practical models to be adapted and implemented in new contexts.

The evidence shows that LHA implementation does not require extraordinary resources or exceptional circumstances. What matters is commitment to collaboration, focus on authentic problems, hands-on methodology, and flexibility to adapt to local realities.

As the ICSE Science Factory project moves beyond formal implementation, the real test will be whether the partnerships, materials, and capacities developed continue to generate new learning opportunities.

The lighthouse metaphor proves apt: these activities have illuminated pathways for collaborative, community-engaged science education that others can now follow and extend.

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9. Annexes

- Annex A- List of LHA implemented, by country
- Annex B- Observation guide and report template for LHA
- Annex C- LHA reports of best practices examples

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Annex A

List of all LHA implemented

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Croatia

LHA no.	Name of the LHA	Topic(s)	Duration (min)	Total number of participants in the LHA	Number of participating females	Age range of the participants	Partners involved [enterprises, etc] Associated partners	Foundational aspects (IBL, Real-life problems-RLP, SSI, CDI)
1	Specularia: robotic greenhouse	Green deal, digitalization	60min	23	16	12-60	FER, PMF, Stemalica	IBL
2	Math and human body	Health	120min	12	7	16-59	PMF	IBL
3	Modern energy in households	Green deal, digitalization	90min	32	10	12-41	FER, HMD	RLP
4	Teach a robot to dance	Digitalization	90min	27	15	12-56	FER, PMF	IBL
5	Analyze text, AI & cryptography	Digitalization	120min	19	6	12-13	FER, HMD, MIOC	IBL
6	With sensors to happy plants - water	Green deal, digitalization	90min	21	14	12-42	FER, HMD, PMF	RLP
7	With sensors to happy plants - water	Green deal, digitalization	90min	14	12	11-14	FER, HMD, PMF	RLP
8	With sensors to happy plants - water	Green deal, digitalization	90min	14	10	13-14	FER, HMD, PMF	RLP
9	Modern energy in households	Green deal, digitalization	90 min	11	4	16-62	FER, HMD	RLP
10	Modern energy in households	Green deal, digitalization	90 min	18	14	14-60	FER, HMD	RLP
11	Plants & the need for light	Green deal, digitalization	90 min	17	11	12-55	FER, HMD, PMF	RLP
12	Plants & the need for light	Green deal, digitalization	90 min	13	11	11-14	FER, HMD, PMF	RLP
13	Plants & the need for light	Green deal, digitalization	90 min	12	9	13-14	FER, HMD, PMF	RLP
14	Measuring temperature & humidity	Green deal, digitalization	90 min	17	12	12-28	FER, HMD, PMF	RLP
15	Measuring temperature & humidity	Green deal, digitalization	90 min	11	9	11-14	FER, HMD, PMF	RLP

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LHA no.	Name of the LHA	Topic(s)	Duration (min)	Total number of participants in the LHA	Number of participating females	Age range of the participants	Partners involved [enterprises, etc] Associated partners	Foundational aspects (IBL, Real-life problems-RLP, SSI, CDI)
16	Measuring temperature & humidity	Green deal, digitalization	90 min	14	10	13-14	FER, HMD, PMF	RLP
17	The importance of plants for life	Green deal, digitalization	90 min	16	12	12-14	FER, PMF	RLP
18	All faces of educational robots	Digitalization	60 min	11	3	9-12	HMD, FER	IBL
19	All faces of educational robots	Digitalization	60 min	12	1	13-14	HMD, FER	IBL
20	Smart & sustainable plant development	Green deal, digitalization	90 min	22	10	11-12	HMD, FER	RLP
21	Smart & sustainable plant development	Green deal, digitalization	90 min	22	5	12-14	HMD, FER	RLP
22	Smart & sustainable plant development	Green deal, digitalization	90 min	11	4	16-62	HMD, FER	RLP
23	Smart & sustainable plant development	Green deal, digitalization	90 min	18	14	14-60	HMD, FER	RLP
24	Experiential quality of immersive applications	Digitalization	60 min	20	5	11-13	HMD, FER	RLP
25	Experiential quality of immersive applications	Digitalization	60 min	15	1	13-14	HMD, FER	IBL
26	The magic of micro:bit - programming is fun	Digitalization	120 min	15	5	13-15	PMF, Global Logic	RLP
27	The magic of micro:bit - programming is fun	Digitalization	120 min	18	7	12-13	PMF, Global Logic	RLP
28	Lego robot drawing	Digitalization	120 min	19	11	12-15	FER	IBL
29	Lego robot hand	Digitalization	45 min	18	6	9-11	FER	IBL
30	Lego robot hand	Digitalization	45 min	16	9	11-12	FER	IBL
31	Math and measures	Health	45 min	12	7	11-14	PMF	IBL
32	Smart & sustainable plant development	Green deal, digitalization	90 min	7	3	10-14	FER	RLP
33	Smart & sustainable plant development	Green deal, digitalization	90 min	16	3	11-14	FER	RLP

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LHA no.	Name of the LHA	Topic(s)	Duration (min)	Total number of participants in the LHA	Number of participating females	Age range of the participants	Partners involved [enterprises, etc] Associated partners	Foundational aspects (IBL, Real-life problems-RLP, SSI, CDI)
34	Robotic arm	Digitalization	60 min	15	1	12-14	FER	IBL
35	Soft robotics	Green deal, digitalization	90min	60	20	14-17	FER	IBL, RLP, SSI, CDI

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Cyprus

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LHA no.	Name of the LHA	Topic(s)	Duration (min)	Total number of participants in the LHA	Number of participating females	Age Range of the Participants	Partners involved [enterprises, etc] Associated partners	Foundational aspects (IBL, Real-life problems-RLP, SSI, CDI)
1	Collecting microplastic from the beach	Environment/Green deal	90 min	23	-	6-7	UNIC, CPI, Partner school	SSI, RLP
2	Air quality in school	Environment/Green deal	120 min	21	-	11-12	CPI	SSI, PBL
3	Green Tech and AI for sustainable solutions: Recycling for sustainable development	Environment/Green deal	60 min	28	-	18-20	UNIC	CDI
4	Promote sustainability using AI programming and gaming	Digitalization	60 min	28	12	18-20	UNIC	CDI
5	Learn about antibiotic and medical waste	Health - Environment/Green deal	20-30 min	40+	-	7 to 50	UNIC Multipliers Project CP. Foodlab Unic Medical School	SSI, RLP
6	3D printing	Digitalization	60 min	12	5	12 to 14	UNIC	CDI
7	Dna extraction lab	Health	60 min	13	7	12 to 14	UNIC Health School	IBL
8	Blood Type Detectives	Health	60 min	13	7	12 to 14	UNIC Health School	IBL
9	Air Quality Explorers	Digitalization - Environment/Green deal	90 min	12	5	12 to 14	UNIC	RLP
10	Virtual STEM Adventures – VR Lab	Digitalization		13	7	12 to 14	UNIC	CDI
11	Marshmallow Tower Challenge	Green Deal	30 min	15	6	11 to 14	UNIC	CDI
12	Bridge Builders Challenge	Green Deal	300 min	15	6	11 to 14	UNIC	IBL-CDI
13	3D Printing in Buoyancy and Flotation Teaching	Digitalization	60 min	6	3	35 to 60	UNIC	CDI
14	3D printing - Designing sustainable earrings	Green Deal - Digitalization	120 min	25	13	5 to 12	UNIC	CDI
15	Dna extraction lab	Health	60 min	40	25	7 to 50	UNIC Health School	IBL
16	Balloon Rocket Challenge	Environment/Green deal	45 min	40	25	7 to 50	CPI	CDI
17	Blood Type Detectives	Health	60 min	40	25	7 to 50	UNIC Health School	IBL
18	Marshmallow Tower Challenge	Green Deal	30 min	40	25	7 to 50	UNIC	CDI

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LHA no.	Name of the LHA	Topic(s)	Duration (min)	Total number of participants in the LHA	Number of participating females	Age Range of the Participants	Partners involved [enterprises, etc] Associated partners	Foundational aspects (IBL, Real-life problems-RLP, SSI, CDI)
19	Light, Shadows & Perception	Digitalization	45 min	40	25	7 to 50	UNIC	CDI
20	GenAI Creativity: Designing Comics, Posters & Videos to Develop Digital Skills	Digitalization	240 min	21	14	18 to 20	UNIC	CDI
21	Urban Heat Island	Environment/Green deal	180 min	12	8	18 to 26	UNIC	IBL
22	Air Quality Explorers	Green Deal/Digitalization	90 min	50	29	10 to 13	UNIC	RLP
23	Robot mouse	Digitalization	60 min	15	5	7 to 10	UNIC	IBL
24	3D Printing in Buoyancy and Flotation Teaching	Digitalization	60 min	20	17	18 to 26	UNIC	CDI
25	Virtual STEM Adventures – VR Lab	Digitalization	90 min	13	8	12 to14	UNIC	CDI
26	Thalassakis the Little Robot Cleans the Sea	Green Deal/Digitalization	30 min	15	5	7 to 11	UNIC	IBL, RLP
27	Recycling by Creating 3D Constructions!	Green Deal/Digitalization	45 min	17	9	7 to 13	UNIC	RLP, CDI
28	Mouse Mission! Find the Code, Unlock the Treasure!	Digitalization	30 min	15	5	5 to 10	UNIC	IBL
29	How to Speed Up Melting the Ice	Green Deal	30 min	12	8	6 to 13	UNIC	IBL, RLP

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Germany

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1	Can you Escape?	Digitalisation	180	19	12	16	university, school	IBL, CDI
2	Molekular Kitchen	Health	120	8	3	12	university, school	RLP
3	Forest Lab Tour	Green Deal	240	13	9	16	university, school	RLP
4	Lessens in Forest – Carbon storage forest	Green Deal	100	22	10	16	university, school	RLP
5	Molekular Kitchen	Health	90	29	11	13	university, school	RLP
6	Molekular Kitchen	Health	90	16	11	13	university, school	RLP
7	Open Schooling and molekular kitchen, PD course with educators as multipliers	Health	240	10	6	45	university, school	RLP
8	Creating digital rallyes with Actionbound	Digitalization	*180*	6	3	40	university, school	IBL, CDI
9	Forest kitchen	Health	*270*	6	3	20	university,	RLP
10	Molekular Cocktails and food additives	Health	*180*	8	4	37	university, school	RLP
11	Dendroecology	Grean Deal	*270*	14	14	13	university, schoool	RLP
12	Forest Lab-Tour	Green Deal	*150*	11	4	40	university, VHS	RLP
13	Forest kitchen	Health	*150*	15	14	40	university, VHS	RLP
14	3D printing	Digitalization	*150*	4	3	50	university, school	IBL, CDI
15	Lamps from the Laser Cutter	Digitalization	*180*	8	7	30	university, VHS	RLP
16	Ecosystem Forest 1	Green Deal	*240*	5	4	20-25	universities	RLP
17	Ecosystem Forest 2	Green Deal	*240*	7	5	20-25	universities	RLP
18	Escape Games/ digital Rallyes	Digitalization	*180*	22	11	16	university, school	IBL, CDI
19	3D printing	Digitalization	*150*	5	1	35	university, school	RLP
20	Maths in Forest	Green Deal	*270*	25	13	15-17	university, school	RLP

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21	From molecular Cocktails and food additives to dysphagia	Health	*540*	11	7	21-65	university, school, VHS	RLP
22	Molecular Cocktails and food additives	Health	-	-	-	-	university, school, VHS	RLP
23	Dysphagia food	Health	-	-	-	-	university, school, VHS	RLP
24	CAD and 3d printing	Digitalization	*420*	26	13	9	Non-formal learning provider, school (NFLP)	IBL
25	CAD and 3d printing	Digitalization	*420*	26	13	9	NFLP, school	IBL
26	CAD and 3d printing	Digitalization	*240*	26	13	9	NFLP, school	IBL
27	Upcycling/Building vehicles	Green Deal	*180*	26	13	9	NFLP, school	RLP
28	CAD and 3d printing	Digitalization	*240*	26	13	9	NFLP, school	IBL
29	CAD and 3d printing	Digitalization	*240*	26	13	9	NFLP, school	IBL
30	Polymers an Environment	Green Deal	*90*	30	20	10-70	School (THG)	RLP
31	Dendroecology and tree ring study	Sustainability	*120*	26	16	10-11	School (SSR)	SSI
32	Bee Wanda	Green Deal	240min + 60min preparation	24	-	7-8	SFZ Tuttlingen	RLP
33	Bee Wanda	Green Deal	240min + 60min preparation	25	13	6-7	SFZ Tuttlingen	RLP
34	Bee Wanda	Green Deal	240min + 60min	26	16	6-7	SFZ Tuttlingen	RLP

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			preparation					
35	Sinken, Schwimmen, Schweben	Green Deal	240min + 30min preparation	25	12	7-8	SFZ Tuttlingen	IBL
36	CAD 3D-Druck	Digitalization	300min + 120min preparation	14	6	9-10	SFZ Tuttlingen	RLP
37	Sinken, Schwimmen, Schweben	Green Deal	240min + 30min preparation	26	15	7-8	SFZ Tuttlingen	IBL
38	Bridges	Green Deal	240min + 60min preparation	16	8	8-9	SFZ Tuttlingen	IBL, RLP
39	Towers	Green Deal	180min + 30min preparation	37	20	6-7	SFZ Tuttlingen	IBL
40	Bee Wanda	Green Deal	240min + 60min preparation	41	17	8-9	SFZ Tuttlingen	RLP
41	Climate Change	Green Deal	180min + 60min preparation	27	15	9-10	SFZ Tuttlingen	IBL, RLP
42	Robotics	Digitalization	240min	25	13	9-10	SFZ Tuttlingen	-

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43	Robotics	Digitalization	240min	25	12	9-10	SFZ Tuttlingen	-
44	CAD and 3D-print	Digitalization	240min + 180min preparation	28	14	9-10	SFZ Tuttlingen	RLP
45	Bridges	Green Deal	180min + 60min preparation	29	15	8-9	SFZ Tuttlingen	IBL, RLP
46	Robotics	Digitalization	240min	26	14	9-10	SFZ Tuttlingen	RLP
47	CAD and 3D-print	Digitalization	180min + 60min preparation	29	13	9-10	SFZ Tuttlingen	RLP
48	Upcyclingcars	Green Deal	180min	17	9	8-10	SFZ Tuttlingen	RLP, CDI
49	Robotics	Digitalization	180min	19	11	12-13	SFZ Tuttlingen	RLP
50	Robotics	Digitalization	180min	25	12	12-13	SFZ Tuttlingen	RLP
51	Climate change	Green Deal	180min	18	10	8-10	SFZ Tuttlingen	IBL, RLP
52	Sinken, Schwimmen Schweben	Green Deal	180min	28	14	7-8	SFZ Tuttlingen	IBL
53	Towers	Green Deal	180min	24	13	7-8	SFZ Tuttlingen	IBL
54	Robotics	Digitalization	240min	27	13	9-10	SFZ Tuttlingen	RLP
55	Climate change	Green Deal	180min	26	14	8-9	SFZ Tuttlingen	IBL, RLP
56	Climate change	Green Deal	180min	25	12	8-9	SFZ Tuttlingen	IBL, RLP
57	CAD and 3D-print	Digitalization	240min	27	13	9-10	SFZ Tuttlingen	RLP
58	Climate change	Green Deal	180min	26	14	8-9	SFZ Tuttlingen	IBL, RLP
59	Bee Wanda	Green Deal	180min	17	9	7-8	SFZ Tuttlingen	RLP

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60	Bee Wanda	Green Deal	180min	18	9	7-8	SFZ Tuttlingen	RLP
61	Robotics	Digitalization	180min	25	13	9-10	SFZ Tuttlingen	RLP
62	Bridges	Green Deal	180min	26	14	8-9	SFZ Tuttlingen	RLP
63	Towers	Green Deal	180min	22	9	6-7	SFZ Tuttlingen	IBL
64	Light and shadow	Health	180min	22	10	6-7	SFZ Tuttlingen	CDI
65	Light and shadow	Health	180min	21	11	6-7	SFZ Tuttlingen	CDI
66	Robotics	Digitalization	180min	24	14	9-10	SFZ Tuttlingen	RLP
67	Robotics	Digitalization	180min	26	12	9-10	SFZ Tuttlingen	RLP
68	Bee Wanda	Green Deal	180min	21	8	8-9	SFZ Tuttlingen	RLP
69	Robotics	Digitalization	180min	21	13	12-13	SFZ Tuttlingen	RLP
70	Robotics	Digitalization	180min	22	11	12-13	SFZ Tuttlingen	RLP
71	Bee Wanda	Green Deal	180min	22	7	8-9	SFZ Tuttlingen	RLP
72	Coding im Kindergarten	Digitalization	120min	27	11	5-7	SFZ Tuttlingen	RLP
73	Coding im Kindergarten	Digitalization	120min	27	11	5-7	SFZ Tuttlingen	RLP
74	Coding im Kindergarten	Digitalization	120min	27	11	5-7	SFZ Tuttlingen	RLP
75	Coding im Kindergarten	Digitalization	120min	27	11	5-7	SFZ Tuttlingen	RLP
76	Coding im Kindergarten	Digitalization	120min	27	11	5-7	SFZ Tuttlingen	RLP
77	Upcyclingworkshop	Green Deal, Digitalization	180min	22	12	8-9	SFZ Tuttlingen	RLP, CDI
78	Upcyclingworkshop	Green Deal, Digitalization	180min	23	14	8-9	SFZ Tuttlingen	RLP, CDI
79	Upcyclingworkshop	Green Deal, Digitalization	180min	21	10	9-10	SFZ Tuttlingen	RLP, CDI

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80	Upcyclingworkshop	Green Deal, Digitalization	180min	20	9	9-10	SFZ Tuttlingen	RLP, CDI
81	Upcyclingworkshop	Green Deal, Digitalization	180min	25	14	9-10	SFZ Tuttlingen	RLP, CDI
82	Upcyclingworkshop	Green Deal, Digitalization	180min	24	14	9-10	SFZ Tuttlingen	RLP, CDI
83	Lego Spike	Digitalization	180min	25	13	9-10	SFZ Tuttlingen	RLP
84	Lego Spike	Digitalization	180min	26	15	8-9	SFZ Tuttlingen	RLP
85	Sinking, Floating, Swimming		180min	15	5	8-9	SFZ Tuttlingen	IBL
86	Lego Spike	Digitalization	180min	22	12	9-10	SFZ Tuttlingen	RLP
87	Lego Spike	Digitalization	180min	20	9	9-10	SFZ Tuttlingen	RLP
88	Upcyclingworkshop	Green Deal, Digitalization	180min	24	12	9-10	SFZ Tuttlingen	RLP, CDI
89	Upcyclingworkshop	Green Deal, Digitalization	180min	20	10	9-10	SFZ Tuttlingen	RLP, CDI
90	Upcyclingworkshop	Green Deal, Digitalization	180min	24	13	9-10	SFZ Tuttlingen	RLP, CDI
91	Lego Spike	Digitalization	180min	25	12	9-10	SFZ Tuttlingen	RLP
92	Lego Spike	Digitalization	180min	25	14	8-10	SFZ Tuttlingen	RLP
93	Light and Shadow	Health	180min	22	12	8-9	SFZ Tuttlingen	CDI
94	Light and Shadow	Health	180min	23	10	7-8	SFZ Tuttlingen	CDI
95	Upcyclingworkshop	Green Deal, Digitalization	180min	18	2	8-17	SFZ Tuttlingen	RLP, CDI
96	Light and Shadow	Health	180min	24	10	7-8	SFZ Tuttlingen	CDI
97	Light and Shadow	Health	180min	25	12	7-8	SFZ Tuttlingen	CDI
98	Alternative Energies	Green Deal, Digitalization	180min	22	10	9-10	SFZ Tuttlingen	IBL, RLP

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99	Sinking, Floating, Swimming		180min	9	7	7-15	SFZ Tuttlingen	IBL
100	Lego Spike	Digitalization	180min	24	12	9-10	SFZ Tuttlingen	RLP
101	Climate change	Green Deal, Digitalization	180min	34	16	8-9	SFZ Tuttlingen	IBL, RLP
102	Alternative Energies	Green Deal, Digitalization	180min	18	10	8-10	SFZ Tuttlingen	IBL, RLP
103	Climate change	Green Deal, Digitalization	-	30	15	9-10	SFZ Tuttlingen	IBL, RLP
104	Lego Spike	Digitalization	180min	25	12	9-10	SFZ Tuttlingen	RLP
105	Bridges		180min	24	13	8-9	SFZ Tuttlingen	IBL, RLP
106	Lego Spike	Digitalization	180min	25	10	9-10	SFZ Tuttlingen	RLP
107	Alternative Energies	Green Deal, Digitalization	180min	22	10	9-10	SFZ Tuttlingen	IBL, RLP
108	Climate Change	Green Deal, Digitalization	180min	25	11	9-10	SFZ Tuttlingen	IBL, RLP
109	Climate Change	Green Deal, Digitalization	180min	24	13	9-10	SFZ Tuttlingen	IBL, RLP
110	Climate Change	Green Deal, Digitalization	180min	24	10	9-10	SFZ Tuttlingen	IBL, RLP
111	Climate Change	Green Deal, Digitalization	180min	22	11	9-10	SFZ Tuttlingen	IBL, RLP
112	Climate Change	Green Deal, Digitalization	180min	23	14	8-9	SFZ Tuttlingen	IBL, RLP
113	Climate Change	Green Deal, Digitalization	180min	24	13	8-9	SFZ Tuttlingen	IBL, RLP
114	Climate Change	Green Deal, Digitalization	180min	20	11	8-9	SFZ Tuttlingen	IBL, RLP
115	Bionics	Green Deal, Digitalization	180min	27	14	9-10	SFZ Tuttlingen	IBL, RLP

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116	Bionics	Green Deal, Digitalization	180min	26	13	9-10	SFZ Tuttlingen	IBL, RLP
117	Lego Spike	Digitalization	180min	23	11	8-9	SFZ Tuttlingen	RLP
118	Lego Spike	Digitalization	180min	22	7	9-10	SFZ Tuttlingen	RLP
119	Lego Spike	Digitalization	180min	25	12	9-10	SFZ Tuttlingen	RLP
120	Body and Health	Health	3h	24	11	9-10	SFZ Tuttlingen	IBL, RLP
121	Body and Health	Health	3h	23	12	9-10	SFZ Tuttlingen	IBL, RLP
122	Body and Health	Health	180min	25	13	9-10	SFZ Tuttlingen	IBL, RLP
123	Lego League	Digitalization	240min	10	1	15 - 17	SFZ Tuttlingen	RLP
124	Lego Spike	Digitalization	180min	24	11	9-10	SFZ Tuttlingen	RLP
125	Body and Health	Health	180min	22	7	9-10	SFZ Tuttlingen	IBL, RLP
126	Bridges		180min	20	12	8-9	SFZ Tuttlingen	IBL, RLP
127	Towers		180min	25	12	7-8	SFZ Tuttlingen	IBL, RLP
128	Lego League	Digitalization	90min	18	11	8-10	SFZ Tuttlingen	RLP
129	Forest Lab-Tour	Green Deal	150 min	5	3	50-70	university, VHS	RLP
130	Escape Room and Actionbound	Digitalization	5h	12	7	14-16	university	IBL, CDI
131	3D printing	Digitalization	5h	17	7	14-16	university	IBL
132	Laboratory visit	Green Deal	90min	8	5	50-70	university, VHS	RLP
133	Dendroecology and Forest	Sustainability	*90min*	24	16	10-11	School (SSR)	SSI
134	What's growing there?	Green Deal	90min	8	7	50-70	University, VHS	RLP

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Portugal

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1	Olive Trees	Green Deal	90 min	12	7	6-43	QPO	RLP
2	Invisible World: Discovering air quality	Green Deal	90 min	22	12	9-10	IE-Ulisboa and School	RLP
3	New Age Researcher	Digitalization/ Green Deal	120 min	42	38	32-60	IE-Ulisboa	IBL
4	Machine Learning	Digitalization	120 min	36	30	32-60	IE-Ulisboa	IBL
5	New Age Researcher	Digitalization/ Green Deal	120 min	42	38	32-60	IE-Ulisboa	IBL
6	Machine Learning	Digitalization	120 min	36	30	32-60	IE-Ulisboa	IBL
7	Using technology to measure	Digitalization/ Green Deal	120 min	37	31	32-60	Academia STEM	RLP
8	Using technology to measure	Digitalization/ Green Deal	120 min	37	30	32-60	Academia STEM	RLP
9	Sound for the Future: Acoustic Comfort in School	Health/Digitalization	75 min	10	9	11-14	IE-Ulisboa and School	IBL
10	Biodiversity	Green Deal	90 min	34	30	32-60	Centro Int. Monsanto	RLP
11	Biodiversity	Green Deal	90 min	32	29	32-60	Centro Int. Monsanto	RLP
12	Sound for the Future: Acoustic Comfort in School	Health/Digitalization	100 min	24	12	10-12	IE-Ulisboa and A.E. Alvalade	RLP
13	Virtual Reality and Choices Behind the Screens - Digitalization in School Context	Health/Digitalization	100 min	130	62	14-56	Agrupamento de Escolas Gil Vicente; Educathec - Digital Academy for Teachers; IE-Ulisboa	RLP, SSI
14	Biodiversity	Green Deal	90 min	37	24	32-60	QPO	RLP
15	Biodiversity	Green Deal	90 min	32	30	32-60	QPO	RLP
16	Sound for the Future: Acoustic Comfort in School	Health/Digitalization	90 min	24	11	10-11	IE-Ulisboa and E.B./E.S. Padre Alberto Neto	IBL
17	Sustainability and Technology	Digitalization/ Green Deal	100 min	21	11	14-15	IE-Ulisboa and E.S. Lumiar	IBL

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18	Sustainable Development: Increasing the Energy Efficiency of Buildings	Digitalization/ Green Deal	180 min	21	9	14-16	ISEL, IE-Ulisboa, E.S. Forte da Casa	IBL
19	Sustainable Development: Increasing the Energy Efficiency of Buildings	Digitalization/ Green Deal	180 min	25	10	15-16	ISEL, IE-Ulisboa, E.S. Forte da Casa	IBL
20	Sound for the Future: Acoustic Comfort in School	Health/Digitalization	45 min	24	11	8-9	IE-Ulisboa and A.E. Alvalade	RLP
21	Sound for the Future: Acoustic Comfort in School	Health/Digitalization	45 min	20		8-9	IE-Ulisboa and A.E. Alvalade	RLP
22	Olivaria	Health, Green Deal	120 min	14	8	>6 and adults	CML/QPO	RLP
23	Laboratory Investigation	Health, Green Deal	180 min	11	6	16-19	FCUL, Escola Básica e Secundária Alfredo da Silva, IE-Ulisboa	IBL, RLP, SSI
24	Discovering the Sheep	Green Deal	60 min	18	10	6-8	CML/QPO	RLP
25	Discovering the Sheep	Green Deal	60 min	16	6	6-8	CML/QPO	RLP
26	Discovering the Sheep	Green Deal	60 min	20	7	6-8	CML/QPO	RLP
27	Olivaria	Health, Green Deal	120 min	14	8	>6 and adults	CML/QPO	RLP
28	The Bread Cycle	Health, Green Deal	75 min	23	11	10-11	CML/QPO	RLP
29	Virtual Reality	Digitalization/ Green Deal	90 min	68	58	adults	IE-ULisboa	RLP
30	Rural pharmacy	Health, Green Deal	75 min	29	8	10-11	CML/QPO	RLP
31	Rural pharmacy	Health, Green Deal	75 min	18	10	10-11	CML/QPO	RLP
32	Discovering the Sheep	Green Deal	75 min	23	13	8-9	CML/QPO	RLP
33	Rural pharmacy	Health, Green Deal	75 min	24	17	9-10	CML/QPO	RLP
34	IA and Corals	Digitalization/ Green Deal	*180 min*	57	47	adults	IE-ULisboa	RLP, IBL
35	AI in Scientific Research	Digitalization	*180 min*	57	47	adults	IE-ULisboa	RLP, IBL

Turkey

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1	Rover Mission	Digitalization	75 min	25	15	18-45	HU, Kafkas University	IBL
2	Heart Rate	Health	45 min	36	18	10-14 (Target group) Families join as well	HU, Kafkas University	Real Life Problem
3	Determination of Water Quality	Health, Digitalization,	45 min	17	9	15+	HU, Kafkas University	SSI, Real Life problem
4	Discover Your Face: Digital Identity and Security event	Sustainability	40 min	16	10	12+	ÖÖV, Maya Schools	SSI
5	Climate of the Future: Changes in Our Environment activity	Digitalization	45 min	10	4	10+	ÖÖV, Maya Schools	SSI, Real Life problem
6	The Energy of the Wind: Reinventing Our Energy event	Sustainability	35 min	12	8	14+	ÖÖV, Maya Schools	IBL
7	Our Virtual Assistants: Time to Understand Our Temperament with Chatbots	Digitalization	50 min	10	7	14+	ÖÖV, Maya Schools	IBL, CDI
8	My Green Home Tricks to Save Energy	Sustainability	40 min	15	6	18+	ÖÖV, Maya Schools	IBL, Real Life problem
9	Creativity in the 3D World: The Magic of Modelling and Printing	Digitalization	60 min	10	8	12+	ÖÖV, Maya Schools	CDI
10	Nature Friendly Fertiliser: Secrets of Composting	Sustainability	35 min	12	5	18+	ÖÖV, Maya Schools, Çiğdemim Foundation	SSI, IBL
11	Hydroponic Greenhouses and Smart Greenhouses: The Innovative Face of Sustainable Agriculture	Sustainability	30 min	10	6	18-30	ÖÖV, Maya Schools	SSI, CDI
12	Exploring Artificial Intelligence in Education	Digitalization	60 min	15	10	18+	ÖÖV, Maya Schools	IBL
13	Active Living: Exploring Health through Sports Science	Health	50 min	10	8	13+	ÖÖV, Maya School, Ministry of Youth and Sports	Real Life Problem,
14	Looking at the Stars and Finding My Direction	Digitalization	45 min	18	11	10+	ÖÖV, Maya School, Doratoy	IBL, CDI

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LHA no.	Name of the LHA	Topic(s)	Duration (min)	Total number of participants in the LHA	Number of participating females	Age range of the participants	Partners involved [enterprises, etc] Associated partners	Foundational aspects (IBL, Real-life problems-RLP, SSI, CDI)
15	Preparing a healthy meal	Health	60 min	25	11	10+	HU, Van Yüzüncü Yıl University, Van Provincial Directorate of National Education, TED Van College	Real Life Problem, IBL
16	How healthy environment we live in	Health	60 min	15	7	12+	HU, Van Yüzüncü Yıl University, Van Provincial Directorate of National Education, TED Van College	SSI, IBL
17	Discovery on the Surface of Mars	Digitalization	60 min	21	12	12+	HU, Van Yüzüncü Yıl University, TED Van College	IBL
18	Sustainable Escape Room	Green Deal, Digitalization	75 min	28	12	10+	HU, Van Yüzüncü Yıl University, TED Van College	IBL, SSI, Real Life Problem
19	Secure Password	Digitalization	45 min	15	5	12+	HU, Van Yüzüncü Yıl University, TED Van College	Real-life Problem, SSI
20	Coding with Artificial Intelligence	Green Deal, Digitalization	75 min	19	6	10+	HU, Van Yüzüncü Yıl University, TED Van College	IBL, CDI
21	Escape Room	Green Deal, Digitalization	60 min	30	17	10+	HU; Kastamonu University, Kastamonu Techno Park	IBL, Real Life problems
22	Coding with Artificial Intelligence	Green Deal, Digitalization	75 min	27	13	12+	HU, Kastamonu University, Kastamonu Techno Park, Kastamonu Directorate of National Education	IBL, CDI
23	Vitamin C Research	Health	30 min	19	13	10+	HU, Kastamonu University, Kastamonu Techno Park	Real Life Problem, IBL
24	Cost of a Plate of Stew Dish to Nature	Green Deal	45 min	13	11	12+	HU, Kastamonu University, Kastamonu Techno Park	SSI, IBL
25	Escape Room	Green Deal, Digitalization	60 min	11	5	10+	HU, Kastamonu University, Kastamonu Techno Park	IBL, Real Life problems
26	Coding with Artificial Intelligence	Green Deal, Digitalization	75 min	15	7	12+	HU, Kastamonu University, Kastamonu Techno Park, Kastamonu Directorate of National Education	IBL, CDI

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LHA no.	Name of the LHA	Topic(s)	Duration (min)	Total number of participants in the LHA	Number of participating females	Age range of the participants	Partners involved [enterprises, etc] Associated partners	Foundational aspects (IBL, Real-life problems-RLP, SSI, CDI)
27	The Hidden Power of Fruits: The Vitamin Hunt	Health	30 min	15	9	7+	HU, Kastamonu University, Kastamonu Techno Park	Real Life Problem, IBL
28	Cost of a Plate of Stew Dish to Nature	Green Deal	45 min	8	5	12+	HU, Kastamonu University, Kastamonu Techno Park	SSI, IBL
29	Health Monitoring in a Changing Climate	Health, Digitalization,	80 min	24	15	12+	HU, Gaziosmanpaşa Necla Ilhan Ipekçi Middle School	IBL, Real Life Problem
30	Attention! Light!	Health, Digitalization,	80 min	20	11	12+	HU, Gaziosmanpaşa Necla Ilhan Ipekçi Middle School	IBL
31	Is there salt?	Health, Digitalization,	80 min	8	5	14+	HU, Gaziosmanpaşa Necla Ilhan Ipekçi Middle School	IBL
32	Sustainable Escape Room	Green Deal, Digitalization	45 min	12	4	10+	HU, ÖÖV, Maya Schools	IBL, Real Life problems
33	Algorithmic Tasks with Robotic Coding	Digitalization	30 min	8	3	7+	HU, ÖÖV, Maya Schools	IBL
34	Which Living Condition is Better	Digitalization Green Deal Health	120 min	25	16	12+	HU, Ankara Beytepe Middle School	IBL, SSI
35	Relax and Take a Deep Breath	Health	40 min	11	5	12+	HU, Gaziosmanpaşa Necla Ilhan Ipekçi Middle School	IBL
36	An Enquiry-Based Activity on a Self-Sustaining Ecosystem	Green Deal	80 min	6	5	12+	HU, Ankara Beytepe Middle School	IBL
37	Sustainable Escape Room	Digitalization Green Deal	60 min	20	13	20+	HU, Ibn Haldun University	IBL, Real-life problem
38	Sustainable Escape Room	Digitalization Green Deal	60 min	40	26	10+	HU, Kastamonu University	IBL, Real-life problem
39	The Hidden Power of Fruits: The Vitamin Hunt	Health	45 min	30	20	7+	HU, Kastamonu University	IBL
40	Maya Chef Workshop	Health	40 min	10	8	6+	ÖÖV, Maya Schools	IBL
41	I learn in nature	Green Deal	75 min	12		10+	ÖÖV, children nature network	SSI, CDI
42	DYI	Green Deal	30 min	10	7	8+	ÖÖV, Maya Schools	IBL
43	STEM EDU	Digitalization	40 min	10	4	10-14 (Target group)	ÖÖV, Rentech	IBL

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LHA no.	Name of the LHA	Topic(s)	Duration (min)	Total number of participants in the LHA	Number of participating females	Age range of the participants	Partners involved [enterprises, etc] Associated partners	Foundational aspects (IBL, Real-life problems-RLP, SSI, CDI)
						Families join as well		
44	Fashion & Design	Digitalization Green Deal	60 min	12	9	20-45	ÖÖV, Gökçen Togay Art Centre, Çiğdemim Foundation	SSI
45	woodworking workshop	Green Deal	60 min	11	6	10+	ÖÖV, Doratoy, Maya Schools	IBL
46	the dance of glass with fire	Green Deal	40 min	10	5	7+	ÖÖV, glassblower Feridun Pekeş	IBL
47	The mysterious world of DNA	Health	60 min	14	9	12--14	ÖÖV, Amgen, ABE Educational Institution	IBL
48	Robotics & LEGO	Digitalization	45 min	17	4	7+	ÖÖV, Maya Schools	IBL
49	Mindfulness	Health	50 min	20	12	for families	ÖÖV, Turuncu Grup Eğitim	Real Life Problem
50	Creative Drama	Green Deal	50 min	15	11	for families	ÖÖV, Dr. Tülay Üstündağ, Elma Publishing	SSI
51	Glass Shaping Over an Open Flame	Green Deal	30 min	16	9	10+	ÖÖV, Moira Art Workshop	IBL
52	Sun Tracking Panel: Smart System for Efficient Energy Production	Green Deal	60 min	12	5	11	HU, Mekano Lab, Dora Toy	IBL, Real Life Problem

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Annex B

Observation Protocol

LHA

Introduction

This document aims to present the observation guide for the lighthouse activities (LHAs) conducted during the implementation phase of the ICSE Factory project, i.e., during Stage 3 (Evaluate) of the Design-Based Research (DBR) approach (Scott et al., 2020).

The template presented in this document is an updated version of a previous one and took into account the feedback provided by the partners. More precisely, the proposed changes to the original script aimed at: 1) decreasing its length; and 2) providing clearer instructions (and examples) for each item.

The purpose of gathering data following the "Observation Template" is to:

1- Collect data regarding the impact of LHAs and, therefore, illustrate international best practices (Objective 1).
2- To support the assessment of the LHAs conducted during the implementation phase of the project and, consequently, facilitate their future improvement (Objective 2).

As such, the focus of this observation is on both the participants and the activities themselves. Specifically, dimensions A (Conceptual knowledge), B (Skills and attitudes), and C (Experienced difficulties) are intended to collect data on the impact of the LHA on participants during the implementation of the lighthouse activity. Dimensions D (Relevance and Effectiveness), and E (Consistency and Practicality), aim to gather data on the assessment of the activity.

The "Observation Template" intended to serve as the reference document for the observation of the LHAs implementation is presented next and examples of illustrative answers are provided (in green).

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Observation Template

Name of the LHA	
Name of the observer	
Date	
Local	
Duration	
Partners involved	
Target group	
Number of participants	
Number of female participants	
Age range of the participants	

Part 1
Impact of the LHA

A. Conceptual knowledge

Theme	**Please indicate the theme(s)**
Environmental issues - Green Deal	X
Digitalization	X
Health	X
Field notes *Please indicate how the LHA promotes the mobilization and/or development of conceptual knowledge related to the themes of the activity. Please provide evidence/ episodes of such mobilization and/or development.* *Example:* *Development of conceptual knowledge related to the harmful effects of high concentrations of carbon dioxide on the environment and human health.*	

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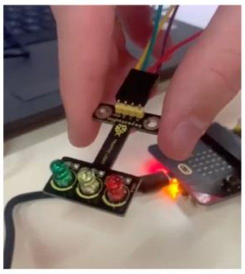
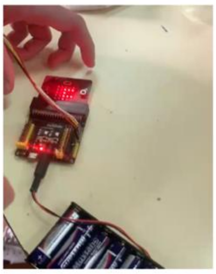
For example, one of the groups prepared a written production, a poster, with the systematization of the main ideas collected.

The title of the poster is: "Causes and consequences of the increase in CO_2 in the atmosphere over the last 100 years". You can read more information: "Causes: burning of fossil fuels, deforestation and other industrial processes" "Consequences: 1 global warming, 2 ocean acidification, 3 ecosystem changes, 4 impacts on human health, 5 climate instability." "The units used to measure the concentration of CO_2 are ppm (part per million) and % (percentage)" "the limit values for the concentration of atmospheric CO_2 in an indoor space is ruled by EN 13779:2007", "establishes standards for air quality indoor based on CO_2 concentration".

According to a written record from the students, they also learned that "(..) air quality (...) is acceptable between 600 and 800 ppm and worrying from 6000 to 8000 ppm" and to this end they will develop "a prototype that indicates the air quality value [CO_2 concentration in ppm]."

Students explained that "Factors such as occupancy and ventilation greatly influence CO_2 values, for example, if we are in a space full of people, without ventilation, CO_2 values will be quite high. On the other hand, if there is ventilation, CO_2 values will decrease. High levels of CO_2 can cause several negative effects on people's comfort and well-being, including fatigue, headaches, difficulty concentrating, eye, nose and throat irritation and even respiratory problems in extreme cases. Furthermore, high levels of CO_2 can affect indoor air quality."

The students also learned how to use and program CO_2 sensors and lights: The program activates the green light when it detects CO_2 values lower than 600ppm. Activates yellow light when values are greater than or equal to 600 and less than 1000 ppm. Activates the red light when CO_2 values exceed 1000 ppm.

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B. Skills and attitudes

	Please indicate one or more items
Attitudes towards science	X
High order thinking skills (create; evaluate; analyze, problem-solving; creativity; decision-making; planning; abstraction; etc.)	X

Field notes

Please illustrate with episodes/evidence how the LHA contributed to the development of the indicated skills and/or attitudes.

Example:

<u>Attitudes towards science:</u>

Throughout the activity, students were deeply involved in it, which resulted in a constant and systematic search for improving the prototype.

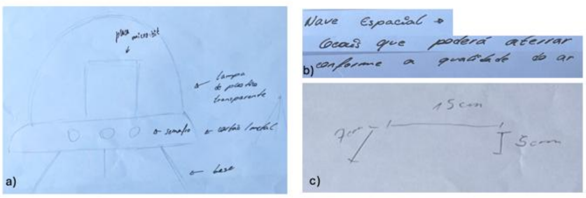
Students' commitment was remarkable, which led them to a constant evaluation of the work carried out as well as great ways of working in groups.

Curious fact: in this group there are students from the science and arts areas and what was observed was that the Science students dedicated themselves to building the prototype and the Arts students dedicated themselves to programming and scientific aspects, which is evidence of the (good) attitudes and interest that students have regarding science.

<u>High order thinking skills:</u>

[Group 1]

This group planned to build a spaceship-like prototype according to the following sketch:



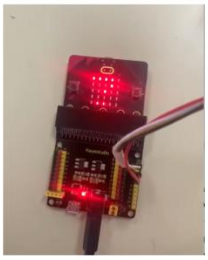
In this particular sketch you can read: a) micro:bit board, transparent plastic cover, traffic light, card/metal and base; b) Spacecraft – places that can land depending on air quality; c) the dimensions of the micro:bit: 7cmx15cmx5cm.

The selection of materials constituted an important stage for the construction of the prototype, as mentioned by the students: *"In creating this prototype we decided to use materials such as plastic and cardboard to make the structure of the ship and then some holographic papers and antennas to the decoration."*

Regarding the operation of the traffic light, the group of students subsequently needed to carry out new research, to know the limit values for the concentration of atmospheric CO_2 in order to be able to use it in the traffic light programming.

Subsequently, the group tested and evaluated the prototype in environments with different concentrations of carbon dioxide, using an alcohol lamp and a precipitation cup to produce and retain this gas.



In an almost final phase, and after discussion and sharing of ideas, the group decided, in order to improve the design of the prototype, to cover and protect the CO_2 sensor, by creating a base for the spacecraft, using of a CD box, which closes when the measurement is not taking place, also allowing it to be opened to remove this electronic component.


[Group 2]

After an initial brainstorming, group 2 remained focused on the study context, testing and evaluating the idea, which led to its reformulation considering environmental themes, as well as research carried out, thus leading the group to a new brainstorming stage.

The students then decided to build a prototype of a cloud as an element present in the atmosphere that will evaluate the concentration of carbon dioxide in it. They planned the structure of the cloud, taking into account the dimensions of the micro:bit, starting from the idea of using an ice cream box with a lid, which would be covered in cotton, inside which the electronic components would be placed. They simultaneously created an explanatory sketch of what the working prototype would look like.

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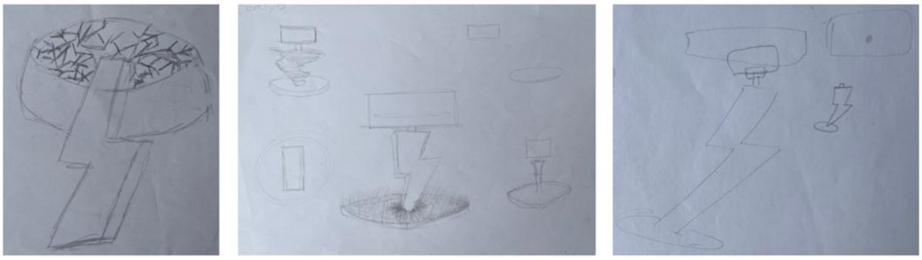
a) b)

a) In the written production you can read: "part where the sound will be released", "lights", the dimensions of the micro:bit 7cmx18.5cmx5cm and "how do I help my planet? b) In the written production it can be read: "Prototype CO2 detector" "automatically illuminated cloud". "Air is sustainable – If the air is sustainable, the cloud remains illuminated and plays a calm sound (wind, sound of herbs)" "Air is compromised – if the air is compromised, the cloud loses lighting and plays an alarming sound (thunderstorm, rain)"

The members of this group also planned possible structures to create a lightning bolt, to be made using modeling clay, with the sole function of serving as a base to balance the cloud.



During the project development phase, students explored using ChatGPT to program a sound like thunder. However, after several attempts, they were unable to achieve the desired sound. In search of an alternative solution, they turned to the "Blackbox" artificial intelligence platform, recommended for programming, and managed to obtain a sound that was closer to what they expected. Despite their success in creating the sound, students faced an additional challenge when testing it in the physical environment of the room and in noisier locations. They found that due to insufficient volume, the sound was not audible enough to convey the desired sensation of thunder. Given this technical limitation, the group concluded that including the sound of thunder would not be viable for the project.

This constraint, combined with constraints related to the lightning-shaped structure, led the students to introduce two changes to their initial idea: using a tree trunk instead of lightning and programming an alarm sound instead of the sound of thunder. According to the students, "Thanks to this, we were not only able to come up with a new idea for our work, but also created something even more creative than we had originally planned."

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[Group 3]

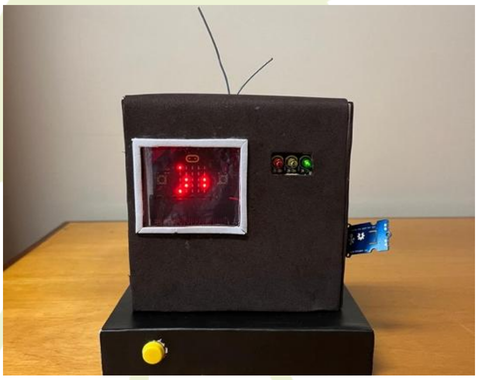
In the first phase, this group had several ideas for the prototype, but, considering its viability, they decided to build a television. This choice was more in line with the idea of the project: to create a television that would inform about air quality, similar to a weather report.

The students demonstrated a clear division of tasks. One of the group members devoted special attention to programming the carbon dioxide sensor, while the others worked on creating and building the prototype. However, the student most involved in programming maintained constant collaboration with her colleagues, both in coordinating the selection of components to be used and in designing solutions for the prototype.

While still evaluating the design and constraints, the group decided that they should make the prototype more realistic, discussing the best way to implement it.

The students considered that, in order to make their prototype more realistic and similar to a television, it would be necessary to include an on and off button. To implement this idea, they asked their subject teachers for help and asked if it would be possible to use a new component.

Upon receiving the new component, the students researched how to program it and developed a new sensor program. With the new program, the carbon dioxide concentration was only measured after pressing the button and while it was pressed. They modified and adapted the structure to include the button.



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[Group 4]

One of the members of this group already had previous experience with sensors. This prior knowledge, combined with new research into programming new components, allowed the group to develop more complex programming and include other technological elements, such as LEDs that illuminated the inside of the greenhouse, something that no other group had used. New components were added to the final prototype: a light that indicates whether the prototype is taking measurements or not and LEDs, constituting an improvement.

The students asked for help programming a fan, since it was not an element they had initially tested. When they realized that, despite turning, the fan did not have the desired effect - ventilating the space when carbon dioxide levels were high - they decided to abandon the idea of using it. This illustrates the students' ability to critically test and evaluate the effectiveness of their prototype components. The decision to abandon the fan after realizing its ineffectiveness demonstrates a pragmatic understanding of the design process, where adaptability and a willingness to reconsider approaches are key to achieving optimal results.



C. Experienced difficulties

	Please indicate one or more items
Understanding of the problem/ challenge	
Specific actions/ processes	X
Other (please specify): use of symbolic language	X

Field notes

Please illustrate the difficulties experienced by the participants during the implementation of the activity.

Example:

Some groups encountered difficulties both in terms of construction materials and in conceptualizing the prototype. For example, in group 4, the choice of cardboard proved to be an obstacle due to its hardness, and it was necessary to adapt the initial measurements and structure several times.

In one of the groups, there was clearly poor time management in carrying out the tasks, with a clear division between the students in the group and some difficulty in communication.

Difficulties were also detected with the use of symbolic language, in this case the chemical formula for carbon dioxide, as can be seen in two posters produced by the students.

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CO2 NA ATMOSFERA


A Era do Carbono
Como é medida a concentração de CO2?
A concentração de C02 refere-se à quantidade de dióxido de carbono que está presente em uma certa quantidade de ar.
A concentração deste é dada em valores extremamente pequenos, costumando-se utilizar a unidade parte por milhão (ppm).
Quais são os valores de referência para a concentração de CO2 atmosférico num espaço interior?
Segundo a comunidade científica, os níveis de CO2 devem manter-se abaixo de 800 partes por milhão. Este valor é frequentemente referido como um limite aceitável para espaços interiores, sendo valores superiores a 800 ppm associados a complicações de saúde, nomeadamente desconforto respiratório, fadiga e dificuldade de concentração.
O que pode levar a um aumento desta concentrção?
A queima de combustíveis, o aumento do uso de transportes, atividades industriais e agrícolas e a desflorestação são alguns exemplos de atividades que levam ao aumento dos níveis de CO2 presentes no ar.
E quais são as consequências do aumento de CO2 no ambiente e na atmosfera?
A alta concentração deste gás resulta na poluição do ar, causando chuvas ácida e desequilibrando o efeito estufa.
O aumento de dióxido de carbono na atmosfera tem também um impacto na saúde humana, sendo responsável pelo um aumento de doenças respiratórias e cardiovasculares, especialmente em crianças e idosos.
António, Bianca, Daniel, João A., Marcos, Miguel R.

Part 2
Assessment of the LHA

D. Relevance and Effectiveness

	Please indicate one or more items
Applicability of mobilized knowledge to real-life contexts.	X
Engagement of the participants in the activity (active participation, questions asked, and discussions generated).	X
Different subjects are considered and well-articulated in the implementation of the activity.	X
Participants' satisfaction with the activity.	X
Other (please specify):	

Field notes

Please illustrate the relevance and effectiveness of the activity.

Example:

Throughout the activity, the students demonstrated high levels of engagement and participated very actively, which also shows great satisfaction with the activity.

Even when plans "failed" and had to be changed, the students were tireless in discussing and seeking alternative solutions to the problems.

The knowledge developed in this task can be applied to real-life contexts, particularly in terms of the importance of monitoring carbon dioxide levels Likewise, the knowledge gained is related to aspects related to air pollution and its effects on the climate, ecosystems and human health.

This activity considers and articulates the following disciplines:

Science: Study of the effects of carbon dioxide

Engineering: construction of a portable, robust and appealing prototype

Technology: Programming and use of micro:bit.

Mathematics: Analysis of collected data.

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E. Consistency and Practicality

	Please indicate one or more items
Clarity of procedures	X
Coherence with the objectives to be achieved	X
Adequacy of resources, time and support and instructions	X
The activity can be adapted to different contexts or groups of participants	X
Other (please specify):	

Field notes

Please illustrate the consistency and practicality of the activity.

Example:

The activity is in line with the outlined objectives.

The procedures are clear.

Depending on the developed prototypes, some work can be done at home or one more lesson could be useful.

Material resources are adequate.

The activity is easily adapted to different contexts or participants.

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Best Practices Examples-LHA

Report Template

WP2

Introduction

This document aims to present the template for reporting Best Practices Examples of lighthouse activities (LHA) conducted during the implementation phase of the ICSE Factory project.

The template presented in this document is an improved version of a previous one and took into account the feedback provided by the partners, and the gaps and difficulties encountered in filling out the previous template.

The main objective of this reporting template is to collect data that illustrate international best practices, considering the field notes collected through the Observation Template.

The best practices examples will focus on the lighthouse activities developed and conducted during the implementation phase, covering the following dimensions:

1. Description of the activity
2. Description of the implementation process of the activity
3. The knowledge, skills, attitudes and beliefs developed by the learners.
4. The difficulties experienced by the learners, the strategies developed to overcome these difficulties and the key success factors of the lighthouse activities.
5. Overall assessment: final reflective remarks.

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Report Template: Best Practices Examples

1. Lighthouse Activity

Name of the activity:

Topic(s): *Please indicate the topic(s): Green Deal, Digitalization, Health*

Foundational aspect(s): *IBL, Real-life problems (RLP), SSI, CDI*

Possibilities of interdisciplinary integration: *Please indicate which subjects can be integrated*

Learning objectives: *Please indicate the main objectives of the activity*

2. Implementation Process

Date:

Local:

Duration:

Partners involved:

Target group:

Number of participants:

Number of female participants:

Age of the participants:

Description of the implementation process of the activity:

Please provide a short description of the implementation process, including the role of the partners and participants.

3. Knowledge, Skills, Attitudes and Beliefs

Please indicate the knowledge, skills, attitudes and beliefs that were developed by the learners.

4. Difficulties and Key Success Factors

Please indicate the main difficulties, the strategies used to overcome them and the key success factors of the activity.

5. Added value of the implemented activity for community members.

Please indicate additional benefit or positive impact that the activity offers to community members.

6. Reflective remarks

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Please provide a reflective text that summarizes the relevance of the implemented activity.

7. Additional material

Please add photos, activity guide, worksheets, etc.

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Annex C

Best Practice Examples by Country

Croatia

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Human body and measuring

1. Lighthouse Activity

Name of the activity: Human body and measuring

Topic(s): Health

Foundational aspect(s): Real-life problems (RLP), Problem-based learning (PBL)

Possibilities of interdisciplinary integration: Physics, medicine, mathematics

Learning objectives:

- To investigate and discover different ways of measuring, including the use of personal references
- To develop the skill of estimating and predication based on the correlated data
- To practice conversion between different ways of representing data (tables, graphs, words)
- Practice scientific thinking through a sequence of questions that foster critical thinking
- Collaborate and communicate effectively in team-based tasks
- Connect science and everyday care about health
- Develop confidence and a positive attitude toward science and engineering

2. Implementation Process

Date: 24/9/2024

Local: Elementary School Petar Lorini, Sali, Dugi Otok, Croatia

Duration: 45-60 minutes

Partners involved: Faculty of Science in Zagreb, Elementary School Petar Lorini from Dugi Otok

Target group: students, educators

Number of participants: 12

Number of female participants: 7

Age of the participants: 14-15

Description of the implementation process of the activity:

The activity has been implemented a spart of a two day visit oft he project partners from Zagreb to the island Dugi Otok. The programme consisted of a sequence of educational workshops. The preparation included selection of problems and organizing activities. The activity was organized to be interactive and engaging with the emphasis of students‘ reasoning and communication of ideas.

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The students were guided by the instructor to think about various questions concerning the measurements of the human body. The focus was to observe data in various forms (representations), some of which the students have not learned in school, but are exposed to in everyday life in media. The workshop was organized into four sections or themes, which are interconnected by the pedagogical approach and use of different mathematical representations.

3. Knowledge, Skills, Attitudes and Beliefs

In the first set of questions students were asked to discuss the height of a person in relation to their steps, measurements of part of body and to use various measuring units, especially informal ones from the classrooms, such as the chair. In this section the students have gained insight into personal references and practiced their creative and lateral thinking.

In the second set of questions the students have investigated their heartbeat rate and discussed the correlation between age and heartbeat rate. Based on the given data, the students have discussed and discovered a linear dependency and used it to predict new values.

In the third section, the students were invited to explore different types of dependencies, not only linear. Based on different graphs, they have learned the concept of correlation and discussed the difference between causality and correlation. This section has supported students' critical thinking and communication of argumentation.

In the final section, the students were invited to make calculations related to the absorption of a medicine. This context is relatable to the students, but also provides opportunities to discuss relevant attitudes and habits about the importance of following doctor's guidelines. Repeated intake of the medicine produces a periodic behaviour in the human body and students were invited to investigate other periodic processes based on the graphical representations.

The workshop helped students to develop positive attitudes towards life science, critical thinking and data-driven reasoning.

4. Difficulties and Key Success Factors

An important aspect of the workshop is that the group of students was small which made it possible for everyone to interact in the discussion. Students were at first a bit shy, but already the first activity engaged them.

Also, the students have not met the instructor before, so there might have been a distance between them. This challenge has been overcome in the first part of the workshop with open communication of the instructor. It seems crucial that there have been many questions posed to the students that they very open answers to and that these answers were listened and further explored in the discussion.

The participants were guided by questions of the form “What would you do?”, “Do you agree with your peers?” and “How do you know?”. Such questions are well-known to encourage curiosity and involvement of students when combined with attention to what the students are interested in and want to consider.

For the instructor it is also challenging that the students vary in prior knowledge, but this was addressed by shifting the level of complexity of the discussion during the activity.

A key success factor is the novelty that a visit of academic professor brings to a small and isolated school. Students were curious and hence collaborated with enthusiasm. Another aspect that made the workshop successful is that this was not the first time that the instructor used such and similar activities, so it was easier to fit the activity to the interests and level of knowledge of the students.

5. Added value of the implemented activity for community members.

As the activity was of a part of a two-day visit of partners to the elementary school on an island, there has been ample of opportunity to foster a new network with the local educators. The local teachers also joined the workshop and the reflection with them about the workshop provided a special type of education close to the format of Lesson Study or some other Community of Practice. The local teaches observed the workshop as a special type of a lesson and afterwards various pedagogical and didactical aspects have been discussed.

The topic, discourse and the style of interaction engaged students, and following the workshop their interest in health and human body has been notable. The activity raised awareness about the scientific approach to everyday activities and our health.

6. Reflective remarks

This Lighthouse Activity has proved to show a successful strategy for establishing a connection between students and scientist by using the principles of open communication, mystery, scientific approach and choice of relevant topics. While the activity focused on questions about human body, which triggers

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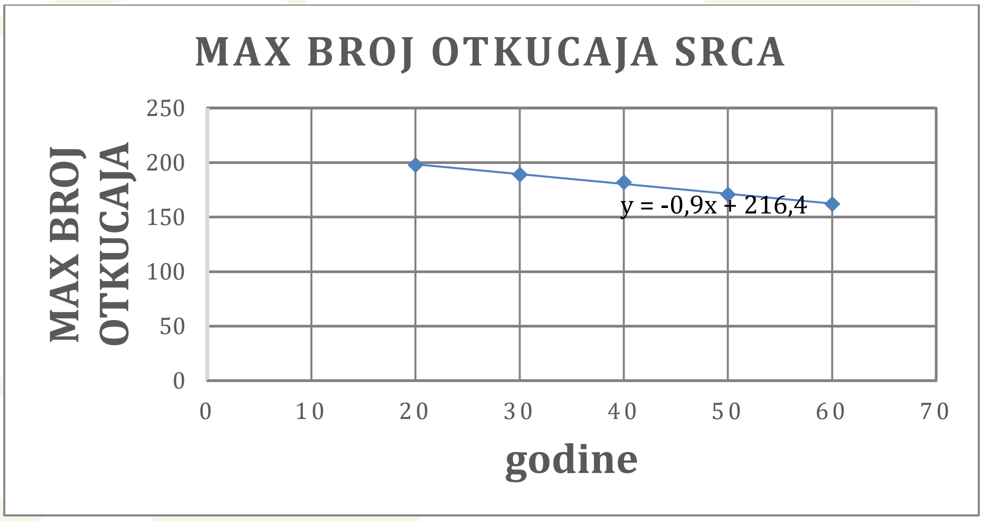
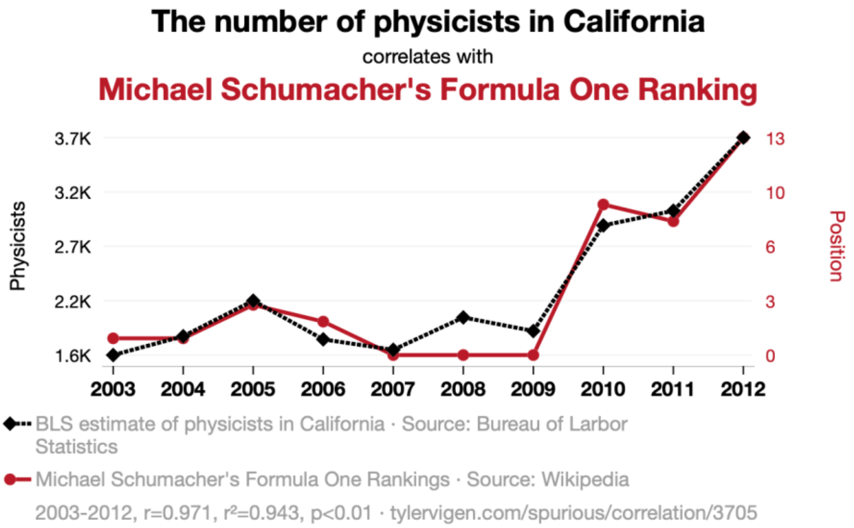
development of knowledge from biology, it has provided an opportunity to approach many different parts of mathematics that might be considered too advanced and abstract when taught in high school without an engaging context that can further support students’ reasoning in solving problems.

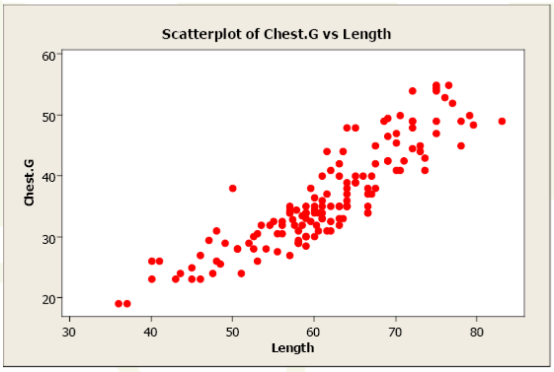
The overall event, of which this workshop was only a part of, was an example of building a partnership that emphasizes the positive attitude towards science which might stem not only from curiosity and fun or relevant topics, but also from the warm and empowering interaction of students with the scientists.

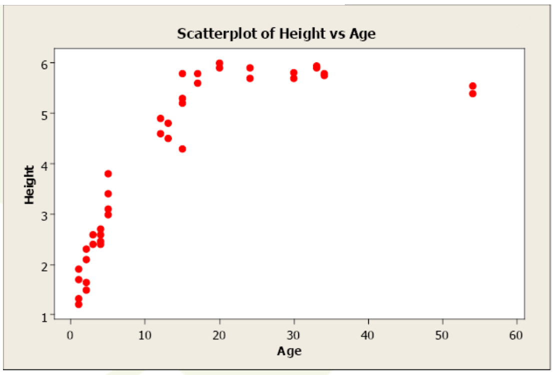
7. Additional material

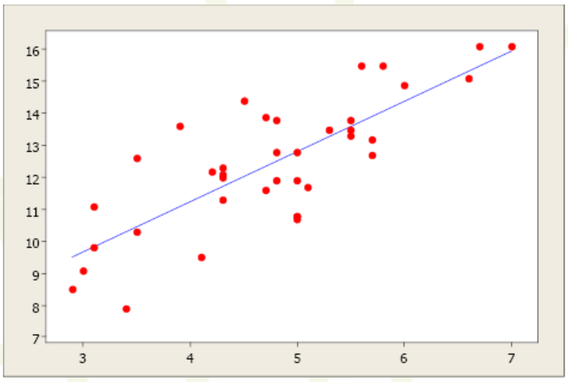
Examples of graphs used in the workshop

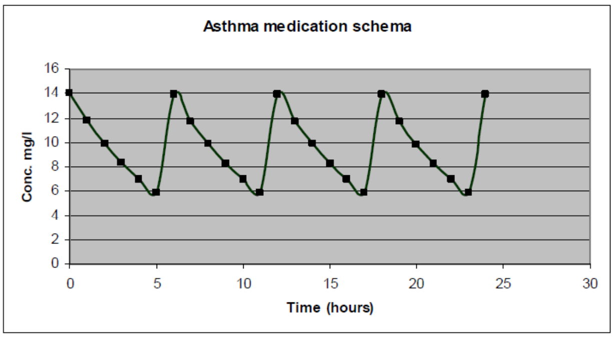












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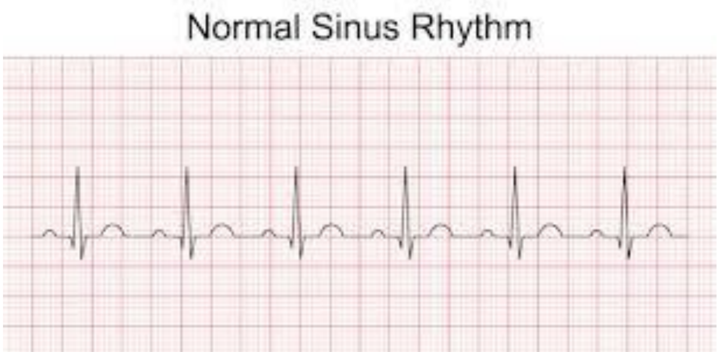
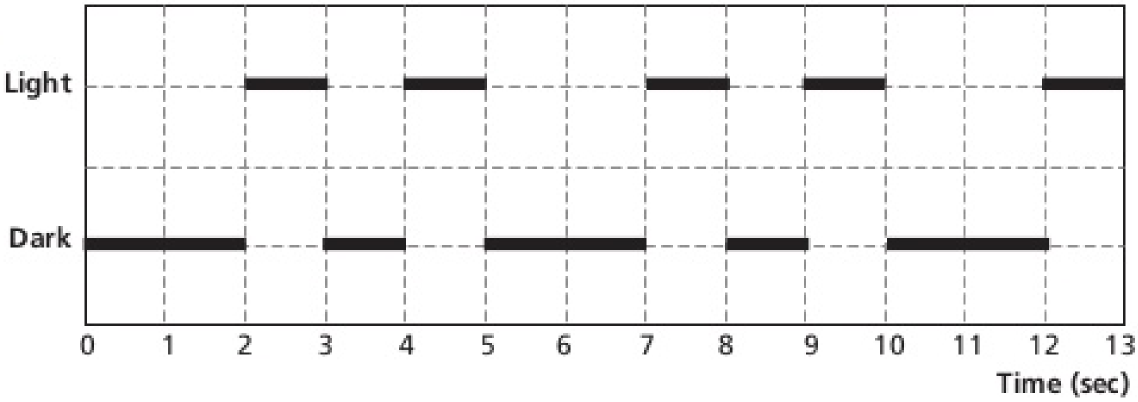


MATHEMATICS UNIT 43: LIGHTHOUSE

Lighthouses are towers with a light beacon on top. Lighthouses assist sea ships in finding their way at night when they are sailing close to the shore.

A lighthouse beacon sends out light flashes with a regular fixed pattern. Every lighthouse has its own pattern.

In the diagram below you see the pattern of a certain lighthouse. The light flashes alternate with dark periods.



It is a regular pattern. After some time the pattern repeats itself. The time taken by one complete cycle of a pattern, before it starts to repeat, is called the *period*. When you find the period of a pattern, it is easy to extend the diagram for the next seconds or minutes or even hours.

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Soft Robotics – Building and Testing a Universal Soft Gripper

1. **Lighthouse Activity**

Name of the activity: Soft Robotics – Building and Testing a Universal Soft Gripper

Topic(s): Sustainability, Digitalization

Foundational aspect(s):

IBL (Inquiry-Based Learning): Students explored mechanical design and actuation by constructing their own soft robotic grippers and testing them on various objects.

RLP (Real-Life Problems): The activity addressed the challenge of designing adaptable grippers for handling diverse objects using simple materials.

SSI (Socio-Scientific Issues): Focused on sustainability by using biodegradable 3D-printed materials and accessible, reusable resources from daily life.

CDI (Contextualized Daily Issues): Grounded in everyday materials like balloons, coffee, and syringes to bridge robotics principles with accessible learning.

Possibilities of interdisciplinary integration: Mechanical Engineering, Material Science, Physics (air pressure, mechanics), Environmental Education (sustainability), Chemistry (granular materials), ICT (3D printing technology), Design and Technology

Learning objectives:

- Understand the principle of granular jamming and pneumatic actuation in soft robotics.
- Learn basic assembly techniques combining 3D-printed components and household materials.
- Explore sustainable materials in engineering design.
- Foster creativity and problem-solving in designing functional mechanical devices.
- Develop skills in iterative testing, observation, and performance improvement.

2. **Implementation Process**

Date: 5 June 2025.

Local: High school

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Duration: Single-session event consisting of a 45-minute interactive lecture followed by a 45-minute hands-on lab session

Partners involved: Faculty of Electrical Engineering and Computing (FER), local high school educators

Target group: High school students (ages 14-17)

Number of participants:60

Number of female participants:20

Age of the participants: 14-17 years

Description of the implementation process of the activity:

This activity was designed as a hands-on introduction to soft robotics through the construction of a simple, sustainable soft gripper. The session began with an interactive lecture where students were introduced to the basics of soft robotics, including its applications in industry, medicine, and everyday problem-solving. Following the lecture, students transitioned into a practical workshop where they built their own soft robotic grippers using accessible materials such as balloons, syringes, coffee, rice, and 3D-printed components made from biodegradable plastics.

Each group of students assembled their gripper by integrating mechanical components and granular fillings to create a pneumatically controlled grasping device based on the principle of granular jamming. They learned to set up and test their grippers on a variety of classroom objects with differing shapes and weights. The activity concluded with live demonstrations of the students' grippers, testing their effectiveness on selected items and discussing design improvements and observed limitations.

3. Knowledge, Skills, Attitudes and Beliefs

Through the activity, students gained knowledge about basic principles of soft robotics, including mechanical flexibility, granular jamming, and the use of negative pressure for actuation. They developed practical manual skills in assembling mechanical components, using adhesives, and setting up simple pneumatic systems.

Importantly, the session fostered a shift in attitude regarding the accessibility of robotics. Students realized that functional robotics systems could be built from simple, everyday materials rather than expensive high-tech components. They also developed an appreciation for sustainability in engineering, using 3D-printed parts made from biodegradable plastics and filling materials sourced from household

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products. The activity cultivated a sense of creativity, curiosity, and confidence in using their own hands to solve engineering problems.

4. Difficulties and Key Success Factors

One of the most significant difficulties was the need to engage a diverse group of students, some of whom had no prior exposure to robotics. While many students are comfortable using smartphones and computers, the conceptual leap to understanding basic principles like pneumatic actuation, air pressure, and granular jamming proved to be a challenge. Initial difficulties in assembling components and preventing air leaks from the gripper structure required patient guidance and trial-and-error problem-solving.

An additional challenge came from keeping the students focused during the assembly phase, particularly for those who struggled with the fine motor skills required for handling balloons, glue, and small 3D-printed parts. However, the immediate visual feedback of success—when the gripper was able to lift or manipulate objects—served as a powerful motivator. The key success factor of this workshop was the tangible, immediate gratification from creating a functioning device, as well as the flexibility for students to experiment with different fillers and object types.

5. Added value of the implemented activity for community members.

This activity provided a unique opportunity for the broader high school community to experience an applied, creative side of STEM education. By focusing on sustainability, simplicity, and do-it-yourself building, the workshop expanded awareness of soft robotics beyond theoretical classroom learning. Students became enthusiastic ambassadors of their work, demonstrating their self-made devices to peers, teachers, and family members. Teachers gained valuable insight into project-based learning and its positive impact on student engagement. Additionally, the workshop introduced the idea that robotics is not exclusively high-tech but can be practical, approachable, and environmentally conscious.

6. Reflective remarks

This activity demonstrated the power of hands-on learning in making complex topics like robotics accessible to young learners. By constructing a soft robotic gripper from simple, sustainable materials, students developed a foundational understanding of soft robotics, mechanical design, and pneumatic control. The direct engagement with physical materials provided a learning experience that transcended abstract concepts, translating technological curiosity into creative confidence. The activity proved that even complex engineering disciplines can be demystified and made enjoyable when students are allowed to experiment, fail, and succeed through building and testing their own creations.

7. Additional material

- *Activity manual*
- *Pictures*

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ICSE Smart Plants

Smart and Sustainable Plant Growing – Three-Week Experimental Workshop with Sensor Technologies

1. **Lighthouse Activity**

Name of the activity: Smart and Sustainable Plant Growing – Three-Week Experimental Workshop with Sensor Technologies

Topic(s): Green Deal, Digitalization

Foundational aspect(s):

- IBL (Inquiry-Based Learning): Students investigated plant growth by conducting experiments using sensors over an extended period.
- RLP (Real-Life Problems): Activities tackled realistic challenges in optimizing plant growth conditions in agriculture.
- SSI (Socio-Scientific Issues): The workshops explored the impact of human agricultural practices on sustainability, resource use, and environmental responsibility.
- CDI (Contextualized Daily Issues): Students applied technology to monitor plant care, connecting school activities with real-world agricultural needs.

Possibilities of interdisciplinary integration: Biology, Chemistry, Physics, Environmental Science, Mathematics, Electronics, Information and Communication Technology (ICT), Sustainability Education

Learning objectives:

- Understand the influence of environmental parameters (water, light, temperature, humidity, pH) on plant growth.
- Learn to apply sensor technologies for monitoring plant health.
- Develop basic electronics and programming skills using microcontrollers and digital sensors.

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- Foster responsible attitudes towards natural resources and promote sustainability through technology.
- Practice data collection, analysis, and communication skills by presenting experimental results.

2. Implementation Process

Date: 8.3.2024. – 26.3.2024.

Local: Classroom setting with live plant experiments

Duration: 3 weeks, structured in four 90-minute weekly workshops with daily plant monitoring by students

Partners involved: **Faculty of Electrical Engineering and Computing (FER), local primary school educators**

Target group: Primary school students (ages 11-14)

Number of participants: 16

Number of female participants: 12

Age of the participants: 11-14 years

Description of the implementation process of the activity:

The *"Smart and Sustainable Plant Growing"* program was organized as a continuous three-week educational activity integrating four separate lighthouse workshops. Each workshop addressed a key environmental factor influencing plant growth: soil moisture, light intensity, air temperature and humidity, and soil pH. Students were introduced to modern agricultural practices through hands-on sessions involving low-cost sensor technology, connected via ESP32 microcontrollers and visualized using mobile applications.

The workshops were sequential, each building on the knowledge of the previous session. Between workshops, students monitored their plants daily, collecting sensor data and observing plant responses to various treatments. The activity was implemented in a classroom setting, using common plant species, simple electronics, and structured observation logs. Each week, lighthouse activities served to introduce new topics, refocus student attention, and deepen their understanding. The final phase included preparation of summary posters and oral presentations delivered to their peers during broader school

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events, allowing the students to share the knowledge and experiences they gained throughout the program.

3. **Knowledge, Skills, Attitudes and Beliefs**

During the three-week activity, students significantly expanded their knowledge of plant biology, environmental conditions, and sustainable agricultural practices. They gained practical skills in using soil moisture sensors, light intensity sensors, temperature and humidity probes, and pH meters. They also learned to work with simple microcontroller systems and understood the basics of how sensor data is collected and interpreted.

An important insight was that despite children's familiarity with modern technology through smartphones, many struggled to grasp basic technological concepts such as sensors, electric circuits, and programming. The hands-on aspect of the workshops helped bridge this gap, providing concrete experiences to support their theoretical learning.

The program promoted positive attitudes towards technology as a tool for solving real-life sustainability challenges. It fostered curiosity about the natural world, responsibility towards living organisms, and awareness of resource efficiency in agriculture. A significant observation was the ethical reflection triggered by some children being tasked with applying stress treatments to plants, prompting valuable discussions about the impact of human actions on living beings.

4. **Difficulties and Key Success Factors**

One of the key difficulties encountered was maintaining continuous focus and motivation among students during the long multi-week activity. Extended plant observation phases risked disengagement, especially in the absence of immediate visual change. Weekly lighthouse workshops proved to be a crucial engagement tool, allowing children to reset their focus, learn new content, and remain motivated by having intermediate milestones.

Another challenge was student discomfort with roles involving deliberate plant stress, such as limited watering or restricted light exposure. This issue, while initially difficult, ultimately became a pedagogical opportunity to discuss ethical experimentation and the responsibilities humans have towards the environment.

Finally, a consistent difficulty was the initial barrier students faced in understanding basic electronics and sensor technology, which required repeated hands-on activities and scaffolded explanations. The most important success factor was the practical and interdisciplinary nature of the activity, combining biology, chemistry, physics, mathematics, and ICT into a coherent educational experience, grounded in real-life problems and relevant environmental themes.

5. Added value of the implemented activity for community members.

The activity had significant positive effects beyond the classroom. Students presented their findings and summary posters during other school events, sharing insights with peers and teachers who were not directly involved in the workshops. This broadened the community's exposure to sustainable agricultural concepts and practical applications of sensor technologies.

Moreover, the activity stimulated discussions within families, with children bringing home new knowledge about optimal plant care, responsible resource use, and technology in food production. Teachers gained valuable experience with interdisciplinary, technology-integrated teaching methods, opening opportunities for similar activities in future curricula.

6. Reflective remarks

This three-week activity successfully demonstrated how sustained, inquiry-driven learning combined with digital tools can provide children with meaningful knowledge and practical skills. The structure of recurring weekly workshops was essential in maintaining student engagement and ensuring gradual learning progression. While some challenges arose in comprehension of technical topics and ethical dilemmas around plant care, these were addressed constructively, turning difficulties into learning opportunities.

The workshops empowered students to not only understand the science behind plant growth but also to become advocates for sustainable practices within their community. The experience highlighted the importance of interactive, hands-on learning, the value of interdisciplinary education, and the potential of school-based experiments to instill responsible environmental behavior and technological literacy at an early age.

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7. Additional material

- *Workshop manual: "Smart and Sustainable Plant Growing: Growing Responsibly".*
- *Supporting slides*
- *Student worksheets and measurement logs*

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Ballon Rocket Challenge

1. **Lighthouse Activity**

   Name of the activity: Ballon Rocket Challenge

   Topic(s): Green Deal

   Foundational aspect(s): Real-life problems (RLP), CDI

   Possibilities of interdisciplinary integration: Physics, engineering, environmental science

   Learning objectives:

   - Design and improve balloon-powered vehicles using basic engineering principles.
   - Practice scientific thinking through hands-on testing and redesign.
   - Collaborate and communicate effectively in team-based tasks.
   - Connect science and technology to environmental sustainability challenges.
   - Develop confidence and a positive attitude toward science and engineering through playful learning.

2. **Implementation Process**

   Date: 30/1/25

   Local: University of Nicosia campus

   Duration: 45-60 minutes

   Partners involved: CPI

   Target group: students, parents, educators

   Number of participants: 40

   Number of female participants: 25

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Age of the participants: 7-50

Description of the implementation process of the activity:

The Balloon Rocket Challenge was implemented during a local science fair as a public, interactive activity designed to engage both students and their parents. The preparation phase involved selecting simple, accessible materials (eg. balloons, straws, string, tape, and paper clips) and setting up guided tracks along which the balloon rockets would travel. The activity was designed to be low-tech but high-engagement, aligning with the themes of sustainability and accessible science education.

On the day of the event, participants visited the designated booth and received a short introduction from facilitators on the basic scientific principles behind the challenge, as well as how this relates to sustainable propulsion systems. The facilitators also briefly introduced the Green Deal context, encouraging participants to think about how simple engineering concepts can contribute to cleaner, fuel-free transport solutions.

Participants formed teams and began experimenting with different rocket designs. Facilitators moved among the teams, providing light guidance while encouraging participants to test, observe, adjust, and re-test their rockets. This iterative process fostered experimentation, creativity, and teamwork.

The activity culminated in a final race, where each team launched their balloon rocket along the track. The event created a lively, fun atmosphere, as teams cheered for one another and compared results. Small symbolic prizes were awarded to the fastest rockets, but the focus remained on learning through play, teamwork, and awareness of alternative propulsion methods.

The open structure of the activity allowed participants to join at any time throughout the fair, and the materials used made it easy for others to replicate the activity at home or in a classroom. The simplicity of the setup, combined with its strong connection to real-world sustainability themes, contributed to its success.

3. Knowledge, Skills, Attitudes and Beliefs

The Balloon Rocket Challenge provided participants both students and their parents, with a playful yet meaningful introduction to basic scientific concepts, engineering thinking, and environmental awareness. The activity fostered both cognitive and affective learning outcomes, encouraging families to learn and problem-solve together.

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Participants gained a clearer understanding of Newton's Third Law of Motion, as they observed how the release of air from a balloon could create forward motion. Through this hands-on demonstration, learners connected abstract scientific theory to a tangible outcome. They also became familiar with the concept of fuel-free propulsion, linking it to current conversations around sustainable vehicle design and the importance of clean, renewable energy in the context of the European Green Deal.

In terms of skills, learners developed problem-solving and design-thinking abilities by engaging in trial-and-error experimentation. They tested multiple rocket designs, adjusted materials, and refined their approach to improve performance. These iterative processes nurtured creativity, critical thinking, and basic engineering reasoning.

The activity also strengthened collaborative and communication skills, particularly as students and their parents worked together as a team. This intergenerational engagement helped foster a shared learning experience and created an open, supportive atmosphere in which participants could discuss scientific ideas regardless of age or background.

From an attitudinal perspective, the activity inspired curiosity about science and engineering while also promoting positive attitudes toward sustainability. Participants were encouraged to consider how innovative, simple technologies can contribute to more environmentally responsible solutions in real life. Many left the activity not only with new knowledge but also with a greater appreciation for the role of science in addressing global challenges, and a belief that learning can be both fun and relevant.

4. Difficulties and Key Success Factors

Although the activity was designed to be simple and accessible, participants encountered a few initial challenges that became valuable learning moments. One of the most common difficulties involved the construction and stability of the rockets. Some teams struggled to properly align the balloon with the straw or secure the components in a way that allowed for smooth motion along the track. These issues often led to rockets veering off course or losing speed prematurely.

Rather than treating these as failures, facilitators encouraged teams to approach the problem through trial-and-error experimentation. Participants were guided to ask questions such as: "What's causing the rocket to tilt?" or "How can we reduce friction?" This process helped learners not only overcome the difficulties but also build confidence in their ability to improve through iteration. The simplicity of the materials used made it easy to try new designs without risk or pressure.

Another minor challenge was the variation in prior knowledge. To address this, facilitators provided brief, informal explanations that connected scientific theory to what participants were observing in the activity. These quick interventions helped make the science both accessible and relevant.

A key success factor of the activity was the collaboration between students with their parents, the activity created a collaborative learning environment that was engaging and inclusive. The competitive element (culminating in a fun final race) added excitement without undermining the educational goals.

Equally important was the low-barrier, high-interest format. Using everyday materials and a familiar concept (a race), the activity succeeded in attracting a wide range of participants. Its alignment with the Green Deal theme, emphasizing fuel-free propulsion and sustainable design, added depth and real-world relevance to what may have otherwise seemed like a simple game.

Overall, the activity demonstrated that combining playful competition, scientific inquiry, and sustainability can lead to highly effective and memorable learning experiences, even within a short time frame.

5. Added value of the implemented activity for community members.

The Balloon Rocket Challenge offered significant added value to the community by transforming a scientific concept into a fun, inclusive, and thought-provoking experience that could be enjoyed by families, educators, and children alike. Taking place during a local science fair, the activity served as a platform for informal science education that was accessible to all, regardless of background or academic experience.

One of the most important contributions of the activity was its ability to engage both students and their parents in co-learning. By working together to design balloon-powered rockets, families participated in meaningful scientific dialogue, often discovering new ways of communicating and problem-solving as a team. This collaboration strengthened community bonds and highlighted the role of shared learning in science education.

The activity also raised awareness about sustainable transport and fuel-free propulsion, connecting a playful challenge with larger societal issues linked to the European Green Deal. It offered a simple yet powerful example of how even basic engineering designs can promote reflection on environmental impact, innovation, and the future of mobility.

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In addition, the event brought energy and excitement to the science fair environment. The festive, game-like atmosphere encouraged spontaneous learning, curiosity, and community engagement with science. Finally, the activity left a lasting impression by showing that scientific inquiry does not require expensive equipment or formal settings. Its low-cost, do-it-yourself nature made it replicable in schools, clubs, and even at home, further extending its impact and empowering community members to take science beyond the fair.

6. Reflective remarks

The Balloon Rocket Challenge proved to be a highly relevant and effective Lighthouse Activity that encapsulated the principles of open schooling, environmental education, and hands-on science learning. By engaging students and their parents in a collaborative, playful, and competitive experience, the activity successfully created a space where scientific inquiry and sustainability could be explored in a way that felt immediate, fun, and meaningful.

At its core, the activity addressed the broader objectives of the European Green Deal by drawing attention to fuel-free propulsion and the need for more sustainable approaches to everyday systems, like transportation. While the activity was simple in design, it opened up important conversations about energy use, resource efficiency, and how innovative thinking can lead to greener futures.

The rocket-building process served as a mini-engineering challenge, empowering learners of all ages to experiment, test ideas, and problem-solve. More importantly, it demonstrated that science is not only a subject to be studied but a process to be lived, through curiosity, teamwork, and real-world relevance.

One of the most powerful aspects of the activity was the shared sense of excitement and discovery that it generated among participants. The mix of learning and laughter fostered a positive emotional connection to science, which is often missing in formal education contexts. It also gave parents a rare opportunity to engage with their children in a STEM-based activity, helping bridge generational gaps in science confidence and interest.

In reflection, the Balloon Rocket Challenge showed that even small-scale, low-cost activities can have deep educational value when they are well-designed, contextually relevant, and open to public participation. It reinforced the idea that science fairs can be more than showcases, they can be living laboratories of community-based learning and innovation.

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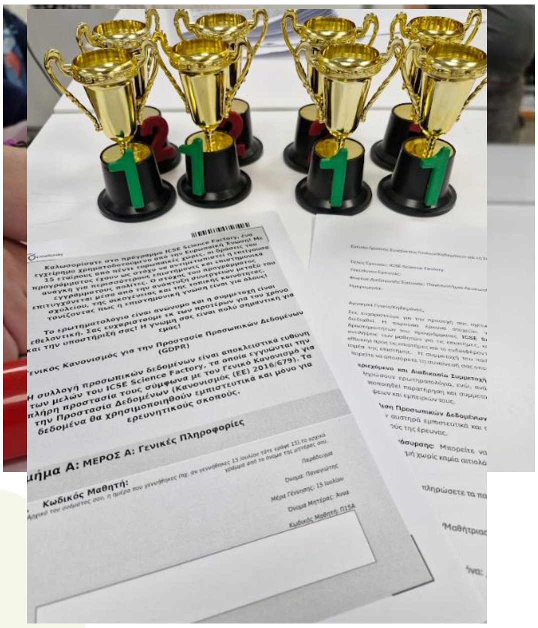
7. Additional material



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3D Printing in Buoyancy and Flotation Teaching

1. Lighthouse Activity

Name of the activity: 3D Printing in Buoyancy and Flotation Teaching

Topic(s): Digitalization

Foundational aspect(s): CDI

Possibilities of interdisciplinary integration: STEAM subjects

Learning objectives:

- Deepen understanding of buoyancy and flotation through hands-on exploration.
- Gain practical experience in 3D design and printing for use in science teaching.
- Explore the integration of digital tools in STEM education.
- Reflect on the use of physical models to support inquiry-based and conceptual learning.
- Strengthen interdisciplinary teaching approaches by connecting science, technology, and mathematics.
- Develop confidence and motivation to implement innovative, student-centered instructional practices.

2. Implementation Process

Date: 30/11/24

Local: CYPRUS STEAME FESTIVAL

Duration: 60 min

Partners involved: STEAME Festival, CPI, UNIC

Target group: educators

Number of participants: 6

Number of female participants: 3

Age of the participants: 35-60

Description of the implementation process of the activity:

The 3D Printing in Buoyancy and Flotation Teaching activity was implemented during the Cyprus STEAME Festival as a specialized session for STEM educators. The goal was to explore how 3D printing can be

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effectively integrated into science teaching, particularly for visualizing and experimenting with concepts related to buoyancy and flotation.

In the preparation phase, the project team pre-printed a variety of 3D geometric shapes, including both hollow and solid models of similar size, to demonstrate how structural differences impact floating behavior. These shapes served as foundational tools for investigating key physical principles such as density, volume, and displacement.

The session began with a brief theoretical introduction to the core physics concepts (e.g., Archimedes' Principle) and their relevance to everyday phenomena and science curricula. Following this, educators were invited to engage hands-on with the 3D printers, not only by testing the pre-made shapes in water but also by designing and printing their own models. This aspect of the session provided participants with direct experience in 3D design software and allowed them to observe the complete cycle of digital-to-physical learning tools.

The process of creating and testing their own shapes gave educators a deeper understanding of the potential of 3D printing in classroom environments, while also highlighting the importance of tangible, inquiry-based teaching methods. Participants worked in small groups to compare results, interpret observations, and reflect on the learning opportunities such models could offer their students.

Facilitators supported the process throughout, encouraging collaboration, guiding discussion, and helping educators link the hands-on experience to pedagogical strategies for different educational levels. The session also prompted broader reflection on how to incorporate digital tools into interdisciplinary STEM teaching, especially by connecting physics with mathematics, technology, and engineering principles.

The activity was very well received, and many educators expressed enthusiasm about adopting similar practices in their own schools.

3. Knowledge, Skills, Attitudes and Beliefs

The 3D Printing in Buoyancy and Flotation Teaching activity provided STEM educators with the opportunity to enhance both their content knowledge and pedagogical practice, particularly in relation to hands-on, inquiry-based science instruction.

From a conceptual standpoint, participants deepened their understanding of buoyancy, flotation, mass, volume, density, and fluid displacement. The use of 3D-printed shapes allowed educators to visualize and

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manipulate these variables in a controlled, physical context. This reinforced core physics concepts in a way that was both engaging and applicable to classroom teaching.

In terms of skills, educators developed basic 3D design and digital fabrication competencies, including how to use the software to model simple objects and operate a 3D printer. The hands-on experience helped demystify the technology and increased their confidence in using it as a pedagogical tool. Additionally, participants practiced collaborative problem-solving and critical reflection, as they designed, printed, and tested models in teams.

Importantly, the activity helped foster positive attitudes toward integrating technology in science education. Many educators expressed a shift in perspective, from viewing 3D printing as a technical or engineering tool to recognizing its potential for enhancing conceptual understanding in physics and other sciences. This shift was accompanied by increased curiosity and motivation to explore interdisciplinary teaching methods.

Furthermore, the experience reinforced educators' beliefs in the value of student-centered learning, where learners actively construct knowledge through exploration and experimentation. Participants saw first-hand how physical models can support differentiated learning and help students visualize invisible scientific principles.

Overall, the activity inspired a sense of agency and innovation among educators, who left with practical ideas for integrating 3D-printed materials into their own curricula to support deeper, more interactive science learning.

4. Difficulties and Key Success Factors

During the 3D Printing in Buoyancy and Flotation Teaching activity, most educators had limited or no prior experience with 3D design software or 3D printer operation, which initially created uncertainty and hesitation, especially during the design phase. Some participants struggled with using the digital tools to create printable shapes.

To address this, facilitators provided step-by-step guidance and real-time mentoring throughout the session. The learning environment was intentionally informal and supportive, allowing participants to ask questions, share challenges, and work collaboratively. Pre-prepared printable templates were also available for those who preferred to start with a basic model before attempting their own designs.

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Time constraints were another minor challenge, as the printing process takes time and limited the number of custom models each group could produce. To mitigate this, some participants continued their exploration after the session, encouraged by the practical value of what they had learned.

Despite these challenges, the activity was successful due to several key factors:

Scaffolded support and mentoring: Continuous facilitator guidance helped participants move confidently from unfamiliarity to active engagement.

Immediate hands-on experience: Designing, printing, and testing their own models enabled educators to experience the full learning cycle.

Strong conceptual connection: The activity maintained a clear link between the use of 3D printing and the core scientific concepts being explored, reinforcing both understanding and pedagogical value.

Collaborative atmosphere: The group setting encouraged knowledge exchange and reflection on how such tools can be used effectively in diverse classroom contexts.

Innovation and relevance: The novelty of 3D printing, combined with its direct relevance to real-world teaching needs, made the activity highly motivating and memorable.

These factors contributed to a successful professional learning experience and laid the groundwork for future classroom applications.

5. Added value of the implemented activity for community members.

The activity offered significant added value to the educators seeking innovative, hands-on approaches to science teaching. By focusing on both conceptual understanding and technological integration, the activity provided a practical model for interdisciplinary STEM education that participants could immediately relate to their own classroom contexts.

One of the main contributions of the activity was its role in bridging the gap between emerging technologies and everyday teaching practices. Educators were able to experiment directly with 3D design and printing, tools that are often perceived as complex or inaccessible. This hands-on experience built confidence and equipped them with the knowledge needed to introduce similar practices in their schools, thus supporting the broader diffusion of educational innovation.

The activity also sparked peer exchange and collaboration, as participants shared ideas, teaching strategies, and reflections during the session. It created a space for educators to engage in professional

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dialogue around how to make abstract physics concepts more accessible to students through tangible, inquiry-based learning tools.

From a systemic perspective, the session reinforced the idea that educator empowerment and capacity-building are essential for the successful implementation of STEAM education frameworks. By offering teachers the opportunity to take on the role of learners, experimenters, and innovators, the activity contributed to a culture of lifelong learning and reflective practice.

Finally, the visibility of the activity within the Cyprus STEAME Festival helped highlight the importance of equipping teachers with the tools and experiences needed to modernize science education. It positioned 3D printing not just as a technical skill, but as a pedagogical resource that can enhance engagement, foster deeper learning, and support cross-curricular connections in meaningful ways.

6. Reflective remarks

The 3D Printing in Buoyancy and Flotation Teaching activity proved to be a compelling and impactful professional learning experience that demonstrated the powerful intersection of technology, pedagogy, and science education. By enabling educators to engage directly with 3D design and digital fabrication tools, the activity demystified emerging technologies and emphasized their practical classroom application, especially for teaching abstract scientific concepts.

Participants gained valuable insights into both the scientific content and the instructional benefits of using tangible models to support inquiry-based learning. The opportunity to design, print, and test their own objects created a sense of ownership, experimentation, and curiosity that mirrors what we aim to foster in students.

Importantly, the session reinforced the idea that meaningful professional development involves active participation and reflection, not passive instruction. By positioning educators as co-learners and co-designers, the activity created space for innovation, collaboration, and skill development.

In reflection, this Lighthouse Activity highlights the transformative potential of STEAM approaches that combine hands-on experimentation with technological fluency. It serves as a model of how educators can lead the way in modernizing science education, equipping learners with both conceptual understanding and 21st-century skills.

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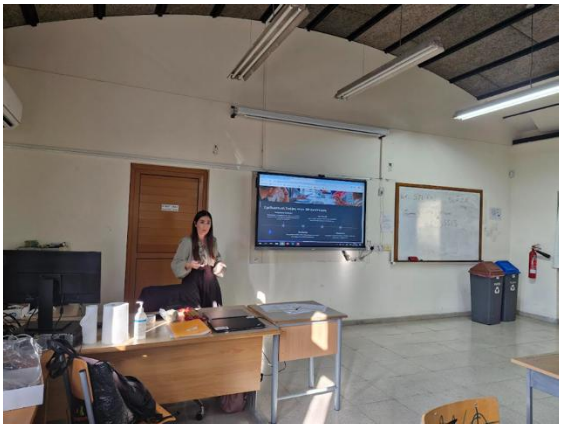
7. Additional material



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Learn about antibiotic and medical waste

1. Lighthouse Activity

Name of the activity: Learn about antibiotic and medical waste

Topic(s): Green Deal, Health

Foundational aspect(s): Real-life problems (RLP), SSI

Possibilities of interdisciplinary integration: biology, chemistry, environmental science

Learning objectives: Explain the environmental and health risks associated with improper disposal of antibiotics and pharmaceutical products. Demonstrate awareness of correct disposal practices and recognize institutions or procedures that facilitate safe medication return and recycling. Engage in critical thinking and decision-making, using scientific reasoning to navigate complex, real-life inspired scenarios. Reflect on personal behavior and societal responsibility in preventing antibiotic resistance and environmental pollution.

2. Implementation Process

Date: 7/4/2024

Local: mall of cyprus

Duration: 30 minutes

Partners involved: Multipliers Project, CP. Foodlab, Unic Medical School

Target group: public

Number of participants: 40+

Number of female participants:

Age of the participants: 7 to 50

Description of the implementation process of the activity:

The Learn about Antibiotic and Medical Waste activity was implemented as part of a larger science fair open to the general public. The activity was carefully designed to encourage informal learning and active engagement around the complex issue of medical and antibiotic waste management.

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The preparation phase involved the development of a large-scale, interactive board game. The project team collaborated to create fictional but realistic characters, including a doctor, citizen, environmentalist, and pharmacist, each representing different roles and perspectives in the medical waste cycle. The board game included scenario and question cards, carefully curated to prompt reflection and discussion on the use of antibiotics, environmental safety, and responsible disposal practices.

On the day of the science fair, the game was set up at an accessible, highly visible booth. Facilitators from the project team guided participants through the rules of the game, while allowing for flexibility in how the public interacted with the characters and content. Visitors joined the activity spontaneously, often drawn in by the visual appeal and the opportunity for discussion.

Participants were encouraged to ask questions and seek guidance from biologists and chemists who were also present at the fair. These scientists acted as content mentors, helping participants understand the correct methods of handling and disposing of antibiotics and medical waste. The interaction with real scientists deepened the learning experience, added credibility to the content, and promoted trust in scientific expertise.

The activity was implemented in a dynamic, non-linear way, with participants free to enter or exit the game at different stages. This open structure allowed for both individual and group participation and supported a range of learning styles and attention spans.

Overall, the implementation was smooth and well-received. The combination of gamified learning, real-life relevance, and direct access to scientists contributed to the activity's success.

3. Knowledge, Skills, Attitudes and Beliefs

The Learn about Antibiotic and Medical Waste activity enabled participants to acquire new knowledge, develop key skills, and reflect on their attitudes and beliefs surrounding a socially and environmentally relevant issue. Participants gained a clearer understanding of what constitutes medical and antibiotic waste, learning why certain substances, such as expired medicines and used antibiotics, require special handling and disposal. Through the interactive format of the board game and the guidance provided by scientists, they became more aware of the environmental and health consequences of improper waste disposal, including pollution and the spread of antibiotic resistance. The activity also introduced them to correct and responsible methods for discarding medical waste, equipping them with practical knowledge that could be applied in everyday life.

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In addition to content knowledge, the activity fostered critical thinking and reasoning skills. The scenario-based structure of the board game prompted participants to consider multiple perspectives and reflect on the outcomes of different actions. Communication was a central part of the experience, as players engaged in dialogue with one another and with experts, discussing ideas, asking questions, and forming arguments based on evidence. The activity also stimulated collaborative problem-solving, as participants worked through real-life inspired dilemmas and negotiated possible solutions.

Importantly, the experience influenced participants' attitudes and beliefs. Many expressed a heightened sense of environmental and social responsibility, recognizing the role of individual behavior in public health and sustainability. The opportunity to interact with biologists and chemists fostered trust in scientific expertise and made science more relatable and accessible. Furthermore, participants demonstrated an increased openness to community-based solutions, acknowledging that managing antibiotic and medical waste effectively requires collective effort and informed citizenship.

4. **Difficulties and Key Success Factors**

While the activity was accessible and engaging for a broad audience, some participants initially found the topic of antibiotic and medical waste unfamiliar and complex. For those without a scientific background, especially children and adults outside the education or healthcare sectors, the terminology and implications of improper waste disposal were not immediately clear. This unfamiliarity occasionally created hesitation or uncertainty when answering the game's question cards.

To address this, the facilitators adopted a supportive, non-judgmental approach, encouraging open conversation and reminding participants that the goal was not to "win" the game, but to explore ideas and learn together. The presence of biologists and chemists played a crucial role in overcoming these difficulties, as participants could turn to them at any point for clarification, explanations, or further discussion. This real-time access to scientific expertise helped to demystify the topic and made the content more approachable.

Another minor challenge was maintaining engagement among visitors with limited time during the science fair. Some participants were drawn to the booth but hesitant to commit to the full game experience. To address this, the activity was designed to be modular and flexible, allowing visitors to join or exit the game at different points. This structure enabled meaningful engagement even in brief interactions and allowed for a steady flow of participation throughout the day.

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One of the key success factors of the activity was its gamified and role-based format, which encouraged curiosity and imagination while making a serious topic enjoyable and memorable. The use of fictional characters helped participants empathize with different roles in society and understand how individual decisions relate to larger systems. Another success factor was the integration of expert support in an informal setting, which gave the activity both credibility and warmth. Finally, the activity's public, inclusive nature, combined with clear messaging, visual appeal, and opportunities for discussion, ensured it reached a wide and diverse audience.

5. **Added value of the implemented activity for community members.**

The specific activity offered significant added value for community members by raising awareness around a critical but often overlooked public health and environmental issue. Through a playful and accessible format, the activity succeeded in engaging individuals of all ages and educational backgrounds in meaningful conversations about antibiotic use, medical waste disposal, and sustainable practices.

One of the most important contributions of the activity was that it bridged the gap between scientific knowledge and everyday life. Many participants reported that they had never considered how leftover or expired medications should be disposed of, or the consequences of discarding them improperly. By presenting this information in an informal and interactive setting, the activity helped participants connect science to their personal habits and responsibilities as citizens.

The presence of scientists at the booth added further value by humanizing scientific expertise and making it available to the public in a non-intimidating way. This helped build trust in science and opened up space for dialogue, where participants could ask questions and express concerns about topics that are rarely discussed outside clinical or academic settings.

In addition, the activity created opportunities for intergenerational learning and community dialogue. Families, children, and elderly participants often engaged in the game together, prompting conversations that extended beyond the event itself. The interactive nature of the activity also encouraged people to reflect on how their actions impact not only their own health but also the environment and broader community.

Overall, the activity empowered participants by equipping them with practical knowledge, promoting critical thinking, and fostering a sense of shared responsibility. It demonstrated that **community**-based

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science engagement can contribute to more informed, environmentally responsible, and health-conscious behaviors.

6. Reflective remarks

The Learn about Antibiotic and Medical Waste activity stands out as an example of how open schooling and informal science engagement can address real-world societal challenges in a way that is inclusive, interactive, and impactful. Its success lay in the blending of scientific content with playful learning, allowing participants to approach a serious issue through curiosity rather than fear or judgment.

One of the most valuable aspects of this activity was its flexibility and adaptability. The board game format made it possible to tailor interactions to different audiences, from young children to older adults, while still conveying core messages about antibiotic resistance and environmental responsibility. This versatility helped maximize outreach at the science fair and created an inviting atmosphere for dialogue and reflection.

The integration of experts into the experience was a powerful element that elevated the educational value of the activity. Participants not only engaged with the game itself but also benefited from spontaneous conversations with biologists and chemists, which deepened their understanding and personalized the learning experience.

The activity also reinforced the importance of community-based learning and public participation in science. It revealed a genuine interest among community members in better understanding how everyday actions, such as disposing of unused antibiotics, can have broader implications for public health and the environment. This underscores the potential for similar initiatives to serve as catalysts for behavior change and local engagement.

In reflection, the activity could be further strengthened in the future by creating printed take-home materials or QR-linked resources, allowing participants to continue exploring the topic after the event. Nonetheless, this implementation demonstrated that when science is presented in a way that is hands-on, human-centered, and socially relevant, it not only informs but also inspires.

7. Additional material

Available here:

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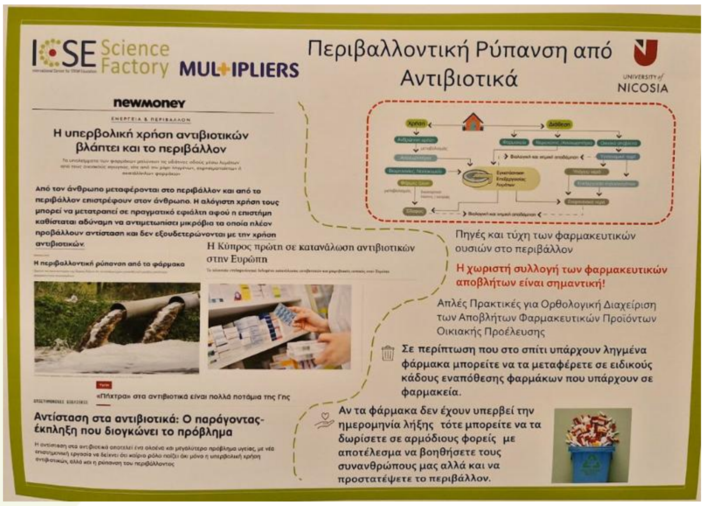
https://bwsyncandshare.kit.edu/s/qBi3eLj4k69x3PN?path=%2F07_Dissemination%20Materials%2FCyprus



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Dendroecology and tree ring study

1. Lighthouse Activity

Name of the activity: Dendroecology and tree ring study

Topic(s): Sustainability

Foundational aspect(s): SSI

Possibilities of interdisciplinary integration: Natural science, Mathematic

Learning objectives: Analysis, application, comparison, conclusion, interpretation

2. Implementation Process

Date: 15.11.2024

Local: Freiburg

Duration: ca. 2 hours

Partners involved: Staudinger gesamtSchule

Target group:10-11 years old

Number of participants:26

Number of female participants:16

Age of the participants:10-11 years old

Description of the implementation process of the activity:

Dendrochronology is the science of tree rings, which are visible rings of outward growth that can be studied by looking at a cross-section of a tree, with each ring representing one year of growth from the centre outwards. In essence, it is a form of environmental monitoring that uses trees as bio-indicators over the long term. This is because trees can record any factor - whether caused by nature or by man - that influences the process of ring formation. Dendrochronologists can study very old trees to find out about past temperatures, rainfall, insect outbreaks, fires and other environmental disasters. They can also reveal information about local or global climate changes by studying large numbers of relatively young trees.

The Workshop aims to help understand :

- Growth of trees at the individual tree level
- Climate-growth relationships
- Age determination on trees

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- Formation of growth rings

In this respect, the workshop is related to the following science theme, which includes: natural sciences and mathematics.

All in all, in this workshop we try to cover finding answers to these questions:

- How do trees grow?
- Why do trees grow rings?
- What do tree rings tell us about the climate and other conditions/circumstances?

The workshop began with a brief introduction to dendroecology. The topics covered in this part were included:

- What does the word "dendroecology" mean?
- What are tree rings and what information can we get from studying them?
- How do trees transmit information about past climate?
- What are the uses of the information we get from studying tree rings?
- What is the importance of dendroecology in relation to other sciences and climate change?

On the day of the workshop, all the equipment was taken to the workshop site.

What we brought there: a microscope, 3 samples to look at under the microscope, an increment borer, many medium tree disc with growth peculiarities, wood cubes of different densities (Thuja plicata, Robinia pseudoacacia, Pseudotsuga menziesii), scale and a tree trunk to take samples from, 30 small tree trunk discs to give away, worksheets, our project flyers.

The workshop took place on 15.11.2024 from 9.50 to 12.00 with a short break.

26 pupils took part as a class from the Staudinger Comprehensive School in Freiburg during normal lesson times. The time budget was slightly more than a double lesson.

3. Knowledge, Skills, Attitudes and Beliefs

The workshop is designed to improve various skills in students such as analysis, application, comparison, inference and interpretation.

From the first part of the workshop and the introduction, students learned about dendrochronology and how the study of tree rings helps scientists answer ecological questions about the recent past.

They were able to draw conclusions about possible climatic conditions that could affect tree growth. The students determined the average age of the trees using some tree rings, investigated whether there were years of poor growth, and drew conclusions about the reasons for this. The workshop helped them to understand that data on past climate change can be obtained from sources other than long-term weather observations, and to recognize the direct influence of climate on the annual growth behavior of trees.

4. Difficulties and Key Success Factors

How to divide the students for 6 different practical activities was a bit challenging because they all wanted to work with borer. Because it was a comprehensive school, the 26 pupils were also at different levels of performance and concentration, which posed a certain challenge in the presentation and implementation of the individual workshop activities.

5. Reflective remarks

I would say that giving the students this opportunity to learn by doing was key to making this happen. They enjoyed being able to do something with their hand in a personal way. This way of learning helps them remember better and makes them more creative. After starting the practical part, they start asking questions that they had faced during the practical part.

We also gave them a paper to take home summarizing the whole Workshop.

And at the end of the workshop, each student received a small tree disk as a memento of the workshop.

All these factors together made our workshop more pleasant for students.

The core of our workshop is to educate citizens, especially children, and raise their awareness about the causes and consequences of climate change.

Knowledge of this phenomenon helps young people to understand and cope with the consequences of global warming, encourages them to change their behavior and helps them to adapt to what is already a global emergency. Education will be a key tool in the fight against climate change in the coming years. In this regard, we found our workshop relevant to the current issue.

For the students and for us, it was a mutual pleasure. The students were so excited about what they learned during the workshop and even asked what other workshop topics we offer. We gave them our project flyer and asked them to share it with their teachers.

We learned a lot about how to present our workshop in the future and how to improve it.

6. Additional material

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Upcycling vehicles

1. Lighthouse Activity

Name of the activity: Upcycling vehicles

Topic(s): Green Deal

Foundational aspect(s): IBL, Real life Problems

Possibilities of interdisciplinary integration: Geography, Physics, Handicraft lesson

Learning objectives:

- The children learn about the terms upcycling, recycling and reuse using real-life examples. They learn about the different components of simple circuits and build their own circuit with a switch. They also learn about the various alternative energies. They then build their own upcycled vehicles from various materials and motorize them. As with the other concepts, each child fills out a research handbook during the morning, which they can take home with them. This contains further building instructions for vehicles not built in class, which they can build independently at home. During the workshop, they also come into contact with mechatronics engineers and engineers and can talk to them about their job profiles.

2. Implementation Process

Date: First version in April 2024, amelioration for three times till Oktober 2024, now final version that works + one version for special education centers

Local: different primary schools in and around Tuttlingen

Duration: around 180min

Partners involved: SFZ Tuttlingen, MINT-Netzwerk Donau-Baar-Heuberg, Mechatronics engineers from Aesculap, pensioners who have worked as engineers

Target group: 3rd and 4th graders + pupils of higher age in special education centers

Number of participants: depending on the classes between 20 and 30

Number of female participants: on average half of the class

Age of the participants: 8 – 10/ till 15 in special education centers

Description of the implementation process of the activity: The elementary school in the Tuttlingen region were contacted and made aware of the offer. As a result, 12 classes got in touch to take part in the LHA. In consultation with the Schülerforschungszentrum and MINT-Netzwerk Donau-Baar-Heuberg, the

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materials were organized and the created script was piloted, which was gradually adapted to the interests and abilities of the pupils.

At the beginning of the workshop, the steps of project management from the idea to the product are discussed together. The children then find out what reuse, recycling and upcycling mean using pictures and objects they have brought with them. At two further stations, they learn about the life cycle of a PET bottle and paper recycling before naming various tools. The children work with these over the course of the morning. After the more theoretical part, the children build their own circuits, first without and then with switches. This serves as a preliminary exercise for the vehicles they will later build themselves. Fast pupils can work on the functioning of a propeller in a differentiated way. After a short break, the children have the opportunity to choose between three different construction projects, all of which are upcycling projects. With the support of the various supervisors, they build either a balloon rocket car, a motorized car made from a PET bottle or a painting rocket made from toilet paper rolls. At the end, the children present their products and race the vehicles against each other. The theoretical content of the morning is recorded in the children's research handbook so that the teacher has the opportunity to check their knowledge and the children can take the learning content back to their families. Many also want to build a car, which is why the building instructions for all projects are listed in the researcher's handbook, thus achieving a multiplication effect.

3. Knowledge, Skills, Attitudes and Beliefs

On a social level, the pupils learn to work as a team for the theoretical part of the workshop.

On a communicative level, they learn to share their ideas when forming hypotheses and to defend their opinions. They learn to present and discuss their scientific results with experts.

At the content level, they learn about the importance of recycling, upcycling and reuse but also to avoid waste. They get to know two recycling processes, learn about different tool groups and how an electrical circuit works. They then immediately transfer their newly acquired knowledge to their own project and can thus apply their knowledge. They also learn how to read plans and implement instructions correctly.

At the methodological level, they learn document, use tools, reflect their ideas critically and frustration tolerance if the ideas don’t work like they have expected.

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4. Difficulties and Key Success Factors

To begin with, the children's cognitive level had to be correctly assessed, which is why the research handbook was adapted three times, both in terms of language and content. Too abstract and complex formulations prevent the understanding of content and lead to chaos and resentment among caregivers and children during the course of the LHA. The revised version of the researcher's handbook was used very successfully in both years 3 and 4. It is important here to pay attention to internal differentiation and to offer cognitively stronger children the differentiation tasks provided in the script, but also to give the other children the feeling that the results of their ideas are already sufficient to gain a sufficient understanding of the problem. It is also important to pick up the children in their own world at the beginning and not to overload them with too many facts. In this workshop the help of two different sort of workers is very important. The mechatronics technicians and engineers are role models for the children and can talk about their working lives. Above all, the children are always very impressed by the work a mechatronics engineer can do, what they learn during their training and that they are allowed to work with the same tools and parts as the adults. The female participants are particularly enthusiastic about these areas.

Classroom management is also a key success factor. Group tables are useful due to the size of the experiments; in addition, the group can be better divided between the supervisors and walking routes remain free.

5. Added value of the implemented activity for community members.

The children's research handbook is a major benefit for community members. They very often ask if they can take it home to show their parents and siblings. This creates a flow of information about the topic into the families. The children discuss with their families and think about their behavior. They also use it as a reminder how to build the cars.

6. Reflective remarks

The LHA was carried out a total of 12 times at different schools and with age groups 3 and 4 and also two times in special education centers, for which the script was adapted again. It turned out that the topic is suitable for both age groups, and also for the children with learning difficulties and mild physical disabilities.

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The different levels of the classes were very well accommodated by the differentiation tasks. In addition, the supervision situation with three teachers and two mechatronics also allows discussions with individual groups while the others can continue working.

In general, it can be said that building something with whole classes works very well when there are five people in the room who can help and when the classroom management is chosen so that each person is responsible for one to two tables with four children each, while another table is supervised by two supervisors alternately as required. In our experience, a single teacher with classes of up to 30 children cannot offer lessons in this form, which is why we see a need for action in the education sector at this point.

The classroom management with group tables introduced after the pretests is suitable for this workshop, especially because each person needs space for their instruments and building stuff.

Teamwork works differently depending on the school and class, but we were also able to observe that the children adapt relatively quickly to their partners because they are really instructed to work together and, after a few failed attempts, find ways to work together largely independently.

Some teams had to be given guidance as there was no tolerance for frustration. In almost all cases, however, a solution was found that was satisfactory for the pupils.

There are children in almost all classes who speak little or no German. In order to integrate them into the morning, the languages required were discussed in advance with the primary school teachers. Pupils from secondary schools who speak these languages were then sought out. They were then taken along to the workshops in order to overcome the language barrier and enable participation. This measure was perceived as very valuable by everyone involved and the primary school teachers in particular were suddenly able to observe activities in children who would otherwise just sit still and do nothing because they didn't understand anything. As the LHA is not a regular lesson in which the integration of the children with the help of language is intended, this measure will be retained in the future in order to promote the motivation of children with language problems in the STEM area in particular. Autistic children who cannot be integrated into the groups pose a challenge in all groups. In each case, individual solutions were found with the help of the teachers.

7. Additional material

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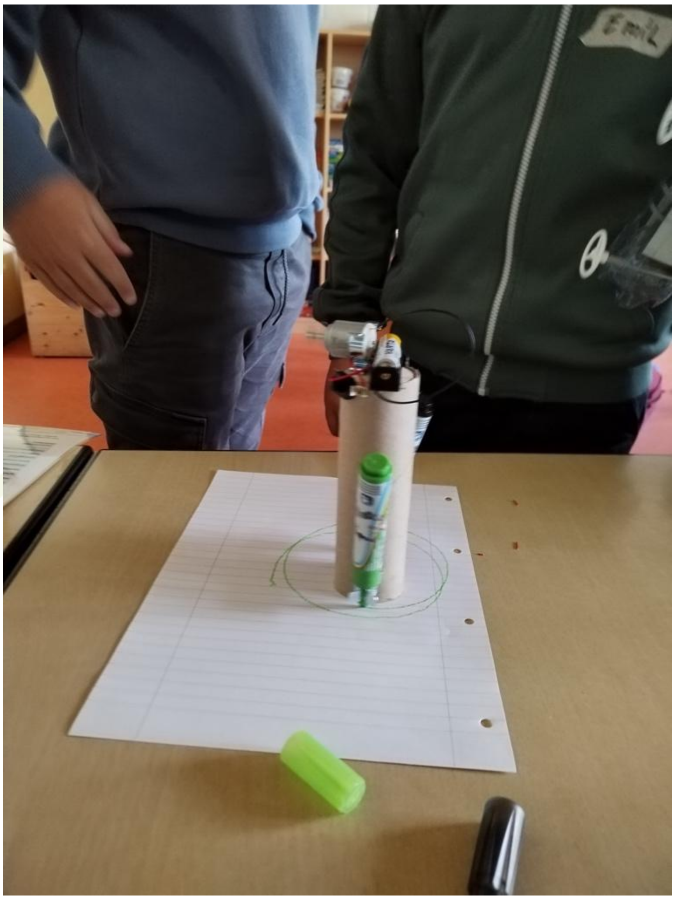

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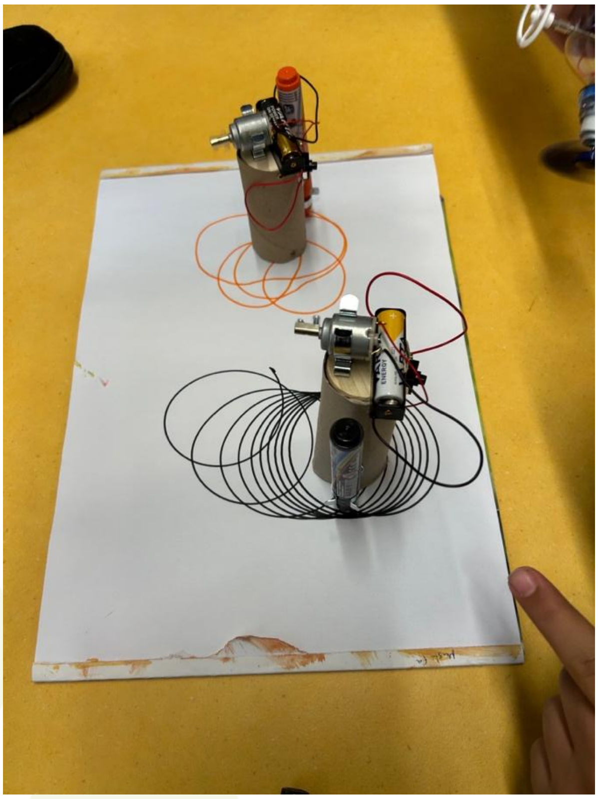

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Climate change – understanding and acting

1. Lighthouse Activity

Name of the activity: Climate change – understanding and acting

Topic(s): Green Deal, Digitalization, Health

Foundational aspect(s): IBL, Real life Problems

Possibilities of interdisciplinary integration: Biology, Geography, Chemistry, Physics

Learning objectives: The children understand what is behind the term climate change and can name factors that have a negative and positive influence on climate change. They can carry out, document and explain various experiments on albedo, melting of the polar ice caps, acidification of the oceans, rising sea levels due to warming and the different behavior of surfaces to heat radiation. They can also transfer their knowledge to their living environment and reflect on their own behavior.

2. Implementation Process

Date: First version in April 2024, amelioration twice till December 2024, now final version that works

Local: different primary schools in and around tuttlingen

Duration: around 180min

Partners involved: SFZ Tuttlingen, MINT-Netzwerk Donau-Baar-Heuberg, Immanuel-Kant-Gymnasium Tuttlingen

Target group: 3rd and 4th graders

Number of participants: depending on the classes between 20 and 30

Number of female participants: on average half of the class

Age of the participants: 8 - 10

Description of the implementation process of the activity: The elementary school in the Tuttlingen region were contacted and made aware of the offer. As a result, 14 classes got in touch to take part in the LHA. In consultation with the Schülerforschungszentrum and MINT-Netzwerk Donau-Baar-Heuberg, the materials were organized and the created script was piloted, which was gradually adapted to the interests and abilities of the pupils. At the same time, pupils from Immanuel-Kant-Gymnasium were trained as STEM tutors to provide support in the primary school classes. This concept is to be continued, as peer learning works very well.

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On the day of the LHA itself, the children receive a condensed input on the topic of climate change in order to get to know the groups and get a feel for the level of the class. The children then experiment independently in groups of four and gradually complete their research handbook, which they are provided with. At the end of the events, the children present the results of their experiments independently. On the basis of this, a connection is made to the children's living environment and possible courses of action are considered. The teacher of the class can continue the topic with further in-depth tasks and ideas and at the same time use the script as a basis for monitoring learning objectives.

3. Knowledge, Skills, Attitudes and Beliefs

On a social level, the pupils learn to work as a team, as the experiments are designed in such a way that they cannot be completed alone.

On a communicative level, they learn to share their ideas when forming hypotheses and to defend their opinions. They learn to present and discuss their scientific results.

At the content level, they learn about the importance of surfaces for the earth's temperature, understand that the earth is a radiating planet, recognize the effects of warming and rising sea levels on us humans and the role of oceans in the context of the climate buffer effect. They will learn about the problem of ocean acidification and what consequences this has for the ecosystem and the world and what they can do to prevent climate change.

At the methodological level, they learn to pipette, document, measure, use digital measuring systems and understand their measuring methods, they learn to form hypotheses and write down data, evaluate them and reflect critically on them.

4. Difficulties and Key Success Factors

To begin with, the children's cognitive level had to be correctly assessed, which is why the research handbook was adapted twice, both in terms of language and content. Too abstract and complex formulations prevent the understanding of content and lead to chaos and resentment among caregivers and children during the course of the LHA. The revised version of the researcher's handbook was used very successfully in both Years 3 and 4. It is important here to pay attention to internal differentiation and to offer cognitively stronger children the differentiation tasks provided in the script, but also to give the other children the feeling that the results of the experiments are already sufficient to gain a sufficient understanding of the problem. It is also important to pick up the children in their own world at the beginning and not to overload them with too many negative facts. In this LHA, important facts about climate change are presented in a two-minute video, which are then discussed in plenary. This phase is important for the supervisors to be able to assess which teams can be formed in order to work successfully. The existing teachers in the classes are very helpful here. Classroom management is also a key success factor. Group tables are useful due to the size of the experiments; in addition, the group can be better divided between the supervisors and walking routes remain free.

5. Added value of the implemented activity for community members.

The children's research handbook is a major benefit for community members. They very often ask if they can take it home to show their parents and siblings. This creates a flow of information about the topic into the families. The children discuss with their families and think about their behavior.

6. Reflective remarks

The LHA was carried out a total of 14 times at different schools and with age groups 3 and 4. It turned out that the topic is suitable for both age groups, but that recording data for more complex experiments poses a challenge for grade 3, as the writing speed is still very low in some cases and the intervals between measurements are 30 seconds, which some pupils were unable to manage. This challenge was overcome by taking longer intervals between measurements. A key finding of the pre-test phase was that there is an incredibly heterogeneous level of knowledge on the topic of climate change within the classes. In order to do justice to all children, the information film we chose at the beginning is very suitable, as children who know nothing at all are picked up at a basic level, while the children who know more can then add information in the subsequent question and answer session and enrich the knowledge of the whole class.

We consider the knowledge gained at the end of the morning to be particularly valuable. In a joint discussion round at the end, the topics of the experiments are discussed again and the effects on the children's lives are discussed. Here it is evident in all classes, regardless of ability level, that key concepts relating to climate change have been understood.

The different levels of the classes were very well accommodated by the differentiation tasks. In addition, the supervision situation with three teachers also allows discussions with individual groups while the others can continue working.

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In general, it can be said that experimenting with whole classes works very well when there are three people in the room and the classroom management is chosen so that each person is responsible for two tables with four children each, while another table is supervised by two supervisors alternately as required. In our experience, a single teacher with classes of up to 30 children cannot offer experimental lessons in this form, which is why we see a need for action in the education sector at this point.

The classroom management with group tables introduced after the pretests is suitable for this workshop, especially because each group needs electricity and tripping hazards can be avoided by cleverly laying the cables.

Teamwork works differently depending on the school and class, but we were also able to observe that the children adapt relatively quickly to their partners because they are really instructed to work together and, after a few failed attempts, find ways to work together largely independently.

There are children in almost all classes who speak little or no German. In order to integrate them into the morning, the languages required were discussed in advance with the primary school teachers. Pupils from secondary schools who speak these languages were then sought out. They were then taken along to the workshops in order to overcome the language barrier and enable participation. This measure was perceived as very valuable by everyone involved and the primary school teachers in particular were suddenly able to observe activities in children who would otherwise just sit still and do nothing because they didn't understand anything. As the LHA is not a regular lesson in which the integration of the children with the help of language is intended, this measure will be retained in the future in order to promote the motivation of children with language problems in the STEM area in particular. Autistic children who cannot be integrated into the groups pose a challenge in all groups. In each case, individual solutions were found with the help of the teachers to give these children access to the topic of climate change.

In terms of content, it was possible to convey all the intended topics in an age-appropriate manner, with the pupils showing particular interest in the experiment on ocean acidification and the consequences for marine ecosystems. Also very popular was the work with the thermal imaging camera and the resulting findings on the subject of thermal radiation.

The first station, where data had to be recorded on different colored surfaces, was somewhat difficult for the children. This station will be revised in future so that the weaker pupils, whose stamina is less pronounced, can also be involved.

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Portugal

Sustainable Development: Increasing the Energy Efficiency of Buildings

1. Lighthouse Activity

Name of the activity: Sustainable Development: Increasing the Energy Efficiency of Buildings

Topic(s): Green Deal, Digitalization

Foundational aspect(s): IBL, Real-life problems (RLP), CDI

Possibilities of interdisciplinary integration: Chemistry, Physics, Mathematics

Learning objectives: Energy Efficiency, Heat Conduction, Mass Thermal Conductivity; Phase Changes, Closed and Open Systems

2. Implementation Process

Date: 2024 May 24

Local: Secondary school (in Lisbon suburbs - Escola secundária do Forte da Casa)

Duration: 180 minutes

Partners involved: Institute of Education, University of Lisbon (IE-ULisboa); Lisbon School of Engineering (ISEL)

Target group: K10 students

Number of participants: 25

Number of female participants: 10

Age of the participants: 15-16

Description of the implementation process of the activity:

This LHA consists of an Inquiry-Based Science Education (IBSE) activity to guide the students to measure and understand thermal conductivity (k) and relate this property to building energy efficiency and climate change. The LHA addresses a real-world environmental challenge within the construction sector, with significant global impact, as it consumes 38% of global energy, mainly for heating and cooling buildings and generates 37% of global CO_2 emissions. Thus, reducing the thermal conductivity of building materials directly increases energy efficiency, mitigates carbon emissions, and supports the United Nations Sustainable Development Goals (SDGs), particularly “Quality Education” and “Climate Action”.

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The LHA follows the Bybee 5E model (Engage, Explore, Explain, Elaborate, Evaluate) (Bybee, 2006) and is implemented through an inquiry task for students. To spark curiosity and engage students, the LHA E-ULisboa and ISEL show the class an image designed to engage students with contexts concerning energy consumption and the development of sustainable cities. The Engage phase begins with a brainstorming session, guiding students towards the construction sector, mainly concerning heating and cooling in buildings. Meanwhile, the thermal conductivity of materials and their correlation with building energy efficiency and global warming start to be discussed. After the Engage phase, students were challenged to work in groups to answer the following higher-order questions: How does the thermal conductivity of building materials affect building energy efficiency? How can it contribute to reducing CO_2 emissions?
During the Exploration phase, students examine an experimental setup, the EcoBuild Electronic Kit, previously developed by the workshop authors, and explain the role and functioning of the kit components. The kit consists of a wooden box (38 × 28.2 × 24.5 cm) internally insulated with expanded polystyrene (EPS) (Figure 1) and equipped with thermocouples and a heat source (230 V, 80 W lamp). The temperature increases across the samples were measured using thermocouples connected to each of the samples' surfaces and collected by an Arduino-based acquisition system. This device measures potential differences, amplifies the signal via a Grove 1-Wire K-Type Thermocouple amplifier, converts it into digital signals, and transmits them to a Microsoft Excel spreadsheet via Microsoft Data Streamer.
This setup enables students to visualise and analyse temperature gradients and material performance in real time, supporting their explanations by drawing on thermal properties applied to the samples.
Using the data in the Excel sheet, students determined the results by applying equation (1) and explained their physical meaning.

$$k = \Delta Q / (A \times \Delta t \times \Delta T/d) \qquad \text{(Eq. 1)}$$

where ΔQ is the energy supplied (which can be determined from the power of the heat source and the duration of the test); A is the cross-sectional area of each sample; Δt is the time interval; ΔT is the temperature difference between the cross-sectional surfaces of the samples; and d is the thickness of the samples.
During the Elaboration phase, students apply the knowledge acquired to address the questions, such as how the measurement of the thermal conductivity of building materials can (i) influence the energy efficiency of buildings and (ii) contribute to the mitigation of CO_2 emissions. To promote collaborative

reasoning, the teacher encouraged discussion within each group and requested that students upload their responses to an online platform, thereby enabling visibility and comparison across the class.

It was anticipated that students would argue, in response to initial higher-order questions (i), that building materials with low thermal conductivity enhance the energy efficiency of buildings by stabilising indoor temperatures and consequently reducing dependence on heating and cooling systems. Regarding question (ii), students were expected to recognise that, given a considerable proportion of the energy used for thermal regulation in buildings still originates from fossil fuels, the construction sector contributes significantly to carbon (CO_2) emissions.

In the Evaluation phase, students were invited to complete a self-assessment of the activity, reflecting individually on the functioning of their group, the knowledge constructed, and the difficulties encountered. This reflective component aimed to foster metacognitive awareness and self-regulatory skills while providing the teacher with valuable insights into students' learning processes and group dynamics.

3. Knowledge, Skills, Attitudes and Beliefs

During the LHA, students developed several key competencies:

Knowledge: They gained a deeper understanding of energy efficiency, the role of innovative building materials, and digital tools like Arduino-based systems in enhancing sustainability. Students applied concepts such as thermal capacity and CO2 reduction to real-world situations, exploring how technology can improve energy-saving solutions.

Skills: Students improved their communication, critical thinking, and high order thinking skills, particularly in problem-solving and data analysis using digital tools. Their ability to collaborate and interpret data results was enhanced.

Attitudes: An increased interest in sustainability was observed, as students enthusiastically engaged in practical experiments.

Beliefs: Students showed the belief in the power of science to drive positive change, particularly in addressing environmental issues such as reducing energy consumption and promoting more efficient energy solutions for building materials.

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4. Difficulties and Key Success Factors

Difficulties: Students encountered challenges in setting up the Arduino-based data logger and thermocouples, organizing group work, and processing data. There was confusion in distinguishing between conclusions and explanations, and some students struggled with understanding and documenting the procedures.

Strategies to Overcome Difficulties: Additional support was provided during the setup, and guidance was given on how to properly document materials and procedures. In future sessions, breaking the LHA into two shorter sessions could help manage the inquiry task and reduce fatigue.

Key Success Factors: Active participation, hands-on learning, communication promotion, and the practical relevance of the inquiry task helped students engage fully in the LHA. The integration of digital tools and real-world applications also enhanced the learning experience. The inquiry-based learning approach encourages students to ask questions, seek relevant information to solve problems, negotiate meaning with their classmates, and communicate their findings.

5. Reflective remarks

This workshop proved highly relevant for the participating students, offering them valuable insight into the application of scientific and digital tools to real-world challenges. By engaging with concepts related to energy efficiency and sustainability, students not only improved their technical skills but also developed a stronger awareness of their role in combating climate change. The hands-on nature of the activities, combined with the relevance to global sustainability goals, added significant value to their learning experience and empowered them to think critically about future environmental solutions.

The LHA adds value to the broader community by equipping students with practical knowledge and skills related to sustainability and energy efficiency, empowering them to contribute to local environmental initiatives and fostering a generation more conscious of their impact on climate change.

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6. Additional material

Figure 1 - Setup for measuring thermal conductivity

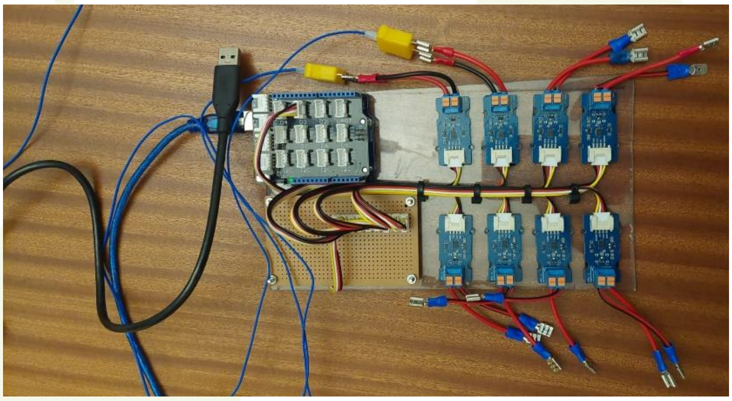

Figure 2 – Arduino-based data logger.

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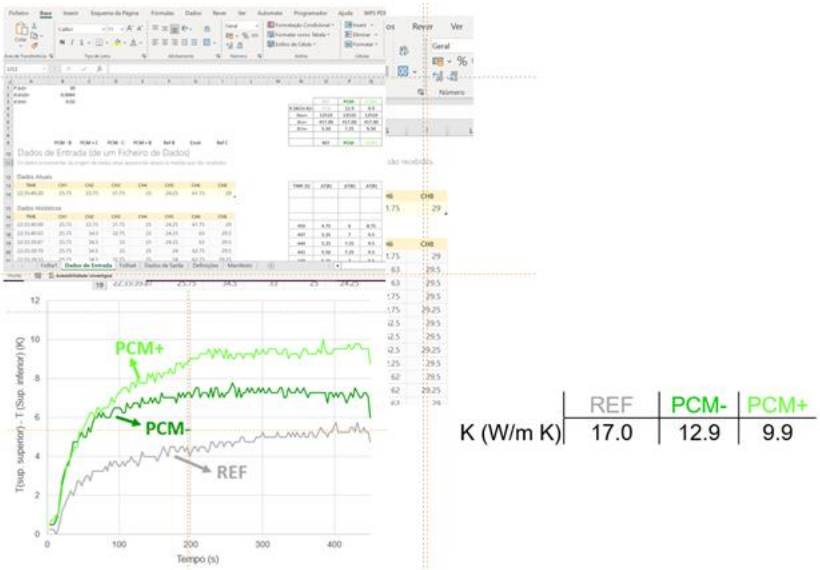

Figure 3 – Example of the datasheet showing the collected data, graphical representation, and thermal conductivity results of the building material samples.

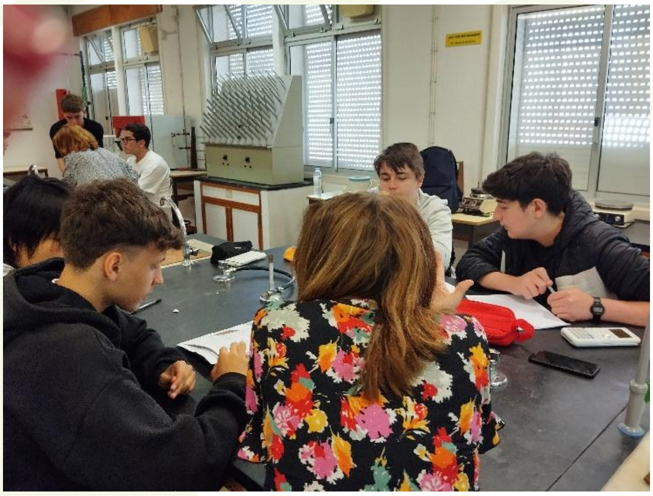

Figure 4 – Example of students during the implementation of the LHA

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Technology and Sustainability

1. Lighthouse Activity

Name of the activity: Technology and Sustainability

Topic(s): Sustainability, Technology, Environmental Monitoring

Foundational aspect(s): Real-life problems (RLP), Problem-based learning (PBL)

Possibilities of interdisciplinary integration: science (biology, chemistry), technology, mathematics

Learning objectives:

- To develop technological and digital skills
- To introduce concepts of sustainability and technology
- To combine the learning of key sustainability concepts with the practical exploration of technology (Micro:bit) for data collection and environmental monitoring
- To encourage research and implementation of solutions to real-world environmental problems
- To empower students to become conscious and responsible agents of change regarding their environment
- To use the Micro:bit as a tool to explore the environment, identify patterns, and reflect on the impact of human actions

2. Implementation Process

Date: 16/05/2024

Local: Secondary School Lumiar, Lisbon, Portugal

Duration: 90 minutes

Partners involved: Institute of Education of the University of Lisbon and Secondary School Lumiar

Target group: students, teacher

Number of participants: 21

Number of female participants: 12

Age of the participants: 14-15

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Description of the implementation process of the activity:

The LHA was facilitated by a researcher from the Institute of Education, who also provided all the necessary materials. The implementation process commenced with a review of the presentation slides on "Sustainability and Technology". This provided the theoretical foundation, covering the concepts of sustainability, the role of technology in environmental monitoring, and an introduction to the Micro:bit as a tool for data collection.

Following this introduction, the practical work began, which was divided into three subsequent phases: programming the monitoring device, assembling the hardware, and executing the environmental data collection.

Phase 1: Programming the Micro:bit

- The first practical step involved programming the BBC micro:bit board using the MakeCode for micro:bit online editor. The code was designed to measure three distinct environmental variables:
- Temperature: The Micro:bit's onboard sensor was programmed to display the current temperature in degrees Celsius (°C) when button A is pressed.
- Light Level: The onboard light sensor was programmed to show the ambient light intensity when button B is pressed.
- UV Radiation: An external UV sensor was programmed to provide a value by creating a variable ("uv") to store the analog reading from pin P0. This value is displayed when buttons A and B are pressed simultaneously.

Phase 2: Hardware assembly

Following the programming, the hardware was assembled. This involved connecting the external S12SD UVR sensor to the Micro:bit. The Micro:bit was inserted into a Keyestudio expansion board, and the sensor was then connected to the board's pins, with the signal pin linked to P0 as specified in the code. This created a portable, self-contained device capable of measuring all three variables.

Phase 3: Data collection and recording

The final phase was the field collection of data. The assembled device was taken to several pre-determined locations. At each location, the values for temperature, light intensity, and UV radiation were measured and immediately recorded in the corresponding columns of the Registration Form ("Ficha de Registo"). This process was repeated for all selected locations, resulting in a complete data table ready for scientific analysis.

3. Knowledge, Skills, Attitudes and Beliefs

The LHA allowed students to understand the effects of human actions on the environment and the importance of sustainability. The vital role that programming and technology play in ensuring sustainability by enabling precise monitoring, analysis, and management of environmental resources was highlighted.

Through the practical use of tools like Micro:bits and sensors, students developed skills to collect and analyze data to identify patterns and trends in environmental conditions. This hands-on approach helped them understand how technology can be leveraged to create sustainable solutions, such as measuring air and water quality or noise levels to inform environmental protection strategies. Additionally, the activity promoted essential 21st-century skills such as critical thinking, problem-solving, and collaboration.

4. Difficulties and Key Success Factors

One of the difficulties encountered during the activity was that some students did not bring their laptops, which made it necessary to form larger groups than originally planned. This adjustment may have reduced opportunities for individual participation and limited the depth of each student's learning experience. Extending the duration of the session could have been advantageous, as it would have provided more time for engagement, collaboration, and a deeper exploration of the underlying concepts.Despite the challenges, the practical and interdisciplinary integration of the activities into the school curriculum was a key success factor. The use of attractive and user-friendly technologies, such as the Micro:bit, significantly enhanced student participation and interest. Ensuring that all necessary resources are available and allowing ample time for activities are crucial factors for the successful implementation of such educational programs.

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5. Added value of the implemented activity for community members.

This activity, as part of the European ICSE Factory project, aims to engage school audiences and the wider community in science outreach. The partnership between the Institute of Education and the local school enriched student learning by bringing a university researcher into the classroom. By empowering students to become "conscious and responsible agents of change", the activity generates a direct positive impact on their community. It raised awareness about sustainability, a topic of great societal relevance, and equipped students with valuable skills applicable beyond the classroom, benefiting the community in the long term.

6. Reflective remarks

The activities with Micro:bits proved to be highly relevant for promoting technological literacy among students, as they provide hands-on experience with modern tools and programming. These activities significantly contribute to raising awareness about the importance of sustainability and the impact of human actions on the environment, highlighting the real-world impact of these actions on daily life. Additionally, they promote essential 21st-century skills such as critical thinking, problem-solving, and collaboration, preparing students for future academic and professional challenges. By integrating practical, interdisciplinary tasks into the school curriculum, these activities ensure that students gain valuable knowledge and skills that are applicable beyond the classroom.

7. Additional material

The images provided in the documents illustrate students actively participating in the activity, both in a classroom setting and outdoors, programming the Micro:bits, connecting sensors, and collecting data in groups. Additionally, a table template was provided for recording data on "Location," "Temperature," "Light Intensity," and "UV Radiation".

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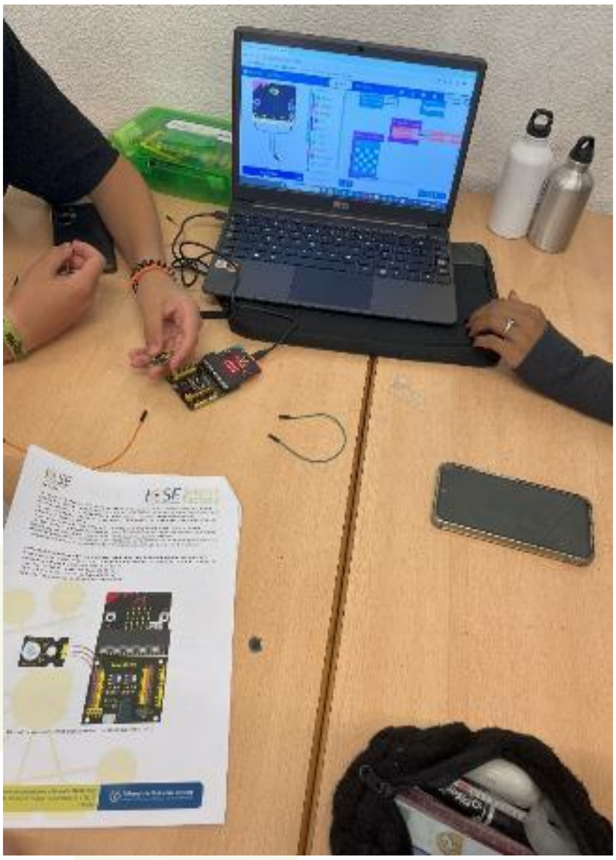
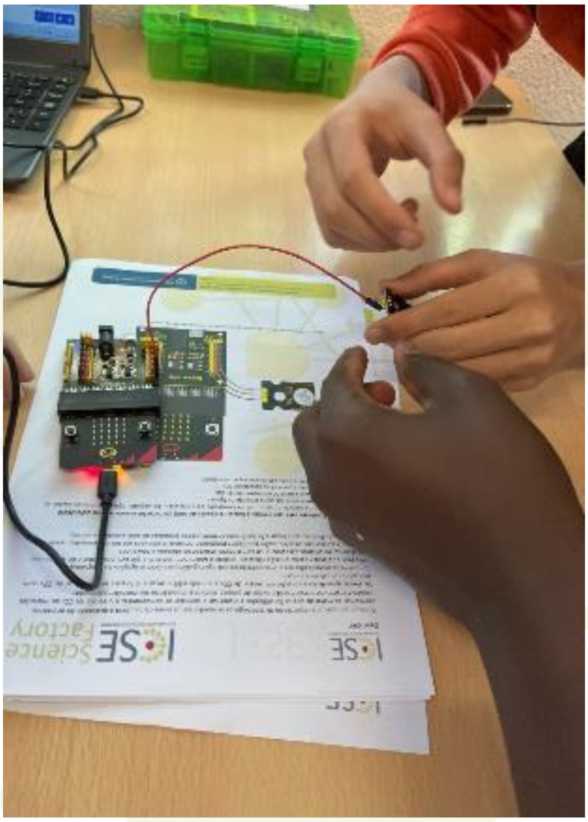


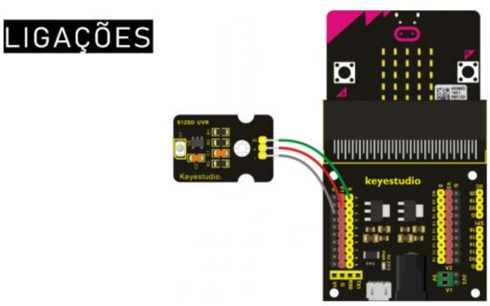


Registration grid for the Location, Temperature, Light intensity and UV radiation – “Ficha de registo”

Local	Temperatura	Intensidade de Luz	Radiação UV

How to program Micro:bit instruction slide

How to assemble and connect the UVR sensor



Block based program used for monitoring the parameters

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Virtual Reality and Choices Behind the Screens - Digitalization in School Context

1. Lighthouse Activity

Name of the activity: Virtual Reality and Choices Behind the Screens - Digitalization in School Context

Topic(s): Digitalization, Health

Foundational aspect(s): RLP, SSI

Possibilities of interdisciplinary integration:

- Portuguese Language (communication skills, host activities)
- Information and Communication Technology (data processing and organization)
- Citizenship and Development (digital ethics and responsibility)
- STEM disciplines (technology applications and scientific methodology)

Learning objectives:

- Develop critical analysis and reflection skills about Virtual Reality benefits and challenges
- Understand VR applications in educational contexts and STEM learning
- Promote digital wellbeing awareness and responsible technology use
- Foster discussion about ethical choices regarding privacy, accessibility, cost, and learning impact
- Enhance communication and presentation skills through data collection and analysis
- Create virtual educational scenarios and explore best practices for VR integration

2. Implementation Process

Date: May 6, 2024

Local: Escola Secundária Padre Alberto Neto - Queluz, Portugal (João Eira Auditorium)

Duration: 100 minutes

Partners involved: Agrupamento de Escolas Gil Vicente; Educathec - Digital Academy for Teachers

Target group: Students from vocational courses and 9th grade, teachers

Number of participants: 130

Number of female participants: 62

Age of the participants: 14-56

Description of the implementation process of the activity:

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The LHA was implemented as a comprehensive session featuring external expert presenting on Virtual Reality applications in education.

The process involved several phases:

Pre-session preparation: Teachers completed forms to register their participation with available classes. Selected vocational course students were assigned specific roles as session hosts, managing participant check-in and signature collection.

Main session: Expert presentation covering VR fundamentals, educational applications, and ethical considerations around digital choices. Interactive discussions addressed accessibility, cost, ethics, and learning impact of VR technology.

Data collection: Students administered questionnaires about digital wellbeing and participants' opinions on VR in educational contexts, specifically for future STEM learning applications.

Post-session analysis: In subsequent ICT classes, vocational and 9th-grade students processed collected data, creating analyses and presentations.

3. Knowledge, Skills, Attitudes and Beliefs

Knowledge developed:

Understanding of Virtual Reality fundamental principles and technological mechanisms

Comprehensive knowledge of VR benefits and challenges in educational and STEM contexts

Awareness of ethical considerations in technology use (privacy, accessibility, responsible usage)

Digital wellbeing concepts and balance between virtual and real-world experiences

Data collection and analysis methodologies for educational research

Skills developed:

Critical analysis skills for evaluating VR impact on learning processes

Communication and presentation abilities through hosting and data presentation

Data processing and statistical analysis using digital tools

Research methodology and questionnaire design

Collaborative teamwork in interdisciplinary projects

Digital literacy and technological competency

Attitudes and beliefs developed:

Curiosity and openness to experimenting with emerging technologies

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Critical reflection on ethical issues related to privacy, accessibility, and responsible technology use

Appreciation for digital wellbeing and maintaining healthy technology relationships

Confidence in discussing complex technological and ethical topics

Valuation of evidence-based decision making in educational technology adoption

4. Difficulties and Key Success Factors

The implementation faced significant challenges requiring careful management. Initial student hesitation emerged when discussing complex technological concepts, as participants lacked confidence in their technical knowledge. Coordinating multiple participant groups presented logistical complexity, particularly managing transitions while maintaining focus on learning objectives. Ensuring meaningful engagement across diverse educational backgrounds proved demanding, requiring accommodation of varying knowledge levels and learning styles. Managing data collection with 130 participants required sophisticated organizational systems to maintain educational quality.

These challenges were addressed through comprehensive student support strategies. Peer dialogue created safe spaces for questioning, allowing confidence building through collaborative discussion. Structured presentations combining expert knowledge with practical examples bridged theoretical concepts with tangible applications through visual demonstrations and real-world case studies. Continuous teacher support built student confidence by providing reassurance, clarifying vocabulary, and helping formulate appropriate questions. Clear role assignments created ownership by ensuring meaningful contributions and preventing passive participation. Follow-up classroom activities reinforced learning through structured reflection sessions and supplementary materials.

The activity's effectiveness resulted from interconnected elements creating optimal learning conditions. Clear planning established well-defined goals for understanding VR basics and exploring STEM applications, providing concrete expectations that guided engagement. Active student involvement transformed participants from passive recipients to contributors through hosting and data collection roles, developing leadership skills alongside technical knowledge. Expert external participation provided solid knowledge foundation and practical insights, bringing real-world expertise that elevated the activity beyond typical instruction. Interactive discussions encouraged students to share perceptions and debate technology choices, fostering critical thinking and communication competencies. Practical VR demonstrations in educational scenarios provided tangible connections between theoretical concepts and applications. Continuous evaluation through systematic feedback helped assess impact and identify improvements, ensuring responsiveness to participant needs while providing valuable data for future refinements.

5. Added value of the implemented activity for community members.

The activity generated significant benefits that extended well beyond the immediate participants to impact the broader educational community. Educational innovation was introduced through cutting-edge technology awareness throughout the school community, effectively preparing students for future digital learning environments by exposing them to emerging technologies and their practical applications in educational settings. Teacher professional development occurred as educators enhanced their understanding of emerging educational technologies and their pedagogical applications, gaining valuable insights into how virtual reality and digital tools can be integrated meaningfully into curriculum delivery and student engagement strategies. The initiative made important research contributions by generating valuable data on VR perceptions in educational contexts, contributing to broader understanding of technology integration challenges and opportunities within secondary education environments. Community collaboration was strengthened through enhanced partnerships between schools, digital academies, and educational research institutions, creating sustainable networks for future collaborative projects and resource sharing. Digital citizenship awareness was promoted throughout the school community by emphasizing responsible technology use and digital ethics considerations, helping students and educators develop critical thinking skills about technology's role in society and personal wellbeing. STEM enhancement occurred through practical demonstrations of technology applications in science, technology, engineering, and mathematics education, showing concrete examples of how digital tools can support inquiry-based learning and real-world problem solving. Knowledge dissemination extended the impact beyond the school through results presented at academic seminars, contributing valuable insights to the broader educational research community and influencing future policy and practice developments in educational technology integration.

6. Reflective remarks

This lighthouse activity demonstrated the effective integration of emerging technologies with critical thinking and ethical reflection in educational settings. The balanced approach combined technological

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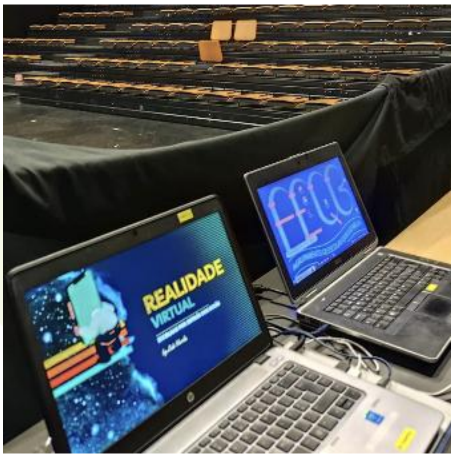
exploration with consideration of implementation challenges and ethical implications, addressing both technical concepts and critical competencies while fostering genuine ownership through active student participation.

The interdisciplinary integration spanning language skills, data analysis, and ethical reflection showed how educational technology initiatives can transcend traditional subject boundaries. Collaboration between institutions and external expert participation created a rich, multi-perspective learning environment that prepared participants for an increasingly digital future while maintaining focus on human values and responsible technology use.

7. Additional material



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Determination of Water Quality

1. Lighthouse Activity

Name of the activity: Determination of Water Quality

Topic(s): Health, Green Deal

Foundational aspect(s): IBL (Inquiry-Based Learning), Real-life problems (RLP)

Possibilities of interdisciplinary integration: Science, Environmental Education, Chemistry, Technology

Learning objectives:

- Understand water quality indicators (pH, conductivity, turbidity)
- Learn how to use sensors for environmental measurements
- Raise awareness about water pollution and its effects
- Develop scientific reasoning and analytical thinking skills

2. Implementation Process

Date: 24.12.2023

Local: Kars STEM Center

Duration: Approximately 60 minutes

Partners involved: HU, Kars STEM Center, Kafkas University

Target group: Students, parents, school director

Number of participants: 15

Number of female participants: 8

Age of the participants: 12-14

Description of the implementation process of the activity:

The activity began with an introduction on water quality and its environmental and health impacts. Participants were shown how to use pH, conductivity, and turbidity sensors.

Water Sample	pH	Conductivity (µS/cm)	Turbidity (NTU)	Observation (e.g., color, smell)
Spring Water				
Tap Water				
Polluted Water				

Artificially Contaminated Water				

Water samples (spring water, tap water, polluted water, and artificially contaminated water) were analyzed. Students recorded their observations, compared the results, and discussed pollution sources and preventive actions. Hacettepe University supported the school with materials, expert facilitation, and guidance during the hands-on session. Kars STEM Centre has helped in comparative analyses with its existing equipment.

3. **Knowledge, Skills, Attitudes and Beliefs**

During the activity, students learned fundamental concepts of environmental science, including pH, conductivity, and turbidity. They experienced working with scientific tools through sensor usage and gained skills in observation, data collection, and interpretation. The activity promoted awareness of water pollution and encouraged students to consider both causes and preventive solutions. By engaging with a real-life problem, learners became more conscious of environmental issues and began to approach them with a scientific mindset.

4. **Difficulties and Key Success Factors**

Some students initially struggled with using the sensors due to unfamiliarity. This challenge was quickly addressed through direct guidance by facilitators. Another limitation was the short time available for in-depth data analysis. Despite these issues, the activity was successful thanks to high student engagement, the real-life relevance of the topic, and the hands-on nature of the task. Hacettepe University's ICSE factory lab support in providing materials and expertise was instrumental in ensuring smooth implementation.

5. **Added value of the implemented activity for community members.**

The activity increased students' environmental awareness, which extended beyond the classroom as they shared their insights with family members. It contributed to broader community understanding of local water quality issues. Additionally, the collaboration between the university and the school set an example of how academic partnerships can promote science literacy and community benefit.

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6. Reflective remarks

This lighthouse activity effectively demonstrated the potential of inquiry-based, real-life science learning. It promoted student engagement and environmental responsibility. The use of scientific equipment made the learning authentic and impactful. Future iterations could include data logging and comparisons with national standards. The model is scalable to other schools and can be adapted to include more advanced environmental analysis tools.

7. Additional material

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Implementation Process of LHA

Introduction and Information Session (10 minutes):

- Discuss the importance of water quality and the factors that influence it.
- Explain how parameters like pH, conductivity, and turbidity affect water quality.
- Introduce the sensors used to measure these parameters.

Materials and Preparation (5 minutes):

- Water samples: natural spring water, tap water, polluted water, and artificially contaminated water (e.g., soapy or salty water).
- pH sensor, conductivity sensor, and turbidity sensor.
- Recording device or computer.
- Notebook and pen.

Measurement Application (20 minutes):

1. Using the pH Sensor:
   Measure whether the water samples are acidic, neutral, or basic. Record the results.
2. Using the Conductivity Sensor:
   Measure the amount of dissolved ions in the water samples using the conductivity sensor. Emphasize that high conductivity may indicate pollution.
3. Using the Turbidity Sensor:
   Measure the level of suspended particles in the water using the turbidity sensor. Highlight turbidity as a visual indicator of pollution.

Data Analysis (15 minutes):

- Compare the measurement results to evaluate which water samples are cleaner.
- Discuss the significance of pH, conductivity, and turbidity results and how they relate to potential

uses of the water (e.g., drinking, irrigation, industrial use).

Conclusion and Discussion (10 minutes):

- Reflect on the overall findings of the activity.
- Lead a discussion on "What can we do individually and collectively to improve water quality?"

Worksheet: Determination of Water Quality

Name: ___________________________

Date: _____________________________

Activity Steps

1. Introduction

- Why is water quality important? Write a short answer:

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2. Measurement Table

Use the sensors to measure **pH**, **conductivity**, and **turbidity** for each water sample. Record your results in the table below:

Water Sample	pH Value	Conductivity (µS/cm)	Turbidity (NTU)	Observation (e.g., color, smell)
Spring Water				
Tap Water				
Polluted Water				
Artificially Contaminated Water				

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Analysis Questions

1. **pH Analysis:**
   - Which water sample has the highest pH? ___________________________
   - Which sample has the lowest pH? ________________________________
   - What do these pH values tell you about the samples?

2. **Conductivity Analysis:**
   - Which water sample has the highest conductivity? ___________________
   - What might high conductivity indicate about the water sample?

3. **Turbidity Analysis:**
   - Which water sample has the highest turbidity? _______________________
   - What does high turbidity indicate about water quality?

Conclusion and Discussion

1. Based on your measurements, which water sample appears to be the cleanest? __________________________
2. Which sample seems to be the most polluted? __________________________
3. Why do you think the polluted sample has those specific measurements?

4. What actions can we take to improve water quality? List at least two:
   a. ____
   b. ____

Reflection

- What did you learn about water quality from this activity?

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Instructions:

- Use the sensors carefully to ensure accurate measurements.
- Record all your observations in the table.
- Discuss your findings with your group before completing the analysis and conclusion sections.

Did you enjoy this activity?

☐ Yes

☐ No

Why or why not? ____

Photos of the implementation process

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Hidden Power of Fruits

1. Lighthouse Activity

Name of the activity: Hidden Power of Fruits

Topic(s): Health

Foundational aspect(s): IBL (Inquiry-Based Learning), Real-life problems (RLP)

Possibilities of interdisciplinary integration: Science, Environmental Education, Chemistry, Technology

Learning objectives:

- Understand the comparative Vitamin C levels in different foods using a simple chemical test
- explore everyday health-related science through hands-on activities
- formulate and test hypotheses about nutrition.

2. Implementation Process

Date: 26.04.2024

Local: Kastamonu Technopolis

Duration: Approximately 60-90 minutes

Partners involved: HU, Kastamonu University, Kastamonu Technopolis

Target group: Parents, public, students, child

Number of participants: 25

Number of female participants: 16

Age of the participants: 6-45 (A wide age range as it is a family event)

Description of the implementation process of the activity:

The activity began with warm-up questions to stimulate curiosity about Vitamin C sources in daily nutrition. Students hypothesized about whether fruits, fruit juices, or supplements contain more Vitamin C. Using a simple iodine reaction test, students compared the Vitamin C content in various food samples. The test involved adding iodine drops to the samples and observing the color change. A lighter color indicated more Vitamin C due to its reducing effect on iodine. This hands-on inquiry approach encouraged experimentation and visual analysis. Participants documented their observations and drew conclusions based on comparative results.

3. Knowledge, Skills, Attitudes and Beliefs

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Learners gained foundational knowledge about Vitamin C, its chemical properties, and its importance for health. They developed skills in formulating hypotheses, conducting experiments, making careful observations, and interpreting visual results. The activity also fostered scientific curiosity and appreciation for how simple chemistry methods can be used to explore everyday health-related questions.

4. **Difficulties and Key Success Factors**

Some participants initially struggled to interpret the results accurately, especially when color changes were subtle. This was mitigated through peer discussion and teacher facilitation. Additionally, ensuring consistency in sample quantities and iodine dosage required careful supervision. Despite these minor challenges, the activity succeeded due to its simplicity, real-life relevance, and the excitement generated by the visual chemical reaction. All participants were actively engaged and enjoyed the investigative aspect of the experiment.

5. **Added value of the implemented activity for community members.**

The activity raised awareness about nutrition and the importance of Vitamin C among participants and, indirectly, their families. It demonstrated how everyday science can be explored with minimal resources, promoting science engagement beyond the classroom. By sharing results and discussions, participants contributed to a broader dialogue on healthy dietary habits in their communities.

6. **Reflective remarks**

This lighthouse activity exemplifies how real-life questions, and low-cost materials can be used to engage all age level participants in meaningful scientific inquiry. It successfully connected science with health and everyday life, encouraging students and child to think critically and act as young researchers. The format is scalable, adaptable, and holds strong potential for cross-curricular integration in science and health education.

7. **Additional material**

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Worksheet: Hidden power of fruits

GROUP NAME:

Vitamin C is very important for human health and it is recommended to take 60mg daily. Although we have opinions about whether there is vitamin C in the foods we consume as a society, we do not have detailed information about which food has a higher vitamin C value. Many detailed laboratory methods are used to determine the amount of vitamin C in foods. However, in this study, we aim to compare the vitamin C levels in foods as high, medium and low without using detailed laboratory methods.

1. Warm-up Questions

Let's answer the following questions about how to get the amount of vitamin C that a person should take daily.

1. Are fruits or juices more effective?
2. Are 100% fruit juices or fruit juice mixtures (concentrate) more effective?
3. How does fresh fruit compare with cooked fruit?
4. What is the situation when fruits are compared with vitamin C tablets or supplements?

2. **Hypothesis (Form a hypothesis to investigate what you are curious about from the answers / predictions you have given to the questions)**	3. **Research Process/Plan (Briefly describe what you will do)**
4. **Findings (The data you obtained during the research process)**	5. **Conclusion** (Briefly write the results you have reached at the end of the research)

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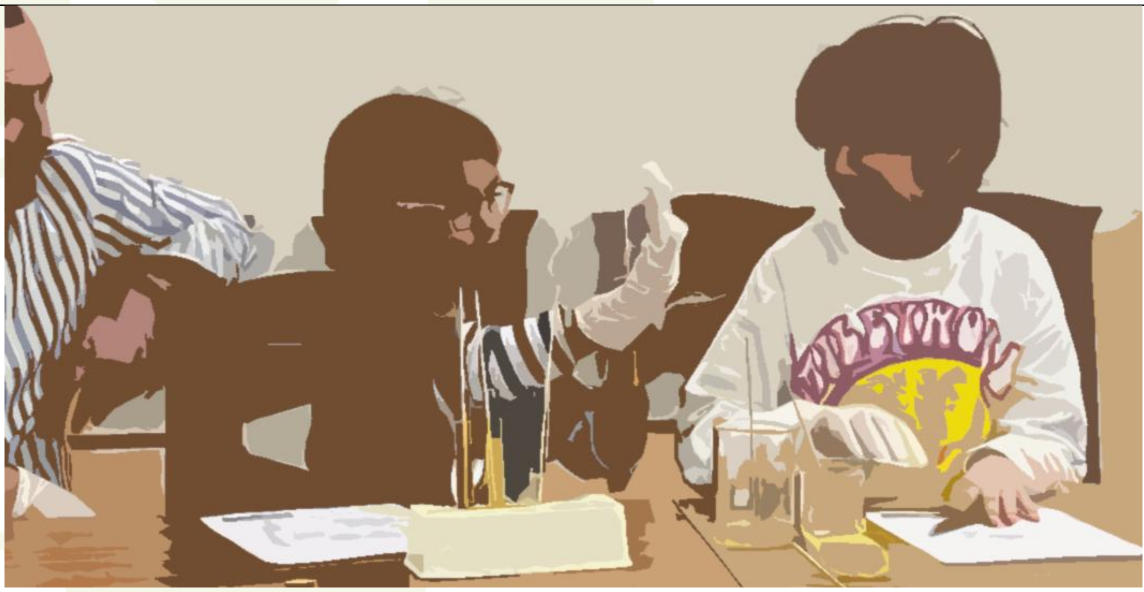

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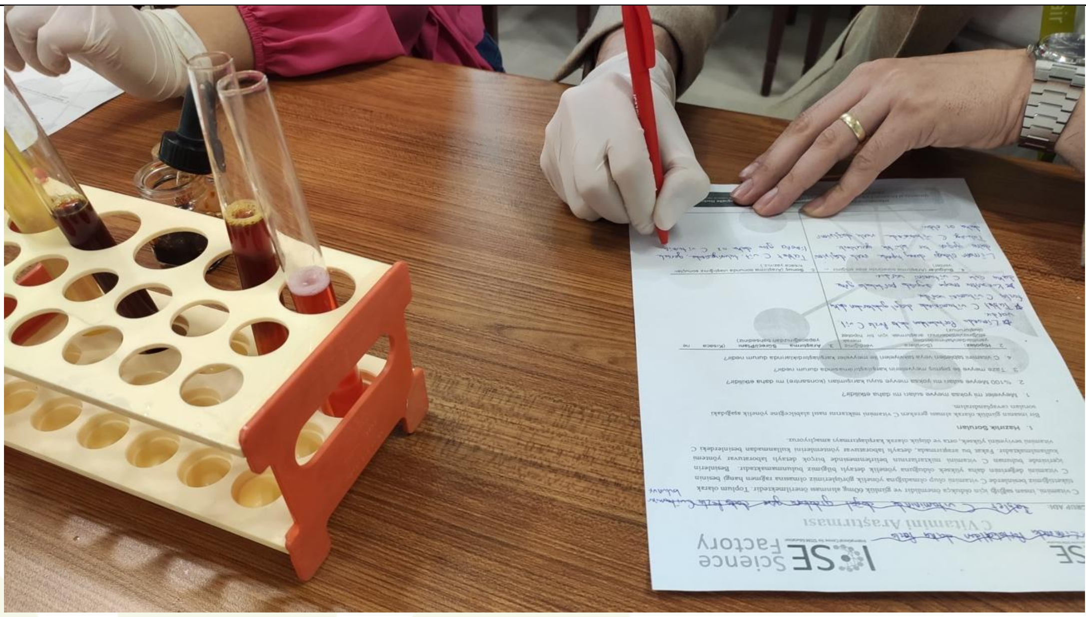

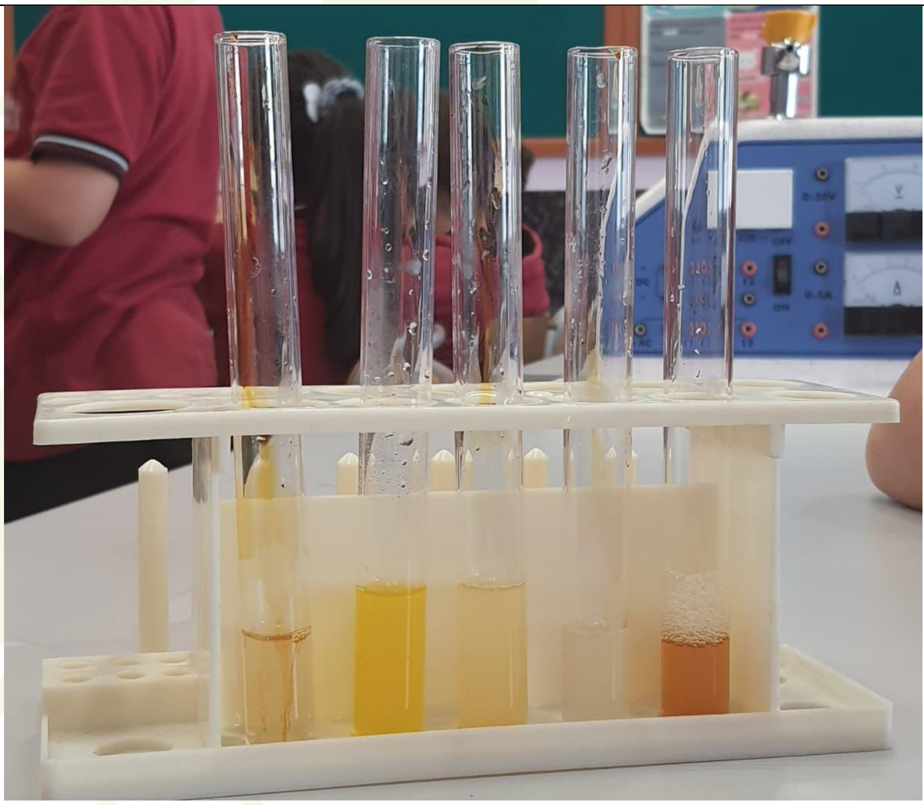

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Sun Tracking Panel: Smart System for Efficient Energy Production

1. Lighthouse Activity

Name of the activity: Sun Tracking Panel: Smart System for Efficient Energy Production

Topic(s): Green Deal

Foundational aspect(s): IBL (Inquiry-Based Learning), Real-life problems (RLP)

Possibilities of interdisciplinary integration: Science, Physics, Engineering, Technology, Environmental Studies

Learning objectives:

- Understand the principles of solar energy tracking systems
- explore the use of light sensors and basic motor mechanisms
- promote sustainable energy thinking through biomimicry design
- engage in real-world problem solving

2. Implementation Process

Date: 14.04.2025

Local: Kastamonu/A secondary school

Duration: 60 minutes

Partners involved: HU, Mekano Lab, Dora Toy

Target group: students, parents, teachers

Number of participants: 12

Number of female participants: 5

Age of the participants: 11+

Description of the implementation process of the activity:

Inspired by the behaviour of sunflowers (known for following the sun), students participated in designing a mechanical sun-tracking system using two LDRs (light-dependent resistors), a simple microcontroller, and a motor. The LDRs were mounted on either side of a solar panel-like surface, and the system was calibrated so that the motor would move the panel toward the direction receiving the most sunlight.

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Unlike more complex systems using Arduino, this activity was based on a more simplified and intuitive electronic setup, ideal for introducing students to the basics of electronics and automation. The scientific content was developed and delivered by Hacettepe University, while the material design and mechanism construction were carried out by Mekano Lab and Dora Toy. The completed system was demonstrated in an outdoor setting and included a discussion on energy efficiency and natural design inspirations.

3. **Knowledge, Skills, Attitudes and Beliefs**

Students gained knowledge about the function of LDRs, basic circuit logic, and motor-based movement. They developed design thinking and problem-solving skills, while also learning how to interpret sensor input for real-world mechanical response. The activity fostered appreciation for renewable energy solutions and nature-inspired (biomimetic) designs.

4. **Difficulties and Key Success Factors**

Some participants found it challenging to understand the logic behind sensor-based motor control, especially without a programming interface like Arduino. Adjusting the sensor placement for balanced detection and achieving consistent motor responsiveness required trial and error. Success was achieved through teamwork, hands-on testing, and the simplicity of the mechanical system. The biomimicry theme captured student interest and made the science behind the design more relatable.

5. **Added value of the implemented activity for community members.**

This activity introduced students and their communities to the concept of sustainable energy using simple, understandable tools. It promoted the integration of technology with nature-inspired thinking, showing how everyday energy problems can be addressed with creativity and low-cost solutions. The project served as an accessible introduction to eco-technology and could inspire similar initiatives within schools or local community centres.

6. **Reflective remarks**

The activity successfully blended engineering, environmental awareness, and creative design. By using a sunflower-inspired approach, students engaged in meaningful learning about energy efficiency and automation without the need for complex coding. The collaboration among Hacettepe University,

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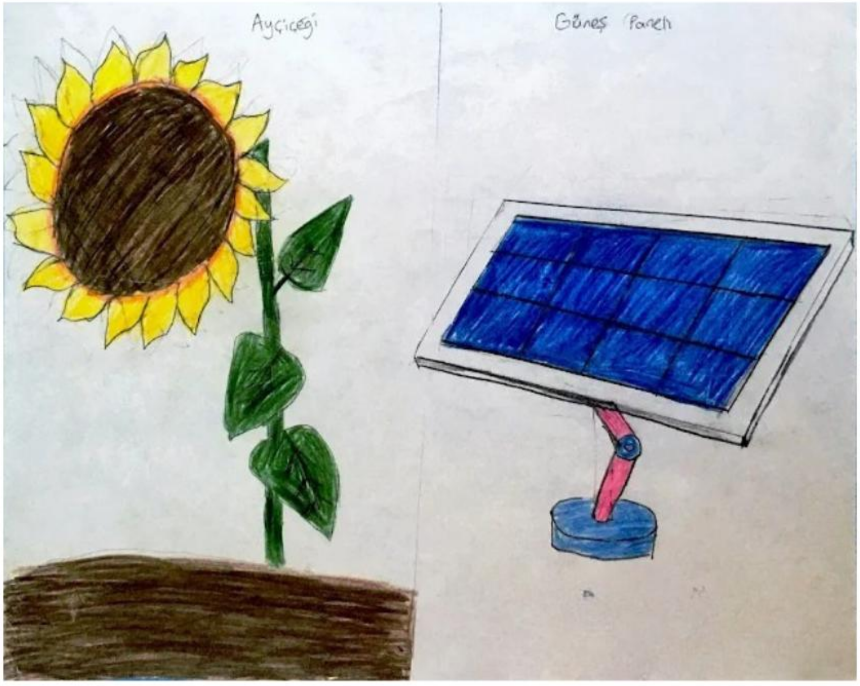
Mekano Lab, and Dora Toy ensured a robust and educational implementation. Its accessibility and engaging nature make it highly replicable and impactful in various educational settings.

7. Additional material



Photos of the implementation process and an example of a result

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