STE(A)M

Methodological door hangers for teachers

Teacher's handbook
to support experiential STE(A)M
education in the 2nd century

IMPRESUSE

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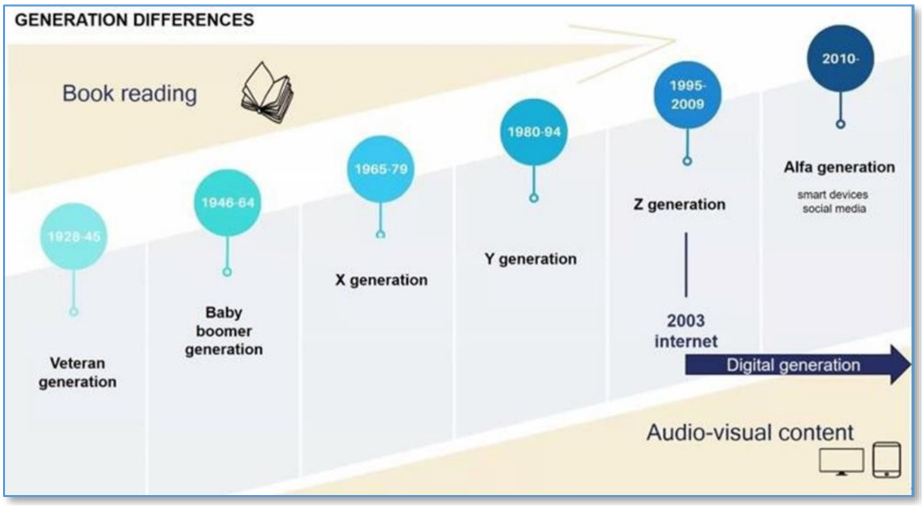
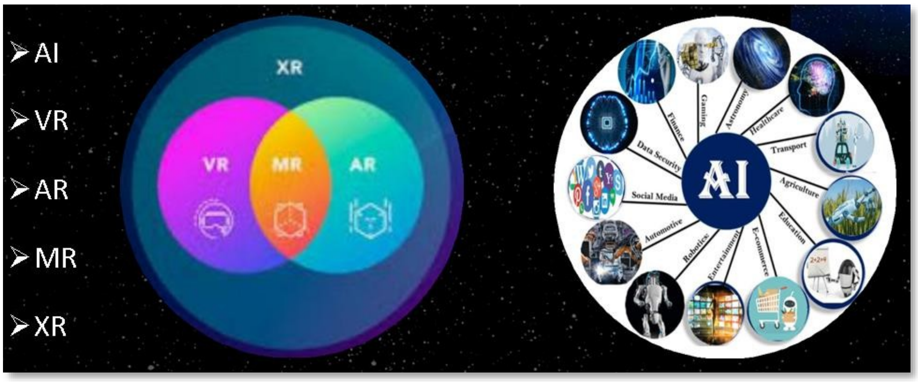
FOREWORD

We live in an era of paradigm shifts. Education is not left out of it. While previous generations learned and acquired information mainly from books and other printed publications, this has changed significantly (Figure 1). The emergence of audiovisual content, ubiquitous technologies and artificial intelligence (Figure 2). The impact of all these instruments cannot be ignored in the educational process.



1. Figure



2. Figure

Unfortunately, **the interest of young people in STEM[1] fields is not as high as it should be**, while humanity is facing challenges such as climate change, pollution, energy crisis, depletion of earth's resources, raw materials, species extinction, epidemics caused by the emergence of new pathogens. Science professionals have an important role to play in solving all these problems, but if there is no interest from young people, there will be a serious shortage of professionals.

[1] STEM is a mosaic word. From the initials of the English words Science, Technology, Engineering and Mathematics.

With our methodological recommendations, we want to contribute to **future and practicing teachers to gain skills** and to enhance their existing experience in STEM education **by using the STE(A)M[2] teaching methodology**.

We hope that our work will help to develop teachers' teaching skills and thus stimulate and enhance the interest of more young people in science.

We would also like to thank the authors of the book and our supporters.

[2] STE(A)M is an educational method. It involves integrating STEM subjects with non-STEM subjects.

INTRODUCTION

What is STE(A)M?

Although STEM subjects are included in the curricula of all European countries, STEM teaching is mainly one-subject time, and studies show that teachers do not usually work together. As a consequence, students may not be able to combine and link knowledge from several STEM subjects or from other subjects. The aim of our book is to address the lack of integrated STEM teaching by creating and testing a conceptual framework of reference for integrated STE(A)M (the "A" stands for all) education.

In addition, this book will help to develop a capacity building programme for STEM teachers in primary schools based on this framework, with a particular focus on contextualising STEM teaching, especially through collaboration between industry and education.

Our book is a tool in the capacity building programme mentioned above.

STEM education is recognised as a priority by public and education authorities in Europe. But student interest in STEM-related studies and careers has not increased despite the rapid development of science and technology. To reverse this trend, the four disciplines - science, technology, engineering and mathematics - are

, and the integration of non-science subjects (**with [A] as "all"**) into a single class, unit or lesson, based on the links between subjects and real-world problems, has led to **integrated STE(A)M education**.

Integrated STE(A)M teaching reflects **the** ambition **to combine some or all four disciplines of science, technology, engineering and mathematics with at least one non-science subject (e.g. literature, history, economics, language, etc.) in a single unit or lesson.**

Why do we need integrated STEM?

The integration of STEM subjects allows students to put the knowledge they have acquired in each subject into context and link it to real-world challenges or STEM careers. For example, if we want to introduce students to the importance of sustainability, we need to look at this topic from multiple perspectives. Consequently, students will learn how to search for relevant information in technology, learn about ways to collect and represent data in maths, and have time to reflect and learn about the ecosystem and design projects on sustainability in biology or economics. This is the first step to ensuring that students are able to understand how this knowledge can help them tackle or solve everyday problems while they are still in primary school.

By integrating more STEM subjects, we encourage the use of pedagogical methods such as project-based learning and encourage students to work together. There is a need for hands-on activities and the use of appropriate tools, but most importantly, teachers need to make good use of the resources between them and work with their colleagues.

Collaboration between teachers working in different STEM fields has been reported as a positive factor for self-efficacy. The integration of engineering and science provides an opportunity to improve students' learning and interest, especially when they are exposed not only to science content but also to scientific inquiry. Indeed, scientific enquiry and design-based thinking underpin decision-making processes in science, technology, engineering and mathematics.

In our book, we give suggestions for effective, efficient STEM teaching in 6 themes:

- Energy
- Food and water
- Sustainability
- Sound and light
- Air
- Universe

STEM(A)M EDUCATION PROGRAMME

Introduction

The STE(A)M (Science, Technology, Engineering, Arts [more recently: All] and Mathematics) integrated educational approach aims to equip the next generation to recognise complex problems, think critically, collaborate and develop creative solutions, based on experiential learning that reflects real-life situations while developing students' skills and emotional intelligence. The future does not wait - tomorrow's society is being shaped within the walls of schools today, so it is crucial to adopt an educational approach that not only imparts knowledge but also shapes mindsets. This is exactly what the STE(A)M programme does: it thinks in terms of complex problems rather than subjects, of creative solutions rather than ready-made answers. Through the integration of science and art, it develops not only cognitive but also emotional and social competences - empathy and precision are developed simultaneously. Learning is not a one-way process, but a co-creation. Students are not passive recipients, but active shapers of knowledge acquisition, asking questions, researching, reflecting. In this way, the classroom becomes a living laboratory where theory and practice build on each other. Teaching in this model is not a guiding but an accompaniment - the teacher is not only a knowledge broker, but also a mentor and a guide, encouraging and guiding. The STE(A)M teaching method accepts mistakes and even considers them part of the learning process. In the spirit of inclusivity, every child is heard, every question is valued. In working together, not only learners but also communities are formed - cooperation is not just a method but a culture. 21st century competences such as digital literacy, collaboration, critical thinking are not slogans, but real tools for making the world a better place. STE(A)M therefore not only develops skills, but also builds character. Learning can be a passion - if it has play, purpose and meaning. Through a teacher's reflective attitude and mentoring, a learning environment is created where choices of the present open up possibilities for the future. The programme is an opportunity for new thinking, new futures, new hope. And a message that real teaching is not just about knowledge transfer, but about building the future. The relationship between teachers and students becomes one of equals: cooperation is based not on hierarchy but on mutual respect and trust. Learning is not only a journey of knowledge acquisition, but also a journey of self-discovery, in which students realise their own potential and capabilities. STE(A)M also gives students the opportunity to engage with real-life issues during their school years. Issues such as sustainability, health, space exploration or even artificial intelligence are not abstract topics but become inspiring realities. Through collaborative projects, students learn the principles of cooperation and responsibility. Through their interactions, students develop their social skills and become more sensitive to the views of others, which is the basis of a democratic society. The integration of different fields of knowledge allows them to think in a coherent way rather than in separate subjects. The role of the teacher is thus significantly transformed: no longer the sole source of knowledge, the teacher is a partner who supports the learning process with appropriate questions, guidance and feedback. The classroom becomes a creative studio where each learner has the opportunity to develop at his or her own pace and style. Accepting mistakes and the opportunity to start again reinforces the learners' sense of self-confidence. The experience of success can be not only the right answer, but also the way to get there. Motivation then becomes intrinsic, which in the long run ensures openness to learning. It is also an inspiring methodology for teachers: an opportunity for renewal, self-reflection and connection with professional communities. STE(A)M develops not only students but also teachers. It is an approach that bridges past, present and future, respecting tradition while seeking new ways forward. STE(A)M is not only an educational model, but also a vision of the future - a world where knowledge, creativity and compassion are in balance.

Target group and reach

The project is aimed at Hungarian, Slovak and Romanian teachers who can integrate STE(A)M into their own teaching practice. As part of the programme, international workshops, digital teaching materials, mentoring and learning communities have been set up. The national and international partnerships allow for sharing experiences and understanding cultural differences as values. Thanks to grant funding, teachers receive regular support, including professional training and participation in international conferences. The STE(A)M approach is in line with the UNESCO and European Commission education guidelines, which promote integrated, inclusive and future-oriented learning. These new models contribute to the renewal of local practices and promote an open and adaptive approach. An international perspective helps teachers to understand and benefit from global educational trends. Discourse between teachers from different backgrounds brings new perspectives into the classroom. Working together helps national education systems to develop by presenting practical, proven solutions. Teachers will be able to apply innovation at local level, taking into account the specificities of their pupils. Partnerships are long-term, not just project periods. Interoperability between educational models increases the effectiveness of learning. Project partners are thinking not only in terms of teacher-teacher links, but also of school and regional networks. International partnerships will continue in the future, thus supporting continuous development and knowledge sharing.

Basics of the STE(A)M methodology

The programme is based on student curiosity, teacher mentoring and a project approach. Teachers act as facilitators, supporting students in their exploration, research and independent learning. This method focuses not only on the content of learning but also on the process of learning. The pedagogical aim is not the passive transfer of knowledge, but its joint discovery. It encourages students not to be afraid to make mistakes, because it is through mistakes that the deepest learning takes place. Teacher mentoring provides personalised support: it takes into account individual learning styles, paces and interests. Lessons are thus an inspiring space where questions can be asked, reflection is free and learning becomes a joyful experience. In project-based learning, students solve real problems, often in an interdisciplinary way, blurring the boundaries between subjects. Learning becomes authentic and relevant, connected to students' real lives. They will develop a sense of responsibility, autonomy and experience that their knowledge has consequences and impact. Teachers do not guide but accompany - they learn and grow in the process. The learning environment is co-created with the students, in which trust, openness and flexibility play an important role. Digital technology is not an end in itself but an integral part of the pedagogical strategy: a tool for exploration, expression and collaboration. In this way, learners become not only "consumers" but also active shapers of knowledge. In the long term, this approach contributes to the education of a generation capable of adapting to and shaping a changing world.

Pedagogical principles in the STE(A)M programme

The STE(A)M programme puts the learner at the centre. The aim is not just to learn the material, but to change the way of thinking, the way of relating to the world and discovering one's own learning paths. A pedagogical methodology that takes into account learners' individual interests and learning styles is more effective in transferring knowledge and motivating learners to learn. Learners are active participants in the learning process: not only observers but also doers. Questions are not handicaps, but gateways to new knowledge. Unlocking learners' interest and creativity is an essential part of the learning process. The role of the teacher is fundamentally transformed from lecturer to mentor. He is no longer a holder of information but a provider of opportunities for discovery. He or she can listen, motivate, encourage and give direction. The teacher is a facilitator of learning, creating a safe and accepting environment for students. Acceptance of mistakes is key in the learning process. It is not failure but the opportunity to improve. Analysing mistakes provides valuable learning experiences and contributes to the development of self-awareness. It also expands the time and space of the lesson. Learning takes place not only within the walls of the classroom, but in projects, in the field, in digital spaces. Learning becomes a real-life experience that is directly connected to reality. Students also learn from each other. Group work, peer-to-peer knowledge sharing develops social competences, empathy and community thinking. The teacher's reflective approach constantly innovates pedagogical practice. She is open to new pedagogical methods, technologies and student feedback. The teacher learns as much as the students. STE(A)M pedagogy not only integrates subjects but also values: it shapes future learners based on responsibility, interest, openness and community experience. The school of the future builds on the wisdom of the past and the innovation of the present. And the teacher is the bridge between these two worlds. Teaching is not a craft, but a vocation - the art of shaping the future.

The core values of the STE(A)M approach

- ✓ *Freedom of creativity:* the learning space should be a place where learners not only learn but also dream.
- ✓ *Courage to ask:* Every question builds a bridge to understanding.
- ✓ *Failure as a catalyst:* failure is not a crime, but the start of a new journey.
- ✓ *Community knowledge:* individual knowledge only becomes a real force in a community space.
- ✓ *Teacher inspiration:* the teacher's presence encourages, inspires and conveys value.
- ✓ *Technology with humanity:* digital tools can only improve if they are driven by human values.

(For thoughts on fundamental values, see Zsuzsa Gulyás 2021: 41-56.)

STE(A)M and the pedagogical paradigm shift

The learning and knowledge models of the 21st century have changed radically. It is no longer enough to impart material knowledge: the key to learning is the development of competences, questioning, critical thinking, applicable knowledge, creativity and empathy. The STE(A)M approach represents a paradigm shift within this framework. The role of the teacher cannot remain static: the teacher is no longer a transmitter of knowledge, but a mentor, facilitator, researcher and inspirer.

The introduction of STE(A)M is more than a didactic transformation, it is a revolution in approach. The teacher has to be open-minded, methodologically up-to-date and mentally resilient at the same time. Key issues are building supportive teacher communities, mentoring, and reinforcing a reflective teaching attitude and a culture of continuous learning. Only in this way can STE(A)M become not only a methodology but also a force for building the future. Flexibility is the key to responding to challenges and cooperation. The teacher is not a lone warrior, but part of a community of learners, where shared development and support is the key to success. The paradigm shift in education is not only happening in schools, but also in the minds and hearts of teachers. An inner openness, the courage to try something new and self-reflection help to move beyond the comfort zone. In fact, STE(A)M is not only a technological and pedagogical innovation, but also an internal transformation. This transformation is not a one-off step but a process that takes time and patience - with ourselves and with others. In this system, the teacher is not only a transmitter of knowledge, but also a shaper of the future. The inspiration that STE(A)M offers can, in the long term, reshape the concept of learning - and with it schools, society and even the world.

Developing digital competences

Developing digital competences is one of the most important educational challenges of our time, as the society of the future is based on information-based knowledge. The role of teachers is changing: they are not only knowledge transmitters, but also digital facilitators, able to navigate the rapidly changing world of technology. Education systems need to keep pace with innovation to ensure that students are well prepared for the challenges of the digital society. One way to do this is to integrate online courses into the curriculum, allowing flexible and personalised learning at a pace that suits the individual. Digital learning materials help to differentiate the learning process, taking into account learners' different abilities and learning styles. Platforms for teachers to share knowledge and engage in professional dialogue. Developing learners' digital competences means not only using tools but also critical thinking, information filtering and ethical online behaviour. Teaching the basics of Artificial Intelligence fosters learners' understanding and responsibility towards technology. As an interdisciplinary discipline, robotics develops problem-solving skills and algorithmic thinking. Teaching data visualisation contributes to the development of data-driven decision-making skills. Digital storytelling combines creativity, language competence and technical skills. The creation of multimedia content motivates students to create independently and to learn experientially. The use of tools and platforms helps to personalise learning. Digital literacy for teachers is essential to improve the quality of education. The digital ecosystem of learning gives teachers new roles and responsibilities. The hybrid education model creates a balance between online and offline learning. E-learning is not a substitute for face-to-face contact, but enriches the educational palette. The digital space is not only a place for learning, but also a community-building space. Increasingly, learning is a space for empowerment through digital skills. Digital solutions offer opportunities to improve time management and the efficiency of curriculum preparation. Pedagogical innovation is becoming an integral part of the possibilities offered by digital tools.

Learning environment in the STE(A)M programme

Going beyond the traditional classroom framework, the STE(A)M learning environment operates as a dynamic, inclusive and error-allowing space. It relies heavily on digital tools, while emphasising the importance of live connections and experiential learning. The STE(A)M classroom is not a static space, but a transformative environment where the physical layout also adapts to the learning objectives. The furniture is mobile, students work in groups and the teacher is free to move around, help, question and inspire. The learning space is based on openness and flexibility, where mistakes are not failures but learning opportunities. Digital tools such as tablets, laptops, interactive whiteboards and VR glasses are not mere accessories but an integral part of learning. They allow learners to visualise abstract concepts, simulate reality-based situations and interact with global knowledge bases. Combining digital and physical spaces allows for individual and collaborative learning is. Students use a project-based approach to find solutions to real problems. The environment supports these processes: creative workshops, brainstorming boards, prototyping tools, digital modelling. The learning space fosters the courage to experiment and the acceptance of failure. According to the STE(A)M approach, the environment is not only a physical place, but also a cultural and emotional atmosphere. The teacher-student relationship is based on trust and mutual respect. Emotion, inspiration and motivation are as important as information in the learning process. The aim of the programme is to create an inspiring learning environment in any setting, whether in school or in community spaces. As well as transforming classrooms, learning spaces can be a park, an art exhibition or a science lab.

STE(A)M and community learning

One of the greatest strengths of the STE(A)M approach to education is that it generates not only individual but also collective learning processes. Learning in school is spatial and temporal: students learn not only with the teacher but also with each other. Learning communities involve horizontal knowledge sharing, i.e. students teach each other based on their experiences. This reinforces self-awareness, peer learning and emotional intelligence. Teaching communities also play a key role in the success of the programme. Teachers share their experiences, problems and ideas in regular workshops. Such collaborative learning is not only inspiring but also helps prevent burnout. STE(A)M projects, organised in the framework of collaborative learning, bring together students and teachers from several schools, creating partnerships across borders. Community learning helps to develop students' self-efficacy while contributing to value-based education. According to the UNESCO 2021 report, the future of learning is shifting towards a participatory learning model embedded in communities (UNESCO 2021). STE(A)M therefore responds to global challenges by creating a learning culture where the acquisition and sharing of knowledge is equally valued. Personalisation of learning is a key pillar of 21st century education. The essence of STE(A)M pedagogy is that the learner is involved in the processing of the learning material through an individual learning path. The teacher does not follow a predetermined curriculum but reflects the learner's interests, pace and learning style. Differentiation tools include individual learning plans, individual project development and self-reflection journals in which the learner can look back on his/her own learning. Pupils can choose their own research topics that connect them emotionally to their learning. AI-based learning support systems, such as Knewton or Century Tech, provide further opportunities to adapt learning to the needs of the learner (Luckin et al. 2016). This approach also contributes to increased motivation to learn, enhanced self-awareness of learning and long-term knowledge retention.

Interdisciplinarity and cooperation

Blurring the boundaries between different subjects makes the learning process more natural and lifelike. Greater collaboration between teachers not only improves learning outcomes, but also enriches the teaching community. Interdisciplinarity helps students to perceive the complexity of the world not as isolated knowledge but as a coherent system. This approach develops problem-solving and critical thinking skills, which are essential in the 21st century labour market (OECD 2018). The integration of different subjects promotes experiential learning, especially in project-based education, where students reflect on real-life situations. This approach provides an opportunity to integrate, for example, biology, environmental science, technology and visual arts in a project on sustainability. Collaboration between teachers strengthens professional self-awareness and opens the way to learning from each other. Workshops between teachers, joint project planning and visits to each other's classrooms create a culture of where teacher collaboration is not an extra task but an integral part of everyday practice. Collaboration between teachers strengthens professional self-awareness and opens the way to learning from each other. Cross-curricular integration also enhances students' interest in finding meaning in what they are learning. The complexity of real-life situations requires that knowledge is not presented in subject bands. Interdisciplinary learning opens the way to individual learning paths and supports students' independent thinking. Collaboration in teacher communities strengthens school organisation, increases professional autonomy and helps prevent burn-out. In the STE(A)M approach, maths, art, science and technology are not separate entities but complementary systems. Collaborative learning allows students to learn about different perspectives and ways of thinking, thus developing empathy and communication skills (Fullan 2007). Cooperation between teachers strengthens the cohesion of the school community, while also allowing for the exchange of new pedagogical tools and methods. Joint planning, lesson observation and feedback build a culture of collegial learning. Drawing on international examples (e.g. Erasmus+ projects), an interdisciplinary approach can enrich teachers' methodological repertoires and help students develop life-linked thinking. International research also confirms that an interdisciplinary approach and teacher collaboration are key to the success of education in the 21st century (OECD 2020). Teachers experience these opportunities as a source of new inspiration and a reinforcement of their professional identity. STE(A)M provides a methodological framework for this process, in which collaboration is not only a tool but also an asset. Links with national and international partners such as Finnish, Dutch and Portuguese schools bring inspiring practices into the common space. STE(A)M encourages learning not only for students but also for teachers. A collaborative teaching workplace culture has been shown to improve learning outcomes and teacher satisfaction (Hargreaves-Fullan 2012: 113-129).

Reflective pedagogy

During the programme, participants will evaluate their own teaching practice through self-reflection. The mentoring process supports teachers' professional development and provides a space for sharing individual experiences. Reflective pedagogy is based on the recognition that the process of teaching is not just the application of methods, but also continuous learning on the part of the teacher. Through reflection on their own practice, teachers become aware of their strengths and areas for improvement (Brookfield 1995: 87-102). Self-reflection makes the impact of teaching on students visible, thus increasing responsibility and empathy. Mentoring is not a hierarchical relationship but a partnership in which teachers share their experiences to help each other develop. The dialogue between mentor and mentee contributes to deepening professional self-awareness. Reflective pedagogy aims at active participation in the learning process and its continuous reinterpretation. Digital tools provide the opportunity for teachers to document and analyse their own teaching practice (video analysis, e-portfolios). This kind of conscious presence strengthens professional autonomy and self-development (Schön 1983: 49-76). Receiving feedback and analysing learners' reactions helps to personalise teaching. Self-reflection also enhances teacher satisfaction, since authenticity is the basis of self-identified pedagogical functioning. Participation in learning communities (e.g. teacher workshops, professional learning communities) provides opportunities for a collective form of self-reflection. Here not only individual experiences but also shared dilemmas and solutions emerge. The development of a reflective attitude can start in teacher education, for example through teaching portfolios and observation diaries. For practising teachers, ongoing self-evaluation can be built into the school year, either in the form of teacher diaries or learning logs. Reflective pedagogy does not exclude emotions from teaching, but consciously integrates them. Experiences in the learning process - success, failure, recognition - are reflected in teaching practice. Reflection provides an opportunity for the teacher to redefine his or her role, its means and objectives. Reflective pedagogy is therefore not just a method, but an approach: a living, evolving and constantly questioned process of teaching and learning. The programme aims to enable teachers not only to apply what they have learned, but to give it new meanings in their own contexts. In this way, teaching becomes truly personal and meaningful. In reflective pedagogical practice, teachers are not afraid to ask questions about their own work - indeed, they see this as the key to their professional development. Conscious teacher presence is a prerequisite for successful and sustainable educational innovation (Zeichner-Liston 1996).

Success stories and good practices

The introduction of STE(A)M-based learning programmes has already led to measurable positive changes in many schools at home and abroad. In Hungary, experience from pilot STEM labs under the Digital Wellbeing Programme (DJP) has shown that student motivation has increased by 40% (DJP 2023: 12-18). Not only are students more active in class, but they are more confident in using digital tools and more often initiate group projects. According to the 2022 report of the STEAM4EDU programme in Romania, 78% of teachers participating in the programme felt that they had undergone a change of approach and had become more open to interdisciplinary working. In Slovakia, research linked to Comenius University found that STE(A)M-based education increased students' motivation to learn independently by 30%. In the "STEM Club" at the Hunyadi János High School in Budapest, students developed a prototype of a solar water heater that was selected as a finalist in the 2023 National Innovation Competition. The project was launched with the aim of raising environmental awareness and sustainability. Teachers at a primary school in Debrecen used digital storytelling to address local environmental issues, with students making films, presentations and podcasts. There are also many inspiring examples on the international scene: NASA's STEM Engagement programme gives primary school students the opportunity to solve space-related challenges (NASA 2024). The European Commission-funded Scientix (2023) project has created international teacher communities to innovate science education. The teacher communities established under the programme play a key role in disseminating good practices. Participants share their experiences through mentoring programmes that help them to develop professional self-awareness and fine-tune teaching strategies. Practices based on cooperative learning support the development of trust and social competences among learners.
Documenting and sharing good practices on digital platforms (e.g. eTwinning, Erasmus+ projects) provides not only inspiration but also replicable model solutions. STE(A)M education is thus not only a tool but also a bridge to integrate future generations into a meaningful, active society.

STE(A)M and the professions of the future

The STE(A)M approach plays a key role in preparing for the 21st century labour market. According to a recent World Economic Forum report (2020), the most important skills for the future include complex problem solving, critical thinking, creativity and emotional intelligence. STE(A)M develops each of these in a way that is immediately applicable in the lives of learners. Emerging sectors such as artificial intelligence, sustainable energy management, robotics and data-driven decision making are all areas where STE(A)M competences can provide a competitive advantage. Students will acquire not only technical knowledge, but also the ability to recognise the connections between information. According to the OECD (2022), education should prepare students for future professions that do not even exist today. STE(A)M can do this by developing in students adaptability, openness to innovation and lifelong learning

your approach. Integrating the digital society and the green economy into the curriculum is not only a matter of realism, but also of responsibility. Students will experience how technology and creativity can be used for community good. The UNESCO (2023) report on the future of education stresses that the key to education is "shaping the future", not just adapting. STE(A)M enables learners to become active shapers of their world. Through the educational process, learners are placed in roles where they can question, create, research - in other words, they prepare their own professional identity. The programme also promotes gender equality by promoting equality within STEM fields. The STE(A)M methodology therefore shapes not only careers but also vocations. Education is no longer
"what we teach", but "how we learn", and the quality of learning will be the measure. The professions and challenges of the future are already in the classroom - the question is whether we can create a learning environment that is fit for them.

Getting around

The education of the future is already taking shape today, not just within the walls of schools, but in the hearts and minds of teachers. The STE(A)M programme is not just a modern pedagogical methodology, it is a change of approach: an approach that gives learning not only knowledge, but also meaning, purpose and life skills. In this system, the teacher is more than a subject specialist: he or she is a mentor, an inspirer, a guide, a light on the learning journey. True teaching is not just the transmission of information, but presence, attention, connection. In the school of the future, the teaching role will increasingly be based on emotional intelligence and understanding communication. STE(A)M is also a pedagogy of courage: the courage to make mistakes, to question, to rethink. In this system, the teacher remains a learner and learning becomes a communal experience. Education for the challenges of the 21st century can only be effective if it is flexible, reflective and future-oriented. Learning must become a source of pleasure, not only for the desire to know, but also for the experience of creation and understanding. In this environment, learners not only acquire knowledge but also experience their own power, responsibility and creativity. The future is unpredictable, but education can provide a safe ground for change. The greatest gift we can give as educators is faith in the future. This faith is not naivety, but a sense of vocation. The STE(A)M programme is one of the most modern and human expressions of this vocation.

Thank you for being part of this journey together!

Zsuzsa Gulyás
education specialist

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ENERGY

1. Energy

STE(A)M-Areas	maths - physics - environment - sustainability

Summary table	
Subjects	maths - physics - science - chemistry
Objective	In the lesson, children are introduced to different energy sources and grouped according to whether or not they are renewable. Pupils record the concepts of renewable and non-renewable energy sources. They then work in pairs on an exercise sheet to look at the advantages and disadvantages of each energy source. The aim of the lesson is to introduce the concept of energy and its role in our daily lives; to introduce the main types of energy.
Age of students	8-10 years
Lesson/project duration	2×45 minutes
Number of students	10-15 people
Online learning tools	interactive whiteboard - projector
Offline learning tools	-
21st century competences	communication - cooperation - teamwork - creativity - innovation - critical thinking - problem solving
Learning objectives	developing competences - learning new skills

Project plan	
The name of the exercise	Energy
The implementation process	
Arousing interest, preliminary questions	What do the pictures represent? What do the pictures have in common? What comes to mind when you hear the word energy? Where do we get energy from?
Preparations	Let's show the animation below: What is energy? Show pictures, for example: a man running, coal burning, a stove, a radiator.
Presentation	What energy sources do you see in the pictures? How could the energy sources in the pictures be grouped?

- non-renewable energy sources (coal, oil, nuclear)
- renewable energy sources (solar, wind, hydro)

1. Figure

Figure 2.

Figure 3.

Figure 4

Has everyone ever seen coal burning in a stove? Let's project a picture of a fire burning in a stove! (It gets hot.) What happens to the coal? (Smoke, soot, ash are produced and the coal burns up and runs out.)

Project a picture of the sun shining over a lake/river. What heats up the water? (The sun.) How long does the sun last? (As long as the sun is shining, but then it heats up again.)

Compare the two energy sources! What do they have in common? What are the differences?
Write down as many things as you can in the table (e.g.: runs out - does not run out, reusable - cannot be reused, pollutant left over).

Figure 5.

Figure 6.

Pairing

Pair the following sentences!

1. The energy resource requirements of nuclear power are small,
2. Because of the flow of air, it is an inexhaustible source of energy,
3. Solar energy is constantly available from the sun,
4. Hydropower on large rivers is inexhaustible,

	5. When coal is burnt, it produces a lot of heat, 6. Petroleum can also be used to produce petrol, a) but solar panels take huge amounts of usable land away from agriculture, for example. b) but burning it is a major air pollutant. c) but the long-term, safe disposal of waste from the plant is not yet resolved. d) but car exhaust fumes are very toxic. e) but the noise can disturb living things. f) but the construction of the power plant will destroy the habitat of many organisms.
Method of discovery	Let's watch the short film! A short film for children about energy production (YouTube) What renewable and non-renewable energy sources did we see? Which energy source pollutes the environment the most? Which are less polluting?
Experiences	The solution is checked in large groups, with teacher explanation where necessary.
Feedback	A brief summary of what you have learned in the session. The teacher evaluates the students' performance in the lesson.
Presentation materials	Collect the answers! You can write it on the blackboard or project it on a computer. If there are some that have been said by more than one person, highlight them.
Results	Based on the characteristics, let's define together what energy is! Energy is what makes things move, like cars, machines, living things or gives them heat. To conclude, everyone should write a sentence about what they have learnt in today's lesson. Start the sentence like this: *It was interesting...* We can also ask what else they would like to know. Then start the sentence like this: *I would like to know...*
Critical thinking	There are materials, movements, from which energy is produced. These are energy carriers. Let's collect examples of energy carriers and write them down! If not all the more familiar energy sources are listed, the teacher should add renewable and non-renewable energy sources.

Subject links

Natural science	Physics: energy, energetics, energy conservation.
Digital culture	Digital devices: smart devices, projector.
Physical education	Energy demand of movements.
Geography	The Earth's energy carriers.

Visual culture	Design a poster to raise awareness of energy saving.
Mathematics	Conversion between energy units. Use of prefixes in units of energy.
Appendix	**Sources** What is energy? Short film for children on energy production (YouTube)

2. What is energy?

STE(A)M-Areas	maths - physics - environment - sustainability

Summary table	
Subjects	Hungarian language and literature - physics - chemistry - mathematics
Objective	Understanding the concept and characteristics of energy carriers, where they occur, their potential uses, renewable energy sources, stocks. Increasing knowledge of orienteering, maps. Energy sources for the 21st century. Formulating a vision of sustainable development. Developing observation and memory. Learning new concepts, explaining unfamiliar words.
Age of students	11-14 years
Lesson/project duration	45 min
Number of students	15-20 people
Online learning tools	Educational videos on energy sources (e.g. YouTube, National Geographic) Interactive games or simulations about energy sources (e.g. "Energy Lab", "Explore Renewable Energy") Virtual tours to wind farms or solar farms Digital tools such as laptop, interactive whiteboard, tablet
Offline learning tools	wrapping paper - glue - photos of energy carriers - paper - writing utensils
21st century competences	communication - cooperation - teamwork - creativity - innovation - critical thinking - problem solving
Learning objectives	developing competences - learning new skills

Project plan	
The name of the exercise	Energy
The implementation process	
Ideas Exchange	What does energy mean to you? What comes to your mind? Sun, wind, coal, wood, petrol, electricity, water, movement, power [Energy sources (YouTube)]
Preparations	Watch a short film on energy carriers. Observation aspects: • What energy sources have you seen? • What is the energy source used for?

	6 energies that could save our planet from destruction! (YouTube) Renewable energy (YouTube)
Presentation	Let's group energy sources! Renewable energy sources. Energy sources (Sutori)
Method of discovery	Choose from the two below! **1. Write an essay!** Why are renewable energy sources important? How does their use affect people's lives? The future is in our hands! Raise awareness of the importance of cooperation! "Energy connects us from beyond the perimeter" **2. Make an awareness-raising poster!** Let's take care of the Earth! Guidelines for our grandchildren on how to use energy more usefully
Experiences	The teams present their posters or read out their writings. They reflect on each other's work with a critical eye.
Feedback	Evaluate students' work. The teams also evaluate each other's work.
Presentation materials	Energy efficiency  Figure 1.
Results	Critical thinking. Developing cooperative skills. Development of creativity.

Subject links

Natural science	Physics: energy, energetics, energy conservation.
Digital culture	Use of digital tools: laptop, interactive whiteboard, tablet.

Geography	The Earth's energy carriers.
History	Evolution of energy sources since the industrial revolution.
Visual culture	Design a poster to raise awareness of energy saving.
Mathematics	Conversion between energy units. Use of prefixes in units of energy.
Appendix	**Sources** The energy that makes the world go round (Prezi) Thermal energy What is a heat pump? What is renewable energy?

3. Energy pathways: from heat to motion - from motion to heat

STE(A)M-Areas	mathematics - physics - chemistry - biology - engineering and design - art
Intercultural relations	**1. Historical energy sources** • **Ancient sources of energy**: discover how ancient civilisations harnessed energy, such as wind and water power to drive mills, or solar energy to dry and heat their buildings. • **Industrial revolution**: the energy industry, especially the use of coal and steam as energy sources, has brought fundamental changes to society. It is worth looking at how energy use has spread and transformed lifestyles. **2. Energy and environmental impacts** Different peoples and cultures have different approaches to their energy sources, taking into account environmental impacts and sustainability. How do different cultures manage energy resources and how is this reflected in their attitudes towards nature? (The environmentally conscious lifestyles of some indigenous cultures can provide much inspiration for more sustainable use of energy. **3. Energy symbols in culture** • **Mythology and religion**: in many cultures, different forms of energy have spiritual meanings. For example, the sun is often seen as a powerful symbol that gives life and energy to the earth. In ancient Egypt, the sun god Ra, and similar sun gods in other cultures, embody power and energy. • **Energy as a creative force**: Taoist philosophy, for example through the concept of chi, emphasises the energy that pervades the world. In the project, such symbols are presented to help us understand that energy is a universal concept. **4. Literary connections** Many literary works depict energy in different forms, such as fire, sunlight or even inner energy as metaphors. Students can also analyse poems or prose excerpts that depict the relationship between energy and man. For example, in the works of Victor Hugo or William Blake, the energies of nature often appear as the great driving forces of the world. **5. Modern cultural parallels** • **Films and media art**: many modern films and series deal with energy sources and their effects, for example on climate change or energy poverty. How do these media portray energy crises or the future of energy? • **Technology and social progress**: different cultures are moving at different paces in the technological innovation of energy use. How does the evolution of energy technologies affect

	culture and society, such as the rise of renewable energy sources.

Summary table	
Subjects	physics - technology - chemistry - biology - art - history - literature
Topics	Key laws. T h e history of scientific discoveries.
Age of students	12-20 years
Lesson/project duration	8×45 min
Number of students	12 persons
Online learning tools	Climate Literacy and Energy Awareness Network How Electricity Works MozaWeb and MozaBook Video Library Sulinet
Offline learning tools	Fritz Kahn 1944. *The wonders of the human body*. Robert Snedden 1998. *Energy*. Dr. László Balogh 2010. *Renewable Energy Handbook*.
21st century competences	innovation - creativity - problem-solving - analytical thinking - active learning - critical thinking - information and communication technologies - cooperation
Learning objectives	acquiring scientific knowledge - deepening understanding of the subject - acquiring summarising knowledge - helping to build learning communities - developing presentation, writing and organisational skills - developing abstraction skills

Project plan	
The name of the exercise	Energy pathways: from heat to motion - from motion to heat
The implementation process	
Enquiry	What is energy and why do we say that it "does not arise and is not lost"? What are the different forms of energy and how do they transform into each other? How can we calculate the kinetic energy of an object or the thermal energy of a liquid? Why does our body need energy and how does it produce it? How do alternative energy sources such as solar or wind power work? What are the phenomena through which we experience energy in everyday life? Why is energy saving important and how can we save energy at home?

		What happens when energy is lost from a system (for example, when the air cools) and what effect does this have on the environment? How can we store energy and why is it important to develop storage technology? What is the difference between renewable and non-renewable energy sources? How do we measure energy and what units do we use? Why do we need fuel to run our cars and what energy transformations take place in the process? How do we use heat in the use of energy sources? Why is energy efficiency important and how does it contribute to sustainability? What are the environmental impacts of our energy use and how can we reduce the negative consequences?
	Inspiration	Collecting ideas from students.
	Preparation	• a thermometer to measure the temperature of the water during experiments • a loop and a needle to prepare the tinfoil spiral for the experiment • aluminium foil (for the paper snake) • soda can (this can be recycled, used or reused)

1. Figure

Figure 2.

Figure 3.

• poster paper or cardboard for visual presentation of the project
• felt-tip pens, coloured pencils and glue for plotting and decorating the results

	• a tape measure or ruler to measure distances, needed to calculate kinetic energy • mini solar panels or wind turbines - if you are making a presentation about renewable energy • simple thermal imaging cameras or temperature stickers • digital scales • thermally conductive materials (e.g. copper wire or aluminium sheets) to demonstrate energy flow • small electric motors or LED bulbs to convert thermal energy into electricity • multimeter
View at	Preparing the equipment, boiling water. Preparing measuring instruments.
Hypothesis	Thermal energy can be converted into mechanical energy. The energy in the system does not remain fully contained as heat is lost to the environment. Warm air has a lower density and therefore rises. The energy can be stored and recovered in different forms, but any transformation involves a loss.
Plan	The aim of the project is for students to understand the different forms of energy, the process of transformation and the concepts of conservation and loss of energy. They will also be able to explore energy transformations through experiments and find answers to questions about the use of energy in everyday life.
Discovery	The project is about using a discovery method to teach students about the laws of physics, and the hands-on mind-on method results in a deeper understanding and more lasting knowledge.
Retrieved from	Students compare their results with their preliminary guesses and formulate their experiences.
Reflection from	Why are the preliminary suspicions and the experienced ones the same or different? Many students mention that hypothesising was an exciting part of the project. "It was fun to guess what would happen and then see if our calculations were correct." How does it feel to experience the joy of discovery?
Presentation	**1. Making a tinfoil paper snake** • Cut a small piece of aluminium foil and form it into a snake-like shape. • Make a tiny hole in the end of the snake with a needle, where you can thread the loop through. **2. Setting up the experiment** • Pour hot water into the soda can (make sure the water is not too hot to avoid accidents). • Place the loop stick on the edge of the box, then hang the paper snake on the stick so that it hangs over the water.

3.A conduct an experiment

- **Measure the temperature of the water**: use a thermometer to determine the initial temperature of the water.
- **Start the stopwatch**: as soon as the snake starts moving, start the stopwatch.
- **Observation**: observe how many turns the snake makes in 1 minute and record the results.
- **Repeat the experiment**: do the same experiment with water of different temperatures (e.g. lukewarm, warm) to see how the snake's movement changes.

4. Data processing

- **Calculating the rotational energy:** The rotational energy (E) is calculated as $E=0.^{5\Theta\omega 2}$, where Θ is the instantaneous moment of inertia and ω is the angular velocity (speed of rotation).

To calculate the mass of an aluminium foil disc, you need the density (ρ) and thickness (h) of the material. The mass of the disc is given by the volume times the density of the material:
Data:

Radius: e.g.: r=4 cm= 0.04 m
Thickness (h): thickness of aluminium foil usually in micrometres or are given in millimetres, which must be converted into metres:
h=0,02 mm 2×10=⁻ 5 m
Density (ρ): the density of aluminium is about ρ=2700 kg/m3 Calculate volume:

The volume of the disc can be counted as a cylinder:
V=πr2h
Calculate mass:
The crowd:
m=V·ρ=πr2h·ρ
Calculate angular speed:
In one minute (Δt), you measure the number of turns (Δθ) and then substitute it into the formula below:
ω=Δθ/Δt

- **Calculating** the amount of heat: The amount of heat (Q) can be calculated using the formula Q=cmΔT, where c is the specific heat of water (about 4.18 J/g°C), m is the mass of water and ΔT is the temperature change.

5. Conclusions

In the experiment, students learn how heat energy can be transformed into a form of motion and how the temperature of the water affects the speed of rotation. By analysing the results, students will also learn about the differences between closed and open systems.

Energy deficit

ΔE=Qwater-Eforg

What percentage of thermal energy is this?

(ΔE/Qwater)×100 (about 99.99%)

	What does energy turn into? Heat energy release to the environment: approx. 91% Friction between needle tip and aluminium foil: approx. 0.5% Mechanical energy: approx. 3.5% Kinetic energy of air: about 2% Air humidity increase: approx. 2% Condensation heat energy: approx. 1% All the energy in the system has not disappeared, it has just appeared in a different form, proving the law of conservation of energy. Comment This experiment gives students the opportunity to formulate their own hypotheses, observe the experimental results and draw conclusions about the observed phenomena, following the scientific method.
Project product	Data collected during experiments, observations and their analysis. Students can take home their own calculations and results, which will help them understand the different forms of energy and their interactions.
Redesign	Give students enough time to redesign their processes and modify their reports.
Stations	
Science station	Science involves thinking, observing, experimenting. It is important to formulate preliminary assumptions and share experiences. Formulating and answering questions about the history of science and society in the world. Collecting, writing up and presenting data. Tools: notebook, computer, pen, mobile phone.
Research station	Self-discovery in the relationship between science and society. How could you reverse the process, i.e. how could you turn kinetic energy into thermal energy? Tools: iPads, books, maps, encyclopaedias, tablets, computers, fiction and non-fiction books.
Technology station	Electronic technology: computers, tablets, smartphones, smartboards, digital cameras. Traditional technology: clothespins, duct tape, paper, tin foil, soda cans, pins, kettles, other handy utensils.
Engineer ing station	Engineering tools and materials: tape, tape, felt-tip pen.
Art and design station	Art and design supplies: markers, paper, scissors, glue.
Mathematics station	Mathematical tools • calculation of rotational energy, • calculation of heat, • evaluation, comparison, deficit.

Receiving station	Making short films about the experiment.
Experiences	After the project, you and the students will evaluate the project together, discuss your experiences and further ideas and plans.
Appendix	**Links** NOVA Labs Energy courses online (Coursera) **Videos** World Energy Council Wonders of Energy Science Unit Videos (YouTube) Fun Thermal Energy Activities to Explore Heat Transfer (Recorded Live) (YouTube) **Summary** Discuss, confirm or refute predictions, preliminary questions. **Group work** Distribute preparation tasks in groups of 2-3 people. Dividing each task into groups. Preparing the product (spiral snake) in small groups. **Experiments** Water heats the air. The warm air rises. The rising air sets the spiral in motion. Search for losses.

FOOD AND WATER

1. From seed to bread

STE(A)M-Areas	mathematics - biology - sustainability - history - ethnography - chemistry

Summary table	
Subjects	environmental studies - mathematics - Hungarian language and literature - music and singing - technology and design
Topics	The bread.
Age of students	7-10 years
Lesson/project duration	6×45 minutes
Number of students	10-12 people
Online learning tools	interactive whiteboard - tablet - smartphone
Offline learning tools	-
21st century competences	communication - creativity - cooperation - teamwork - problem solving
Learning objectives	Learn about a very important staple food - bread.

Project plan	
The name of the exercise	From seed to bread
The implementation process	
Question	What is bread? What is flour? What seeds can be used to make flour? What types of flour are known? How do you turn seeds into flour? What is in which bread? What is white bread? What is brown bread? What do we call rye bread, rye bread? What is wholemeal bread? What is sowing, harvesting, threshing, milling? How is flour made into bread? What is sourdough? How does yeast work? What is the difference between sourdough and yeast?

Inspiration	Mapping students' prior knowledge: what prior knowledge do students have about the topic? Who bakes bread at home? How does mum or grandma make it?
Preparation	Raw materials to buy: salt, flour, water, yeast, leaven (good if it's live), jar, rubber ring, kitchen scales, breadmaker, wheat, rye and corn grains, wheat flour, corn flour, rye flour, a sifter or a baking pan. Make an appointment with the bakery.
Presentation	Students learn about the concept of bread. They choose the ingredients of bread from a selection of ingredients. They compare the grains of wheat, rye and corn. They distinguish between wheat, rye and corn flour by touch. They discuss the proportions of ingredients in different types of bread. They try out the hand-sowing and seed-dressing of the soil, which was common on old farms. They learn about harvesting tools of the past and present. They will watch a video about hand threshing. Learn about *the A coast* which describes the harvesting and grinding of wheat. A visit to a bakery. They observe the growth of yeast, the presence of carbon dioxide during the yeast's so-called run and its effect on the dough. They make dough from water and flour. Its growth is observed. They bake bread and pastries in craft activities. They interpret the recipe and measure the ingredients. Knowledge to be acquired Bread: Bread is a cereal-based food. It is made from cereal and maize flour. It is kneaded with water and salt. It is fermented with yeast or yeast. They can be of different shapes and sizes. It can be baked in an oven or on a hot surface on a stone slab. Most common breads: White bread contains 100% white flour. Half-brown bread contains 15% light rye flour and 80% semi-white bread flour. Rye bread should contain 40% rye flour. Wholemeal bread contains wholemeal flour (flour in which the kernel and the germ are retained along with the kernel.)
Forecasts	I wonder what happens to the yeast when I mix it with the sugar? What happens to it when I stir it into warm sugary water or warm sugary milk? I wonder what happens to the leaven when you add flour and water?
Design	They learn about the reproduction of yeasts by observation.
Discovery	**The yeast** Yeast is a single-celled fungus that plays an important role in baking and fermentation. Yeast cells take up sugars (e.g. glucose) from their environment.

	Sugars are broken down in a biochemical process called fermentation. During fermentation, yeast breaks down sugar into alcohol (ethanol) and carbon dioxide in an oxygen-free environment. The carbon dioxide is released as a gas, which creates bubbles in the dough during baking, for example, making it loose and airy. It is observed that the yeast liquefies with the addition of sugar, the addition of liquid triggers the growth of yeasts, the yeast foams and bubbles appear on its surface. The dough will rise in the warm place, becoming looser and more bubbly due to the yeast. **The sourdough** In jars, you can observe the presence of yeasts, the characteristic sour smell of lactic acid and acetic acid in live sourdough starter. They "feed" the sourdough and then, using a rubber ring as a level indicator, they can observe the growth of the sourdough. You may find from your own experience that this process is faster for yeast and slower for starter.
Knowledge sharing	Students compare their predictions with their experiences. The group explains to the others what white bread, brown bread, rye bread and wholemeal bread are.
Productum	Home-made bakery products.
Stations	
Chemistry	Observation and experimentation. Yeast growth, carbon dioxide production, presence of lactic and acetic acid. Tools: yeast, sugar, water or milk; leaven, flour, water, jar, rubber ring.
Mathematics	Measurement of quantities; unit of mass. Tool: kitchen scales.
Technology and design	The process of baking bread. Tools: baking tray, flour, salt, water, bread machine or oven.
Hungarian language and literature	Reading a bread recipe, highlighting the main points. Tool: printed recipe.
Vocal music	Learning a Hungarian folk song: *under the shore*.
Technology	Electronic devices: computer, tablet, smartphone, interactive whiteboard. Tools in the home: bowls, glass, scales, rubber ring, bread maker. Ingredients: flour, yeast, water.
Experiences	Joint assessment with the students. What did you like best? How did I feel? What did I learn?
Appendix	From harvest to mill (YouTube) Hand threshing (YouTube)

Baking bread (YouTube)
Bread baking workflow (LearningApps) A day in the bakery (YouTube)

2. Adventures in the world of bread

STE(A)M-Areas	technique and design

Summary table	
Subjects	mathematics - Hungarian language and literature - technology and design
Topics	The bread.
Age of students	7-8 years
Lesson/project duration	45 min
Number of students	10-15 people
Online learning tools	interactive whiteboard - computer
Offline learning tools	A story written by a teacher.
21st century competences	communication - teamwork - cooperation - technological literacy - creativity
Learning objectives	Let's learn about the journey of bread to our table, with a special focus on the steps of bread making, the raw materials, and the success of the work.

Project plan	
The name of the exercise	Adventures in the world of bread
The implementation process	
Generating interest	Zoltán Zelk's poem *You know it, he knows it* helps to get in the mood for the theme.
Preparation	Preparation of salt and flour paste, preparation of baking utensils. Salt and flour paste: • 1 cup of flour • 1 cup of fine grain salt • half a cup of water • 1 spoonful of oil
Presentation	**• Guessing game with poem reading, interpretation of the poem** **• Listening to stories, talking** **• Bread Baker scavenger hunt game** **• Salt and flour bakery: bakery presentations, product demonstrations** **1. Guessing game with poem reading, interpretation of the poem** We play a round of guessing with Zoltán Zelk *Zelk*'s poem *You know, he knows*!

(5 verses, 5 tips - What is the poem about? After each stanza, students write down their guesses.)
Let's see which one reveals what!

- sunlight, rain: plant
- man: tested plant
- cutting, mowing: cereals
- chewed with teeth: grain for food
- bread: wheat

2. Reading a fairy tale - a conversation about fairy tales

Once upon a time, Anna lived in a small village. Anna loved fresh, fragrant bread and always spoiled herself with her mother's freshly baked bread.
But one day, when her mother fell ill, Anna felt she had to learn how to bake bread. Anna asked her elderly neighbour, Uncle Little, who was famous for it, for help. Uncle Little started to teach Anna to bake, and Anna started to learn how to make bread.
the art of bread baking. First he taught her how to mix flour, water, leaven and salt to make dough. Anna was very focused and slowly began to understand the process. The dough was ready,
Anna formed them into small loaves in her hands and let them rest. During this time, Uncle showed her how to heat the oven and keep it at the right temperature. Anna watched the loaves in the oven with excitement. When they were golden brown, Anna proudly took them out of the oven
from the oven. They smelled wonderful and the bread was as delicious as she had ever eaten. Anna realised that baking bread was not just
ability, but also an art. From then on he baked bread regularly for the enjoyment of the whole village. His mother also recovered, and together they enjoyed the fresh
the smell and taste of bread. Anna's life became even richer and she always remembered the old man who taught her this wonderful craft.

Talking about the story:

- What was Anna's problem at the beginning of the story and how did she solve it?
- Tell me at least three things she learned from Little Uncle!
- List the bread-baking steps Anna followed in the story.
- What is the message that the story conveys to the reader?

3. Bread Baker scavenger hunt game

The game leader hides various baking tools in the classroom (apron, stretching board, kneading board, flour, cake mixers, squeezers, etc.). The groups are asked to find all the treasures.

4. Salt and flour bakery

The groups open bakeries. They make their own name tags and signboards. They make their baked goods from salt and flour dough, which they then present to others.

Presentation materials	Breads and pastries made from salt and flour dough. Signboards of bakeries.
Appendix	The text of the story can be projected on an interactive whiteboard. **Source used** Lecture by Ildikó Rácz, teacher consultant. 16 November 2023.

3. Let's have a crumb party!

STE(A)M-Areas	technique and design

Summary table	
Subjects	biology - chemistry - digital culture
Topics	The recycling potential of bread.
Age of students	9-10 years
Lesson/project duration	6×45 minutes
Number of students	10-15 people
Online learning tools	interactive whiteboard - computer - tablet
Offline learning tools	-
21st century competences	communication - cooperation - teamwork - creativity - critical thinking
Learning objectives	Bread is a treasure, don't waste it, treasure it! Let the students learn about the possibilities of recycling bread! Make them aware of the harmful effects of food waste, educate them to be environmentally aware! Aim to develop sustainable consumption habits.

Project plan	
The name of the exercise	Let's have a crumb party!
The implementation process	
Arousing interest, preliminary questions	A story to set the mood ***Bread is life*** *Once a man found a nugget of gold, he rejoiced. He picked it up and took it to the jeweller. He asked, "How much is my nugget worth?" "A thousand rubles," the jeweller replied. Not believing him, she went to another jeweller. The dealer estimated the nugget at five thousand rubles. But the young man - the happy owner of a gold nugget - had second thoughts again and went for a third to a jeweler... The third jeweler, after weighing the gold, said it was worth ten thousand rubles.* *The young man was completely confused and decided to go to the wise man for advice.*

"I know there's nothing more valuable in the world than gold," he said to the old man with the grey beard, "but I can't tell you the real value of a nugget.
The wise man took the gold in his hand and said: "Your nugget, good boy, is worth a fortune. But do not be proud of it, for you are wrong to think gold the most precious thing in the world. Try not to eat for a week! One piece
you will give me a nugget of gold for a loaf of bread. Now understand what is the most precious thing in our lives."

- Have you ever been really hungry?
- Why do we not really know this feeling?
- What happens to the food you keep?
- Have you ever heard the term "food waste"?
- What does it mean?
- What damage can it cause?
- What can you do about it?
- Why not throw bread in the bin, for example?
- Have you ever heard the expression "frugal kitchen"?
- How can you recycle your leftover snacks, your leftover bread, rolls, bread, bread rolls, bread rolls?

Inspiration

Listening to students' ideas based on the preliminary discussion. Taking stock of recycling possibilities.

Preparation

A week before the project day, ask the students to put the baked goods they have not eaten in a canvas bag.
Forming groups.
Preparation of graters, dishes, bowls. Purchase of eggs, salt, pudding powder, milk, cocoa powder, salad ingredients, 5 litre jar of dunsts. Preparation of toaster, electric stove.

Presentation

Counting the leftover baked goods collected by the pupils. What could we use it for?

- Grate it into breadcrumbs.
- Make a pudding and sprinkle the breadcrumbs on top.
- Cut the kiflikariki into hot chocolate.
- Let's make French toast!
- Make a salad and top it with toasted bread cubes!
- (We can also pickle any kind of vegetables in the classroom, e.g. cucumbers, cabbage, carrots, beetroot, radishes.)

Forecasts

Curing: what happens to the vegetables? What can we observe?

Design

Food waste has serious environmental, economic and social impacts. Here are the main areas where it is causing problems:

1. Environmental impacts
   - Greenhouse gas emissions
   - Waste of productive resources
   - Biodiversity loss

2. Economic impacts
   - Financial losses
   - Agricultural and logistical costs

	3. Social impacts • Food safety problems • Social awareness and responsibility 4. Health effects • Changes in shopping and consumption habits due to food waste often lead to the over-purchase of unhealthy foods, while fresh, nutritious ingredients are often wasted. This can contribute to unhealthy diets and increased obesity. Leavening is a traditional fermentation process, most commonly used to make bread and to ferment pickled cucumbers or other vegetables. Fermentation is a process where naturally occurring yeasts and lactic acid bacteria break down carbohydrates, giving the products a distinctive sour taste and texture. The yeast in the bread helps to trigger fermentation. It also needs to be warm, around 20-25 °C, and in sunlight. Warmth and sunlight speed up the fermentation process. When the juice becomes cloudy and the vegetables taste sufficiently sour, fermentation is complete. The chemical processes that take place during fermentation effectively preserve food, providing nutrients and beneficial microorganisms. The lactic and other acids produced during fermentation give the product a sour taste and prevent the growth of harmful micro-organisms. These natural biochemical processes are not only safe, but also healthy, as they contribute to the health of the digestive tract and strengthen the immune system.
Discovery	Students can observe the processes that take place during the fermentation process, the clouding of the brine, the lactic fermentation. They can also smell the sour smell and taste the sour taste of the vegetables. The activity gives them ideas for recycling baked goods.
Knowledge sharing	They describe their experiences during the fermentation experiment. They work in groups to collect and present the effects of food waste.
Reflections	What happened to the vegetables? What colour, texture, taste?
Presentation	Presentation and sharing of recycled baked goods made by the groups.
Productum	Presentations. Prepared foods, pickled vegetables.
Experiences	Joint evaluation of the project: • What have we learned? • What have we experienced? • How did we feel during the session?

Stations

	Chemistry, biology	Observation of lactic acid fermentation.
	Technology	Tools: computer, tablet, interactive whiteboard.
	Appendix	**Videos** No Leftovers - How we can do something about food waste (YouTube) No Leftovers - The impact of food waste on the environment (YouTube) No Leftovers - Food waste (YouTube) No leftovers - to stay healthy by shopping consciously You can help (YouTube) No Leftovers - Causes of food waste (YouTube) Preventing food waste (YouTube) **Source used** Lecture by Mrs. Henrietta Molnárné Bodnár, teacher advisor. 16 November 2023.

4. Introduction to molecular gastronomy

STE(A)M-Areas	chemistry - physics - biology - art
Interdisciplinary links	This curriculum provides an introduction to the basics of molecular gastronomy and introduces three important techniques: spherification, foaming and gelification. During the lessons, students will learn about the science behind molecular gastronomy and then try out the different techniques to experience for themselves the process of transforming the dining experience and the science behind them.

Summary table	
Subjects	chemistry - physics - gastronomy - filmmaking
Topics	Molecular gastronomy.
Age of students	15-20 years
Lesson/project duration	3×45 minutes
Number of students	4-20 people divided into smaller groups (e.g. groups of 4)
Online learning tools	Videos.
Offline learning tools	Heston Blumenthal 2022 *Is this a Cookbook: Adventures in the Kitchen* Jose Sanchez 2015 *Molecular Gastronomy: Scientific Cuisine Demystified*.
21st century competences	Creativity - Manual dexterity - Problem solving - Experiential learning - Recognising the links between information - Using information technology - Cooperative skills - Working in a team
Learning objectives	learning by experience, carrying out experiments to obtain information that can be processed with scientific rigour - deepening understanding of the subject - forming groups of students, developing their ability to process images - developing abstract thinking

Project plan	
The name of the exercise	Introduction to molecular gastronomy
The implementation process	
	Activity I: Building theoretical knowledge
Theoretical background	Introduction to molecular gastronomy, spherification

Aim: To introduce students to the basics of molecular gastronomy and to learn one of the most important techniques: spherification (making balls from liquids).

Tools and materials:

- sodium alginate
- calcium chloride solution
- Water
- fruit juice (e.g. orange juice or strawberry juice)
- tools needed: mixing bowls, straws or syringes to shape the balls

Realisation

Course of the lesson

1. Introduction to molecular gastronomy (10 min)

- The concept of molecular gastronomy: combining science and cooking, cooking based on the laws of chemistry and physics.
- The benefits of using molecular gastronomy: new flavours, textures, spectacular presentation.
- Short video or pictures of the results of molecular gastronomy (e.g. caviar, foams, other textures).
- Introducing Heston Blumenthal, a prominent figure in molecular gastronomy.

2. The theory of compartmentalisation (5 min)

- Explaining spherification: how to create a gel-like shell surrounding liquids.
- Chemical process: the reaction of sodium alginate + calcium chloride, which allows liquids to be turned into gelatinous balls.

3. Demonstration (10 minutes)

- Prepare a calcium chloride solution in a bowl.
- Mix the juice and sodium alginate in another bowl.
- Using a syringe or spoon, drop the juice into the calcium solution and watch the balls form.
- After 1-2 minutes, remove the balls and rinse them in water.

4. Student experimentation (10 minutes)

- Pupils can make their own spherified balls individually or in small groups.
- They can try different juices, teas or other liquids.
- Students can observe the effect of different sizes of balls on flavour and texture.

5. Conclusion and summary (10 minutes)

- Students evaluate their spherification experiment: how did the taste change when the liquids became balls? What new experiences did the balls of different colours and sizes give?

6. The experiments are documented with photos and video footage, which are then made into a summary video.

	Activity II: Making foams - airy textures
Target	Students will learn the basics of foaming and try out how to make different types of foam, such as fruit or spice foam.
Realisation	Tools and materials: • siphon (foaming bottle) • nitrous oxide (N_2O) cartridges • lecithin powder (stabiliser) • fresh fruit juice (e.g. lemon, strawberry) • water, sugar (optional) • various flavourings (e.g. spices, herbs) **Course of the lesson** **1. Introduction to foaming** (10 minutes) • An explanation of the basics of foaming: how to introduce air into liquids to get a foam, mousse or spongy consistency. • The role of the siphon: how the foaming cylinder works and why nitrous oxide (N_2O) is used for foaming. • Use of lecithin: helps to stabilise the foam, reduces surface tension. **2. Theory and making of foam** (5 minutes) • Mixing and preparation of lecithin and juice (or spiced liquid). • How to use the siphon: how to fill it with liquid and insert the N2O cartridges. • Create stable foams, mousses and special airy textures. **3. Demonstration and student experimentation** (15 minutes) • Each student can make their own foam using the siphon. • You can try different flavourings (e.g. citrus, spices, herbs). • Students serve the mousse on different dishes, such as soups, desserts or salads. **4. Conclusion and summary** (10 minutes) • Tasting and evaluation: how was the texture of the foam? How did it affect the taste of the food? • Why is foam stability important? How can they create the best textures? **5. Photo and video documentation**
	Activity III: Gelling - a new texture
Plan/Objective	Students will learn about the technique of gelling and will be able to make a variety of gels.
Realisation	Tools and materials: • agaragar or gelatine • water, juice, tea, broth

- pots, mixing bowls
- plastic moulds

Course of the lesson

1. Gelation theory (10 minutes)

- What is gelation? How do agaragar and gelatine work?
- Difference: agaragar (plant-based) vs gelatine (animal-based), their use in food.
- Texture of the gels and enhancement of the eating experience.

2. Demonstration of gelation (5 minutes)

- Using gelatine and agaragar: how to dissolve and use the materials.
- Trying different liquids (e.g. juice, tea, broth).
- The liquids are cooled and poured into moulds, then gelled.

3. Student experiments (15 min)

- Students can also make their own gels from different liquids.
- Serving and tasting can be done after about 60 minutes of resting time, when students can evaluate their jelly and share their experiences.

4. Conclusion and summary (10 minutes)

- Evaluation of the finished gels.
- How does gelation affect textures?

5. Photo and video documentation

	Activity IV: Making videos
Plan	Our aim is to process the photos and videos taken during the sessions and experiments.
Realisation	We use a video editing application to process images and videos.
Experiences	After the sessions, students can set themselves further ideas and goals.

Interdisciplinary link

Digital culture	The fourth activity can be used in a digital culture lesson, as it introduces students to a simplified form of image processing.

5. "You are what you eat" - Chaos Theory

STE(A)M-Areas	maths - physics - biology - medicine - nutrition - art - sport - history - sustainability

Summary table	
Subjects	maths - physics - biology - chemistry - geography - art - sport - history - foreign languages - digital culture - engineering - medicine - nutrition - sustainability - meteorology - politics - chaos theory
Topics	Surface area, volume, density, mass, weight. Changes of state. Optics, camera. Human body, organs. Artificial dyes, compounds, mixtures. Climate, topography. Colours, painting, sculpture. Ages and people, nationality, ethnography. Artificial intelligence. Statics. Design. (Diseases, food sensitivities. Food recycling. Weather. Fashion trends. Kuglof, cappuccino.)
Age of students	6-18 years
Lesson/project duration	4×45 minutes
Number of students	10-15 people
Online learning tools	tablet - PC - smartphone - interactive whiteboard - projector
Offline learning tools	Listed in the tasks to be implemented.
21st century competences	communication - cooperation - teamwork - creativity - innovation - critical thinking - problem solving
Learning objectives	Students can recognise chaotic phenomena in their everyday life and environment: food, flow, play, weather, biology, medical studies, etc. Students will be introduced to the basic concepts of chaos theory; introduction to advanced mathematics and science: phase diagrams, simulation, use of computer science, ejectors, error propagation, etc.

Project plan	
The name of the exercise	"You are what you eat" Chaos Theory
The implementation process	
Generating interest,	Why do we eat? What do we call food? Chaos or instability?

preliminary questions	In what science is chaos theory used? What is the link between simulation and real phenomena? What do we know about chaos theory? What are chaotic phenomena?
Preparations	What topics should we look at again? What topics do we review? What online/offline information can we use? What tools do we need?
Presentation	There are experiments that can be done, but there are also experiments whose conditions are too complicated. We can learn the essence of chaos.
Preliminary assumptions	What can we learn about chaos theory?
Method of discovery	Examining a wide range of aspects of chaos theory. Classical mechanics is about special, rarely observed cases of motion. Scientific movement experiments in the classroom are not easy to demonstrate and can become chaotic.
Experiences	In our everyday lives, we observe chaotic phenomena. These were not scientifically described until the 20th century. Chaos theory is based on classical physics, but it is the subject of modern research. Chaos is used in a very wide range of scientific and artistic fields.
Feedback	Make a note of the material you encountered. Evaluate them. Why you recommend them to people interested in the subject. Also record whether you found it useful or not! Write down why!
Presentation	Tools • paper, pen or pencil (different colours) • digital camera • PC or laptop • smartphone **1. Make a chaotic tea!** **2. Exercises with clay** **3. Fun with chaotic games** **4. Lace and fractals (phase diagrams)** **5. Fractals - handmade/natural** Some areas that could be great examples **1. Area. History.** Some learners understand concepts more easily if they know the historical background. Everyone should learn about what questions were asked, when and how scientists sought to explore science. Science's main steps towards chaos theory a) International level • Weierstrass • Kovalevskaya • Carlwrigt and Littlewood

- Kolmogorov
- Lorentz

b) Hungarian aspects

- KöMAL 1965, Miklós Vermes
- Péter Szépfalussy, Tamás Vicsek, Márton Gruiz, Tamás Tél

2. Area. Basic concepts.
There are some basic concepts that appear in most secondary school curricula, yet are very important in chaos theory.
We need to study or review these:

- balance (concept and types)
- instability or chaotic series
- the laws of classical physics
- error, propagation of error

3. Area. Mathematics.

- fractals: Mandelbro pile, Cantor pile, Koch snowflake, Sierpiński mat, Menger sponge
- fractals in nature: biology - flora, biology - fauna, geography, meteorology, etc.
- art: creating fractals with origami
- the dimension of the fractal: 1D, 2D, 3D, logab, factors, quotient dimension definition, Poincaré map

4. Area. Chaotic experiments.

- similabda
- yoyo
- inga
- chaotic sculptures
- the magnetic pendulum
- chaotic clock
- non-harmonic oscillator
- smoke
- chaotic water mill
- induced oscillation

5. Area. Chaotic activities.
Chaotic tea:

- marble cake and coffee with cream

Kaotic activities:

- wormwood
- rubber ball in a bowl
- the ebru technique

6. Area. A wide range of applications. Solar system, meteorology, flow, drift, self-oscillation, feedback in electrical circuits, biochemical processes, heart function, brain function, population dynamics, random number theory, and many other fields.
generation, encryption, ball games, economic process modelling, mixer operation, dough mixing process

7. Area. IT.

- the Atwood machine

	• the mathematical pendulum • the polar coordinate system • simulation • Dynamics Solver • different solutions: chaotic and intermittent solutions
Results	Marble cake with coffee. Jojó. Presentation. Video. Allocated poem. Origami. Nail polish. Painting with ebru technique. Origami fractal. Sponge.
Critical thinking	Review the concepts and methods we use. Evaluate them! Suggest or replace!
Subject links	
Natural science	Physics (particle physics, chaos theory, density, mass, weight, state changes, optics, camera, solar system, hydrodynamics, gyroscope, experiment, error and error propagation, phase diagram, Lyapunov kit, fractals, equilibria: stable, neutral, unstable, chaotic, magnetic pendulum, swinging Atwood machine, ball in a bowl).
Research	Problems in the history of science: Poincaré, Kovalevskaya, Kolmogorov, Lorentz, etc. Explore the fields where chaos is applied (astronomy, meteorology, drift, flow, vibration, swelling of electrical circuits, brain and heart phenomena, chemical and biochemical processes, population dynamics, cryptography, random and chance phenomena, economics, ball games, etc.). Modern mathematics, numerical methods, fractals, dimension. Order in chaos. Chaos in art: films, videos, promotional clips and articles.
Technology	We also emphasise active pedagogy and promote practical, reflective didactics in problem-based learning. There are also many possible solutions in this area, such as pendulums, toys, manicures, yo-yos, food, origami, graphs, experimental tools, etc. IT-related: PC, smartphones, digital camera, internet, Dynamics Solver, YouTube. Non-computer equipment: scissors, ruler, blank paper, graph paper, (coloured) pencils, yo-yo, (simileball), cigarettes, matches, bowl, rubber ball.
Physical education	Sports equipment: fitness measurement.
Engineering sciences	Tools and materials: radio locator, chaotic clock, pendulum: magnetic, double, calculator, PC, internet, graph paper, ruler, pencil, magnetic pendulum: button magnets, wooden rod and board, glue, markers.

Visual culture, arts

Art and design props: poems, novels, jokes, anecdotes, etc., ebru technique, melanzs, origami, manicure, fractal art.

Tools and materials: paper and pen or video recorder, water, bowl, paint, cloth or wooden yo-yo, plasticine, origami paper, scissors, nail polish, nail polish remover, cotton wool, small bowl, water.

Mathematics

Mathematical tools

- surface, volume,
- maps distributed,
- calculator,
- PC, laptop or smartphone,
- paper, markers.

Appendix

In Hungarian

Butterfly effect (theory) (Wikipedia) Chaos theory (Wikipedia)
Tamás Meszéna:Teaching Nonlinear Phenomena in Secondary School József Jaloveczki:Investigating Nonlinear Phenomena Student Research Groupsin Szeged mathematicians sort out the chaos (National Geographic) Szatmáry-Bajkó Ildikó: Chaos experiments in high school physics
Szatmáry-Bajkó Ildikó 2006. "Chaos"? - Yes! - Chaos theory in secondary school. *Physics Review*. LVI/11: 376.
Márton Gruiz 1998. The relation of chaotic mechanics to Plato and puff pastry. *Nature's World*. 129: 389.
Fractal (Wikipedia) Fractal art (Wikipedia) Fractals (YouTube)
Chaos theory unravels the centuries-old mystery of variable stars (Index) Péter Nagy - Péter Tasnádi: The World of Fractals - Playful Science Tamás Meszéna Meszéna: Fractals and Chaos

In English

Chaos theory (Wikipedia)
Chaos: The Science of the Butterfly Effect (YouTube)
How Chaos Theory Unravels the Mysteries of Nature (YouTube) Chaos theory explained: A deep dive into an unpredictable universe Understand meteorologist Edward Lorenz's chaos theory
Fun with Fractals (YouTube)
Fractal (Wikipedia)
Fractals are typically not self-similar (YouTube) What is a Fractal?
JoAnn Trygestad: Chaos in the Classroom: An Application of Chaos Theory

6. The life-giving water

STE(A)M-Areas	sustainability - science - biology - geography - art

Summary table	
Subjects	biology - geography - art - sport - digital culture - meteorology
Topics	What can water be used for? Where and in what form do we find water in nature? Rivers and still waters. States of water. Sports facilities in winter and summer. The water cycle. How to take care of the water? Water use in the household.
Age of students	8-10 years
Lesson/project duration	3×45 minutes
Number of students	16-20 persons
Online learning tools	tablet - interactive whiteboard
Offline learning tools	word cards - puzzle
21st century competences	communication - cooperation - teamwork - creativity - critical thinking - problem solving
Learning objectives	Protecting water as a source of life; developing responsible, environmentally aware behaviour. Learning about the water cycle. The different states of water. Creating a shared notebook.

Project plan	
The name of the exercise	The life-giving water

The implementation process

Generating interest	Listening to Judit Halász's children's song "*In the Rain*". Talking about water: • Why is it important that it rains? • Why do we say that water is the source of life? • Where and in what form do we encounter water in nature? • What can water be used for? Grouping: 4 groups • Hikers • Meteorologists • For commercial use

	• Athletes Making the cover page of the shared notebook: everyone should write down one word that comes to mind about water (these words will be written on the cover page).
Preparations	Making word cards for group formation: From the four word cards, we make a total number of cards equal to the number of people in the group. Each student chooses one word card to form a group. Printing 4-5 pictures of water sources; puzzle picture of a river and a lake; word cards for the water cycle; word cards for the classification of rivers and still waters; pictures of types of precipitation and their formation; preparation of cardboard, thick markers, coloured pencils, drawing paper, glue, scissors for a lapbook.
Presentation	Students work in 4 groups. **1. Group 2: Hikers** • Pupils go on an imaginary trip to see resources in pictures. • They put the river and still water vocabulary cards in ascending order (spring, vein, rivulet, stream, river, stream; lake, sea, ocean). • They put up a puzzle of a lake and a river. • The characteristics of the river and lake are collected. They stick them on their lapbook pages. **2. Group 2: Meteorologists** • They draw the water cycle. On the tips of a square sheet of paper, children can read the steps of the water cycle. The tips of the square sheet are folded in the middle and drawn according to the description on that part. They stick the finished work on their own lapbook page. • They pair the types of precipitation with images and an explanation of how they are generated. They stick it on their lapbook page. **3. Group 2: Users** • How can we save water at home? • They watch a short video about it and from that they gather information to write down on the group's own lapbook page. **4. Group 2: Athletes** • Draw pictures of water sports! Don't forget winter sports (ice, snow)! • They stick the finished pictures on their own lapbook page.
Knowledge sharing	Each team presents the tasks they have completed and the pages they have made in the lapbook. Then the completed sheets of cardboard are stapled together to form a shared lapbook.
Experiences	Pupils also jointly evaluate the work of the groups and their own work. We will use the lapbook to explain what we have learned about water and why we need to save and look after it.

Appendix

Links
Judit Halász: In the rain (children's song, concert excerpt) (YouTube)
water saving
World Water Day (YouTube)
What can we do to protect our drinking water?

Images from
Sources
Hog Spring (Wikipedia)
Redstone Spring (Wikipedia)
Liberty Spring (Wikipedia) Great
Spring (Wikipedia) Rainfall
types
gizzard shad
(Wikipedia) dér
(Pixabay)
additional precipitation types
CleanPNG
for puzzle picture
River (Pixabay)
Lake (Pixabay)

Word cards for group tasks
1. group
Source - the origin of running water
Ér - the smallest surface watercourse
Tadpole - surface watercourse larger than a stream, smaller than a river Stream - watercourse smaller than a river
River - a surface watercourse between 100 and 1000 km long
River - a surface watercourse at least 1000 km long Ocean - a large mass of salt water spread between continents Sea - a large volume of salt water
Lake - standing water closed on all sides Word cards for the topic lake-river:

- flowing in a stream
- destructive work by removing sediment from the riverbed
- has a flow direction
- located in the estuary
- closed on all sides
- may be artificial standing water (e.g. fish pond, mine pond)
- carrying out construction work by depositing alluvium
- has a right and left bank
- standing water
- can be natural standing water (e.g. lake, marsh, bog)

2. group
For the water cycle (these definitions are placed in the corners of the square)

- The light mist that rises precipitates at high altitude and forms clouds.
- Precipitation, which can be in liquid or solid form, falls from above.
- Water in rivers, lakes and seas is constantly evaporating, but so are living things. Then the light vapour rises.

- Some of the raindrops that fall are absorbed by the ground, while others are used by living organisms in their life processes. The water that seeps into the soil and deep underground flows and collects below the surface.

3. group

Types of precipitation:

drizzle, fog, rain, dew, slush, snow

- It is actually a cloud that forms near the ground. Warm, moist air flows over the cooled ground. This cools the air and turns the water vapour into tiny droplets.
- It falls from the clouds to the ground in individual drops of water. It is in liquid form.
- When the air has a higher moisture content and the water vapour cools, it turns into a liquid. In summer and autumn, it is particularly visible in the early morning.
- When the air has a higher moisture content and cools below 0 °C. A whiteness of tiny ice crystals covers the grass and plants near the ground.
- is formed below 0 °C. If the lower layers of air are cold, it does not melt as it falls.

Source used

Lászlóné Farkas, teacher advisor, introductory session on environmental education. Teachers' Professional Day. 2022.

7. Water, water, clean water

STE(A)M-Areas	sciences - maths - mother tongue - visual arts - geography - music - environmental studies

Summary table	
Subjects	mathematics - Hungarian language and literature - visual arts - games and movement - sciences
Topics	Density. State-of-matter changes. Artificial colours, dyes, compounds, mixtures. Climate. Colours, painting.
Age of students	6-11 years
Lesson/project duration	7×45 minutes A study trip to the local waterworks takes 1-2 hours.
Number of students	10-24 persons
Online learning tools	interactive whiteboard - laptop - speaker - projector
Offline learning tools	Illustrative images.
21st century competences	communication - collaboration - teamwork - creativity - critical thinking - problem solving - technological literacy
Learning objectives	helping students to form communities of learners - developing fine motor skills - learning through play - developing auditory skills

Project plan	
The name of the exercise	Water, water, clean water
The implementation process	
Enquiry arouse, preliminary Questions	What do we know about water? When do we use water? Do we know any poems or sayings about water? How much water can you put in a pot? Can water have a voice? What does the dripping/splashing/falling/rushing of water sound like? How does water make a bed for itself? How can I purify the water? How does the water mix? What are the properties of water? What is the water cycle? How does water evaporate? What are the states of water? Is there any liquid that is denser than water?

	Can we paint with ice? Can living things live without water?
Preparations	Sourcing of raw materials: • experimental equipment (e.g. beakers, sand, flat transparent box, ice, heating device, liquids of different densities, kettle, paper towel) • watercolour, paper • instruments for measurements (glass jars of different sizes)
Presentation	The aim of the project is to teach children aged 6-11 about the properties of water, its role in life and its importance in the natural cycle in a playful and experiential way. Through experiments, experiments and creative activities, children will discover the different forms, sounds, states of water and its essential role in life. **1. What do we know about water?** Aim: To acquire a basic knowledge of water (its properties, its role). Activity: Talking about water, brainstorming, simple experiments (e.g. how water mixes with salt or sugar, vinegar, oil). **2. When do we use water?** Aim: To learn about water use in everyday life. Activity: making a list or drawing of when we use water at home or how it occurs in nature. **3. Do we know any poems or sayings about water?** Aim: To learn about water-related literature and folk traditions. Activity: collecting songs, poems and reciting them together. **4. Can water have a voice?** Aim: To understand and perceive the different sounds produced by water. Activity. **5. What does the dripping/splashing/falling/rushing of water sound like?** Aim: To understand the relationship between water movement and sound effects. Activity: to create sound effects using buckets of water, dripping taps or musical instruments (rainstick). **6. How does water make a bed for itself?** Aim: To demonstrate the erosive effects of water. Activity: experimenting with sand and water: creating a riverbed during play. **7. How can I purify the water?** Aim: To understand the importance of clean drinking water. Activity: construction of simple filtration systems using sand, coal and gravel.

8. What are the physical properties of water?
Aim: To discover the colourless, odourless, tasteless and thermal properties of water.
Activity: temperature measurements in different conditions (boiling, freezing).

9. What is the water cycle?
Aim: To understand the natural cycle of water. Activity.

10. How does water evaporate?
Aim: To demonstrate the evaporation process.
Activity: experiment with heating, observation of evaporation.

11. What are the states of water?
Aim: To learn about the solid, liquid and gaseous states of water. Activity.

12. Is there any liquid that is denser than water?
Aim: To compare the density of water with other liquids. Activity.

13. Can we paint with ice?
Aim: Creative activity using the ice state of water.
Activity: painting with coloured pieces of ice.

14. Can organisms and plants live without water?
Aim: To understand the indispensability of water for living things. Activity: experiment: plant growth with and without watering.

Preliminary assumptions	Water has a voice. Can we decide the amount of water by the sound? Water is vital for nature and for the human body.
Design	It is important for children to learn this information in a playful and interactive way, so that they can develop a deeper understanding of and interest in natural phenomena. The above information and activities will help to make the project enjoyable and educational for them.
Method of discovery	Some knowledge on these questions that we can explore with the children: What do we know about water? • Basic properties:Water is a colourless, odourless and tasteless liquid, the most abundant solvent on Earth. Chemical structure: two hydrogen atoms and one oxygen atom bonded together (H_2O). • Necessary for life: water is essential for all living things to survive, as water is needed for cells to function. • Natural role: water is involved in climate, weather regulation, the food chain and geological processes.

Experiences	The children said they had fun learning about water through experiments and creative activities, and found it interesting to discover natural phenomena on their own. They stressed that playing and creating together helped them to better understand the importance of water in our lives.
Feedback	The children's feedback showed that through playful activities and experiments, they found it much easier to understand the properties and role of water. Working together and sharing their experiences helped them to develop teamwork and environmental awareness.
Presentation materials	The experiments and materials that the children used during the project. Posters, workshop products, pictures.
Results	By the end of the project, children will have a systematic and experiential knowledge of the properties of water, its cycles and its role in life and nature. This not only deepens their existing knowledge, but also develops their critical thinking, creativity and environmental awareness.
Critical thinking	Throughout the project, the children's critical thinking developed in several areas. They learnt to observe processes, ask questions and draw conclusions, for example when observing changes in the state of water. They were able to identify the steps involved in purifying water and understand why sustainable water use is important. In analysing the results of experiments, they developed the ability to recognise cause and effect relationships and the accuracy and scientific character of their own experiences.

Subject links

Natural science

I. How does water form a bed?

Tools needed

- a large bowl or flat dish (such as a baking dish)
- sand (or fine-grained soil)
- Water
- small glass or jug for pouring water
- (optional: pebbles, plants, tiny toy figures to create the landscape)

Preparation

1. **Sand layer:** fill the bottom of the bowl with sand and smooth it out. If you like, use it to build up some familiar 'topography' - for example, hills, small hills between which the water will flow.
2. **Medermint:** Draw a thin groove in the sand with your fingers, which will be the starting riverbed.
3. **Additions (optional):** place small pebbles or plants to create a "landscape" to visualise the natural path of the riverbed.

Procedure of the experiment

1. **Pour water into the** bowl: carefully start pouring water into one end of the bowl (e.g. with a glass or jug). Watch as the water begins to widen or deepen the pool you drew with your fingers.
2. **Note the erosion:** water is constantly moving the sand, washing out the existing cavity and transporting sediment to lower points in the bowl. Observe how the water naturally makes its own path.
3. **Create ramifications:** if you pour more water or make more trenches in the sand, the water will "branch out" and create smaller streams.
4. **Change the terrain:** build mounds of sand to see how the water bypasses them and forms a new bed.

II. How does water evaporate?

Aim: Children understand the process of water evaporation, its relationship with temperature and natural cycles. In this activity, they carry out simple experiments and visualise what they have learned using digital tools such as a smart board.

II.1. What is evaporation?

Tools: interactive whiteboard, pictures or videos about the water cycle

Let's start with a conversation: 'Have you ever seen a puddle disappear in the sun? Or hot tea steaming?"
On the interactive whiteboard, display a simple animation or picture of the water cycle (e.g. the sun heats the water, the water evaporates and then forms clouds.)
Ask: "What do you think happens to water when it evaporates? Why can't we see it afterwards?"

II.2. Monitoring evaporation

Tools

- a glass of water
- a spoon
- a hairdryer
- a small bowl of water
- sheet of paper (to illustrate the acceleration of evaporation)

Slow evaporation

Fill a glass with water and place it on the windowsill. Ask the children, "What will happen if we leave the glass here for a while? Why?"
Record the children's answers on the interactive whiteboard.

Accelerated evaporation

Put a spoonful of water in a bowl and run a hairdryer over it on low heat. Ask: "Why does the water disappear faster?"

Animations and experiments on the interactive whiteboard explain that warm air accelerates the movement of water molecules, making them evaporate more easily.

Evaporation on surface

Drip a little water onto a sheet of paper, leaving one part free, and point a hairdryer at the other. Observe which part evaporates the water faster.
Let's talk about "How does more surface area help evaporation?"

Understanding the evaporation process

On the interactive whiteboard, open a simple interactive game or simulation showing the water cycle (e.g. sunshine, evaporation, cloud formation, rain). Children can also drag or move the elements themselves (e.g. the sun over the water to trigger evaporation).

Mother tongue session

Do we know any poems or sayings about water?

Aim: To introduce children to the importance and properties of water and to present this natural element through different genres (songs, poems, songs).

Tools: paper, coloured pencils, musical instruments (e.g. rattle, drum, tambourine), postcards of the water, projector or other digital device

Introduction - An imaginary journey into the world of water
Let's start the session by talking about water together. Ask the children what they know about water, what happens to it, where we encounter it in our everyday lives. Once they have shared their ideas, lead them into a short story about water in different forms (stream, lake, rain, ice) and ask them to try to imagine what it might feel like to be there.

Poems about water
Erzsi Gazdag: *Summer Rain* and *Raining Rain*
Sándor Weöres: *Lake Water*
Sándor Kányádi: *If I were a shower*
Erzsi Földi: *Splashing*
Vilmos Gryllus: *Hailstorm*

Geography/ integrated music

Experiment: the sounds of water - Discover how water sounds!

Aim: Children can discover how different movements of water make sound. The experiment helps them to understand how the movement of water and its environment influence the sound they hear.

Tools

- a small bowl of water
- a plastic cup or glass container
- a spoon or wooden spoon
- a spray bottle (or spray can)
- various "bodies of water" (e.g. a small tub of water, rainwater, running water from the garden if available)

- paper and pen to write down observations

Preparations: first, prepare the different bodies of water that the children can observe. If possible, the experiment can be carried out with different types of water (e.g. tap water, rainwater, water from the garden). If these are not available, you can also do the experiment with a single source of water.

Procedure of the experiment

Introduction: let's start the conversation about the sounds of water. Let's start by asking children how they think different sounds can be heard from water and what water sources they know (e.g. stream, sea, waterfall).
Demonstrate the experiment and explain how the movement of the water affects the sound.

I. Sound of dripping water

1. Fill a bowl with water and place the bowl in front of the children.
2. Ask the children to watch the water dripping. This can be done using a spray bottle or a small tap to drop drops of water into the bowl.
3. Observation: ask the children to listen to the sound the water makes as it drips. Make a note that the dripping sound is "soft" and "intermittent".

II. Imitating the sound of a stream

1. Take a plastic cup and place it in a small pot of water, just below the surface. Ask the children to observe what happens when the glass is moved slowly in the water (back and forth, up and down, etc.) Fill the glass with water and slowly pour the water into the container close to the surface.
2. You can drip water over the rim of the glass with a spoon, trying to imitate the sound of a stream.
3. Observation: note that the water splashes intermittently and the sound is continuous and soft. Have the children note how the sound changes as the water moves.

III. The sound of the waterfall

1. Pour more water from a higher container into another larger container, such as a plastic cup into a bowl, to imitate the sound of a waterfall. The rapid movement of water can make a more powerful sound. You can use animation or movies of different waterfalls: Niagara Falls, Angel Falls, etc.
2. Observation: children listen to how the water rushes when it rains fast. Discuss that the sound of water falling is powerful and requires rapid water movement.

Comparison: ask the children to compare the three sounds. Which was the softest? Which was the loudest? What differences did they hear between the three different water movements?
Discuss why different movements of water make different sounds. How does the speed and volume of water affect the sound you hear?

Visual arts

Painting with ice - Exploring the states of water

Aim: Children can explore the changes in water and use ice creatively to paint. This activity helps children understand the freezing and melting process of water while providing an artistic experience.

Tools

- ice cubes, which can be prepared in advance
- watercolours
- white paper (or watercolour paper)
- brushes
- bowls or plastic containers
- paper towels
- tray for storing ice cubes

Preparations: the day before, freeze the coloured water so that the children can work with the coloured ice cubes prepared in advance.
You can also use simple food colouring to colour the ice if you don't have watercolours.

Procedure of the experiment
Introduction: let's start with a brief discussion of the states of water. Let's start with a short introduction to water states. Ask the children what forms of water they encounter (liquid, solid, gas) and how water changes its state at different temperatures. Explain that today we will use ice, the solid state of water, for painting.

Preparing the ice pieces: prepare the coloured ice pieces and place them on the trays. Each child will be given a small block of ice or ice cube to paint with a paintbrush.

Creative painting

1. Ask the children to transfer the ice cubes onto the paper and watch the ice pieces melt as they paint. The colored ice cubes will leave an imprint on the paper as they melt.
2. Using the brushes, children can use different colours on pieces of ice while watching the ice melt and the colours blend.
3. Observation: ask children to observe the following:
   How does the ice change during painting? What happens when the ice melts?
   How do the colours mix? Do new colours form as the ice melts?
   How does it feel to paint with cold ice? How does it feel when the ice melts quickly?

Imaging and creative work: as ice melts quickly, children need to pay attention to how they work with it. Encourage them to quickly create something, such as a colourful landscape, abstract, or abstract.

a work of art, or anything inspired by the melting ice. Melting ice can provide interesting textures and shades of colour.

Summarise and talk: after the children have finished painting, sit them down and talk about the experience of creating. What happened to the ice? How did the colour and texture change? How did the pieces of ice transform and change during the painting process?
Show how we can create interesting patterns by watching the ice melt.
Ask the children to tell you about their works, what they depicted, what inspired them.

Closing: at the end of the session, ask the children to let the paintings dry. If time allows, we can try to refreeze the remaining water to make other ice blocks and rediscover the art of creating with water.

Mathematics

Exploring space through play

Annex 1: Exercise units of measurement

Aim: To learn the basic units of volume (litres, decilitres, millilitres, etc.). Comparison of volume using different vessels. Practice estimation and measurement.

Tools needed

- different sizes of utensils (e.g. glass, bowl, jug, bottle, glass)
- a measuring vessel (e.g. a measuring cup scaled to litres and decilitres)
- water or other liquid (e.g. coloured water for visual effect)
- paper and pencil for note-taking

Course of action

1. Getting to know the volume of space: talk about what volume means. Examples: '1 litre of milk', 'half a litre of soft drink', '1 decilitre of juice'. Show the relationship between litres, decilitres, millilitres:

1 litre= 10 decilitres= 1000 millilitres

2. Estimation and measurement

- Estimation: place different containers on the table and ask the children to guess how much water fits in each one. Examples: is a glass about 2 decilitres? A small bottle is half a litre?
- Measurement: fill the containers with water and pour into a measuring cup. Record the results!
- Comparison: compare the capacity of the containers: "Which container holds more water?" Note whether 5 decilitres is equal to half a litre!

3. Convert units of measurement playfully

- Give the children different practical "tasks":
  "How many decilitres of water do you have to put in a bottle to make 1 litre?"
  "A pill bottle contains 750 millilitres of water. How many decilitres is that?"
- Let them experiment with the answer themselves, while practising the unit conversions.

4. Competition or group work

Group exercise: give the children the containers and ask them to measure out exactly 1 litre so that they can use all the containers.
Competition: who can measure half a litre or 3 decilitres accurately the fastest?

Environmental knowledge

How do we purify water?

Children will learn the basic methods of purifying water through simple hands-on experiments. They will understand why it is important to purify water and how this process takes place in waterworks.

Why is clean water important?

Talk to children about why it is important to drink clean water. Give examples: compare pictures or samples of clean drinking water and contaminated water.
Ask: "What do you think happens when you drink contaminated water? How can water be purified?"

Water treatment methods

Tools

- a bowl of dirty, contaminated water (e.g. contaminated with sand, leaves, seeds)
- filter (coffee filter or gauze filter)
- activated carbon or cotton
- sand and gravel (for cleaning)
- clean dishes
- funnel
- glass or clear plastic bottle

Go to

1. **Testing of contaminated water**
   Pour contaminated water into a bowl. Ask the children to observe what dirt they see (sand, leaves, debris, seeds, etc.).
   Ask: "How would you clean the water in the bowl if you don't have a machine or special equipment?"
2. **Introduction to the screening process**
   Place the funnel over a clean bottle or flask. Add a layer of gauze or coffee grounds, then a layer of sand and gravel.
   Slowly pour the contaminated water into the funnel and watch how the sand and gravel filter the water.
   Explain that this is one of the basic methods for removing solid contaminants.
3. **Compare**
   Pour the purified water into another bottle and place it next to the contaminated water. Ask the children to observe the differences. Discuss that this water is not suitable for drinking yet, but it is closer to the purified water.
4. **Summary of water treatment**
   Discuss with the children that soil in nature filters water in a similar way.

Explain that in waterworks, this process is done on a much larger scale and with even more efficient technologies.
Ask: "What other ways can you think of to purify water?"

Visit to the local waterworks
Ask water company staff to explain the water purification process, especially in a way that children can understand.
Give the children notebooks to draw what they see (e.g. filtration equipment, reservoirs). The children can show each other their work.

Appendix

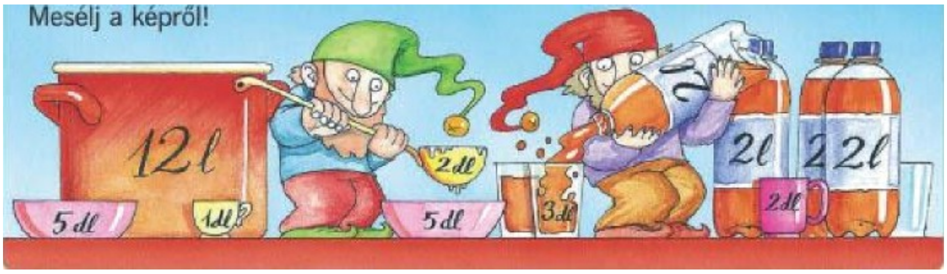
Links (videos, ideas, resources)
Psalms for Kids - The Water Cycle (YouTube) The Water Cycle (Genially)
Water cycle with video and pictures The states of matter
The water cycle (YouTube) The water cycle 2 (YouTube)

Collected songs on water
Debrecen has a water The trout
Oh that many a fish may grow
Gryllus Vilmos: *The Tortoise*
Gryllus Vilmos: *Raspberry*
Vilmos Gryllus: *On top of a chimney*
Gryllus Vilmos: *Stork* Gryllus Vilmos: *Peace Dinner Under the Beach*
Hey, fishermen, fishermen The goose has fallen on the ice
Hey, the wind is blowing from the Danube To the fishing lake of Panyit
By I would go on the Tisza
From under the reeds and the mist
Uncle Stork, stork
Stork takes his son
Here is a small well
Drip, drip, drip Sándor Weöres: *Melting* Sándor Weöres: *Water of the Lake*
The Danube is wide
Little duck bathing
The middle of Lake Balaton is fenced with reeds Ess rain, ess

More tales about water Éva Fésűs: *The Frog King's Slippers* Éva Fésűs: *The Envious Bear*
From the source to the sea - A tale of water
Zoltán Zelk: *Parácska*
Vladimir Sutyeev: *The small boat*

Brothers Grimm: *The Fairy Godmother*
The Brothers Grimm: *The Frog King and Vashenrik The Oak and the Reed* (*Animal Tales*)
The Treacherous Frog (*Animal Tales*)
The finicky egret (*Animal stories*)
The Weasel, the Rabbit and the Cat (*Animal Tales*) Ferenc Móra: *The World Traveller's Bare Eye* Ferenc Móra: *The Water Bearer's Daughter*
Ferenc Móra: *The mill of Séd*
The goldfish (Elek Benedek: *Hungarian folk tales*) *The 13 swans* (Elek Benedek: *Hungarian folk tales*) *The fox and the stork* (*The most beautiful fairy tales of the world*)
The Tale of the Stream (Zoltán Zelk: *Forest Fun*)
Zoltán Zelk: *The Ambitious Cloud*
Halkisasszony (*77 Hungarian folk tales*)
The Tortoise and the Beast (*I'm telling a story today*)
Swan the hero (*I'm telling a story today*)
Józsi Halász (*I'm telling a story today*)
The beautiful reed lady (Zilahi Józsefné: *Fairy tale - poem in kindergarten*) Zelk Zoltán: *Where are you running to, water spider*
Duck story (Mrs. Zilahi József: *Fairy tale - poem in kindergarten*)
Stork, stork (Mrs. Zilahy József)
The Polar Bear (Mrs. József Zilahy)
Why sea water is salty (Japanese folk tale)
The Tale of the Frog with the Red Hat (Polish tale)
Sándor Kányádi: *Pitty-potty and litty-lotty*
The tiny tiny tiny fish
Erzsi Gazdag: *The trout and brook*

Annex 1: Exercise units of measurement

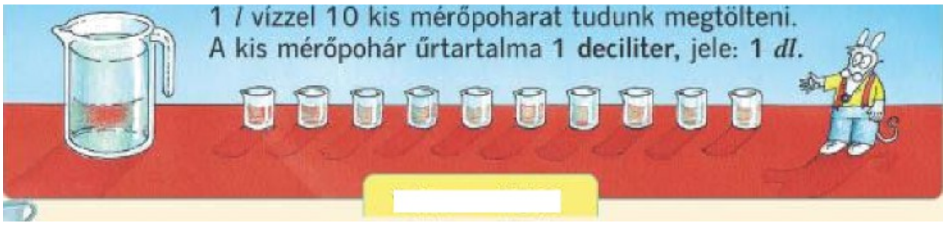


We would use the mèrëcé're mèrôhengert for the content.

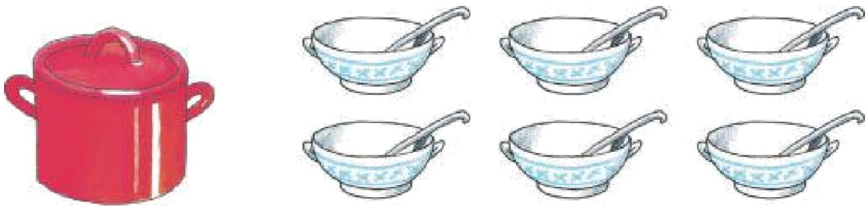
The unit of capacity is litres. Symbol-" f.

This bottle contains 2 / mineral water.
mérőszám mértékegység

J litèr



How many 3 litre IevœestAlas can you fill with 12 litres of soup? Colour that many bowls!



In which pot can you make more biscuits? Use a number to put the pots in order! Start with the biggest one!

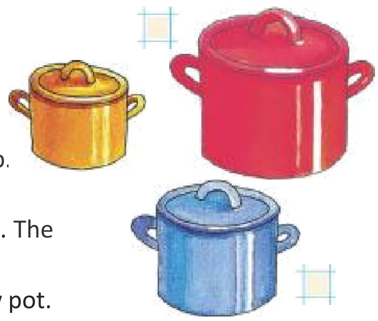
True or false7

I The sàrga pot holds the least amount of soup.

!Ÿ! The sàrga pot holds less soup than the pot.

The blue pot is the best place to make soup. The blue pot holds more soup than the red pot.

!Ğ! The red pot holds more soup than the yellow pot.



8. What do we know about water?

STE(A)M-Areas	physics - earth science - chemistry - computer science - art
Intercultural relations	Water as a necessity of life, our finite freshwater supplies are an important issue everywhere. Water is essential for life (biology, physics, chemistry, history, society).

Summary table	
Subjects	natural science
Topics	Water.
Age of students	10-18 years
Lesson/project duration	4×45 minutes
Number of students	max. 30 persons
Online learning tools	The materials are available at stations showing examples of the work of each group.
Offline learning tools	The materials are available at stations showing examples of the work of each group.
21st century competences	innovation - creativity - problem-solving - analytical thinking - active learning - critical thinking - information and communication technologies - cooperation
Learning objectives	acquiring scientific knowledge - helping to build learning communities - developing manual skills - developing abstraction skills

Project plan	
The name of the exercise	What do we know about water?
The implementation process	
Preliminary Questions	Is the pencil broken? Can you walk on water? Can you blow a candle with a bubble? Why is the oil stain coloured? How to colour a white flower? What does this mean: pH 5.5? What is corrosion? Hard or soft water? Can pond water be made drinkable? Tap water or mineral water?

		Slow water, washing ashore? - The surface-forming effects. Water scarcity: can we help?
	Ideas Exchange	Forming groups. Assigning topics. Collecting ideas from students.
	Preparation	Gathering the equipment needed for each experiment, setting up the experiments, preparing the task descriptions and explanations.
	Introduction	Each group will create a station of the interactive exhibition. Each station should have a description and a tool to try out.
	Hypotheses	Learning about the versatility, interesting properties and finite quantity of water can increase students' environmental awareness.
	Goals	Learning about the versatility, interesting properties and finite quantity of water can increase students' environmental awareness.
	Discoveries	Each group will create an element of the interactive exhibition through a cooperative division of labour within the group. The completed exhibition each pupil gets to know the results of all the groups by "playing through".
	Productum	While visiting the exhibition, pupils learn through play.
	Reflections	Why are the preliminary suspicions and the experienced ones the same or different?
	Presentation	Students will create an interactive exhibition that everyone can see and try out the different tools.
	Tools	Experimental tools.
	Redesign	After the first trials, changes to individual instruments or corrections to write-offs may be necessary.

Stations

	Presentation	Below are some examples of ideas that might be used to create some of the elements of the exhibition. In fact, each time you do the exercise, you create a different kind of exhibition. **1. Optical illusions with water (refraction)** Find surprising and interesting optical phenomena related to water, e.g. if the pencil is broken.  Figure 1.

Online learning material

[12 amazing optical illusions]
[Amazing Water Trick - Amazing Science Tricks Using Liquid (YouTube)]

2. Thin film interference

Why is the oil stain coloured? A thin layer of water on the surface creates an interference phenomenon. Let's find the explanation and make a model using colourless nail polish and photographic cardboard.

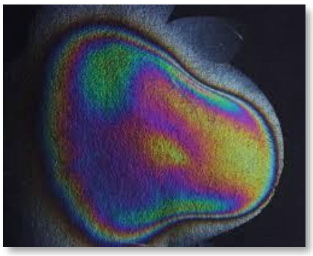


Figure 2.

Online learning material

Exploring Materials - Thin films Thin-film interference (Wikipedia)
Thin Film Interference (part 1) (YouTube)

3. Surface tension of water

Can water be carried in a sieve?
Upside down bottle

4. Curvature pressure

How to blow a candle with bubbles?

3. Figure

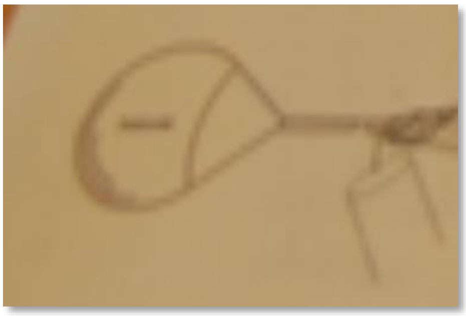


Figure 4.

5. Capillarity and flowers

Colour changing flowers experiment
Color Changing Flowers - Science Experiment for Kids

5. Figure

6. Acids and bases
pH test for red cabbage
The healthy pH indicator (Facebook)

7. Is the water hard?
Hard Water Experiment
Hard Water Experiment

8. Water purification Make a water filter! Make a Water Filter
Sand Filter Science Experiment Water Filtration Science Project

9. Slow water, washing ashore - surface shaping effects
Weathering, erosion, deposition
Weathering, Erosion, and Deposition Experiment (YouTube)

10. Water scarcity
Water shortage (all ages)
The Water Crisis - Lesson Plans for All Grades The topic can be part of several "stations".
Complex Science Handbook (page 132)

11. Tap water or mineral water
Is there a significant difference between tap water and bottled water? Tap Water, Bottled Water

12. Scientific test on the angle - corrosion
What is corrosion?
Corrosion of metals (NKP)
Experiment to prove that the presence of air and water are essential for corrosion/rusting (YouTube)

Experiences	Making an exhibition, working in a team is also an important experience. In addition to learning about the specific content of the exhibition, the experience of seeing how well a group has managed to create an understandable and usable exhibition element is also important.

9. Forces acting on aquatic animals

STE(A)M-Areas	mathematics - science - computer science - engineering - sustainability
Intercultural relations	Differences between ecosystems (biodiversity) in different areas of the Earth.

Summary table	
Subjects	biology - physics - mathematics
Topics	Physical explanation of animal behaviour in water. Forces acting on underwater animals.
Age of students	15-18 years
Lesson/project duration	4×45 minutes
Number of students	10-15 people
Online learning tools	tablet - PC - smartphone - interactive whiteboard - projector
Offline learning tools	Instruments for experiments.
21st century competences	communication - cooperation - teamwork - creativity - innovation - critical thinking - problem solving
Learning objectives	interdisciplinary learning - acquisition of scientific knowledge - experimentation

Project plan	
The name of the exercise	Forces acting on aquatic animals
The implementation process	
Generating interest	• Insects on the surface of lakes. For many organisms, the water surface is an excellent habitat. Light insects and spiders like to populate the surface of lakes and slow-moving streams. • The length of a mollusc bug is usually 1 cm. When standing in the water, the surface of the water beneath their uniquely structured legs is slightly indented, acting like a membrane. • The feet of the mink are not oily, but the last taste of the foot in contact with the water is covered by a fine, air-filled cushion of fine hairs, similar to skis. There are also insects that rely on the water not only for the last taste of the foot, but also for the whole foot. • They tap their feet on the water, creating a small pit. By "leaning" against the wall of the pit, they can move forward thanks to the force exerted by the pit on their feet. They can cover a distance of up to 12 cm with a single foot strike, accelerating to speeds of up to 90 cm/s.

	• In many of the photographs taken in a particular way, you can see that the surface of the beetle resting on the surface of the water is slightly depressed under its feet. Their feet are not wet by the water. • The dorsal-web bug is a distant relative of the molnarka. It lives below the surface of the water, with a boat-shaped body adapted to an aquatic lifestyle. The camouflage makes its back light and its belly dark, covered with flat and dense fur. On the surface of the water, the air bubble in the fur cushion below the surface causes their body to adhere to the water surface membrane. They "cling" to the water surface from below. They also take in air from the air bubble (also called physical lungs), but sometimes they themselves break through the membrane-like surface to take in air.
Preparations	Discuss the following topics! If we dive into the world of corals, rays, turtles and sharks, we can see the dangers these magnificent animals face and what we can do to help them survive. • ¾ of the Earth is covered by oceans and seas, so we shouldn't call the planet Earth, we should call it water. • Underwater ecosystems play a major role in slowing climate change and reducing the amount of carbon dioxide in the atmosphere. • In 1997, almost 90 percent of the coral reefs in the Maldives were destroyed by a natural phenomenon known as El Nino.
Presentation	**1. Experiment** Cut out a 5-6 cm long boat shape from paper-thick aluminium foil. Carefully place it on the surface of the water and drop a small drop of dishwashing liquid or a bar of soap on the end of the boat shape. The small boat will then move in the opposite direction. As the detergent reduces the surface tension of the water by about a third in the vicinity of the drop, the boat's previous equilibrium is upset and it moves in the direction of the resulting force. **2. Experiment** Changes in pressure cause damage to the deep-sea fish, which students can experience for themselves in a spectacular experiment. All they need is a medical syringe and marshmallows.
Preliminary assumptions	Aquatic animals are "lighter" in the water. They are buoyant. They can "walk" on the water because of the surface tension of the water. Fish change their average density by using their swim bladder.
Questions	Do bodies of lower density than water float on the surface of the water? If the density of the body is equal to the density of water, then the body is in equilibrium at any depth, floating? Do solid bodies with a density greater than water sink in water? Hollow bodies made of a material with a density greater than water float on the surface of water, and their average density is less than the density of water? How do animals survive the enormous hydrostatic pressure in the deepest parts of the ocean?

Method of discovery	Design an experiment to justify the previous questions! Check your results by calculation!
Experiences	For example, the pressure in water at a depth of about 10 metres is the same as the air pressure at sea level. The bodies in the water are therefore subjected to twice the atmospheric pressure, about 200 kPa. Every additional 10 metres increases the pressure by 100 kPa.
Presentation materials	**Unique diving "practices" of aquatic animals** The seas, oceans and lakes are home to a rich variety of life, with the habitat of an aquatic creature often extending from the surface to areas hundreds of metres deep. In order to use its energy in the most economical way, to perform the activities necessary for its survival, the animal must be able to achieve what is known in the literature as 'neutral buoyancy' at all depths. This state is nothing other than the adjustment of the buoyancy to the current depth. As water depth increases, pressure increases and temperature decreases, and all aquatic animals have had to adapt to these conditions. In all their locations, the force of gravity on the animal must be balanced against the buoyancy, and this requires some skill to control. The diving and surfacing of aquatic animals is a rapid process, but to stay at the desired depths for a longer period of time requires cunning, mostly achieved by varying the average density of the animal. **What are the catches that aquatic animals use to change their average density?** Let's start with the fish! Animals living in water have an average density close to that of water, so the buoyancy force acting on them completely balances the force of gravity, they float. This is reflected in their structure, with a skeletal mass that is only a few percent of their total body mass, without the need for the massive support structure of their terrestrial counterparts. While the skeleton of fish is about 8% of their total body mass, and that of frogs, both aquatic and terrestrial, is about 11%, the rabbit's skeleton is as much as 15%. An interesting organ in bony fish is the swim bladder, which is used to regulate the depth of swimming. The swim bladder wall has remarkable elastic properties. The fish uses its swim bladder to "set" its average density according to its current depth. The closed swim bladder fills with gas when it needs to increase volume, but when it gets deeper, the higher pressure causes the swim bladder to compress, increasing the average density of the animal. As the size of the bladder varies, so does the volume of the fish and therefore its average density.
Results	Present your experiences in a presentation or show your peers the experiments with explanations!

Subject links

Natural science	**The law of Archimedes** In nature, the largest creatures on Earth live in water. The duck gives the impression of a lumbering bird as it waddles on the ground. Not so in water! On the surface it glides effortlessly.

Bodies are lighter in the water, and their movement is not as slowed down by water as it would be on land. The lower friction and buoyancy forces acting on bodies in the water have had a significant influence on the structure and behaviour of aquatic organisms.

If we take the density of the insect ρ to be the same as that of the water $\rho = 1\ g/cm^3$ and the surface tension of the water with respect to air $\sigma = 72.8$ dynes/cm, then Fmax = 19.7 dynes. Therefore, the mass of the insect is approx.

0.02 g, and the approximate linear dimension is 3 mm (1 dyn=0.1 mN).

Hydrostatics

The properties of fluids at rest can be described by the laws of hydrostatics. The surface of a liquid at rest on Earth is horizontal and perpendicular to the force of gravity. At a given depth in the fluid, the pressure, the hydrostatic pressure, increases in direct proportion to the depth h, $p = \rho\, g \cdot\cdot\, h$, where ρ is the density of the fluid and g is the value of the acceleration due to gravity at that location. The hydrostatic pressure of a 76 cm high column of mercury is in equilibrium with the pressure of air, according to Torricelli's experiment. The value of the air pressure can be easily calculated from the above equation, 101000 Pa=101 kPa.

buoyancy

Submerged bodies are subjected to a buoyancy force, the value of which is the weight of the volume of water corresponding to the volume of the body submerged in the liquid. $F = g \cdot \rho \cdot V$ When swimming, the resultant of the forces acting on the bodies is zero, the force of gravity is balanced by the buoyancy.

Gas laws

Sharks are cartilaginous fish, they have no swim bladder. They have to resort to other diving practices. Their skeletons are made lighter by the fact that they are made of cartilage instead of bone. But they have other ways of changing their average density. The shark's liver is the organ used to set their average density at any given time, and can be as much as 25-30 percent of the animal's total body weight (mammals only 5 percent). The shark's liver contains about 70 percent oils and other organic matter with a density lower than that of seawater. The shark adjusts its average density to suit its habitat by changing the volume fraction of the substances that make up its liver. The density of seawater is $\rho_t = 1.026\ g/cm^3$ and the density of oils $\rho_o = 0.90$-

$0.92\ g/cm^3$, and the density of squalene $\rho_s = 0.855\ g/cm^3$.

the 51 swim bladders of bony fish, so sharks are constantly on the move to avoid sinking.

The squid, or cuttlefish, is, contrary to its name, not a fish but a mollusc, related to octopuses. When diving, it is regulated by the cephalic tube, which accounts for almost 10% (9.3%) of the total body volume.

Biology	Molnárka. Back-swimming bug. Dipper bug. Halak. Cetek. Deep-sea animals.
Digital culture	Digital tools: interactive whiteboard, smartphone, laptop, tablet, PC. Making a presentation.

Physical education

Sports equipment: swimming equipment.
Suitcase scales:

- Measure your buoyancy in the pool while you are fully submerged in the water!
- Determine the density of your body from the measured data!

Mathematics

Mathematical tools: calculator.
Conversion between units of pressure, use of prefixes.

Appendix

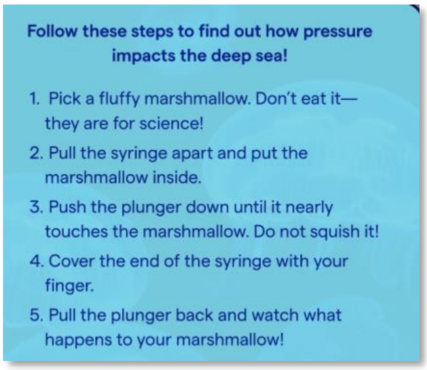
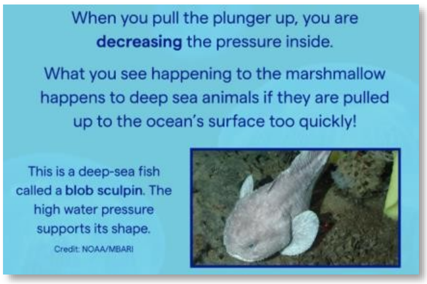


Figure 1.

1. Buy a soft marshmallow piece! Don't eat it, we're using it for scientific purposes!
2. Put the candy in the front of the syringe and push it in using the plunger!
3. Push the plunger in so far that there is no air left in the syringe next to the candy.
4. Close the end with your finger!
5. While holding the syringe shut (to prevent air from leaking in from the outside, slowly pull back the plunger and watch what happens to the marshmallows!

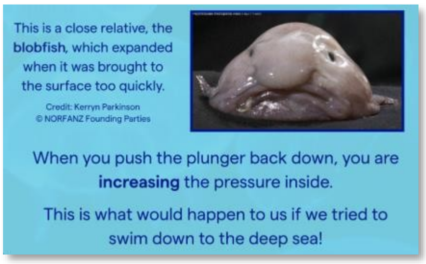
2. Figure



3. Figure

As you pull the piston backwards, the pressure decreases as the volume increases (at a constant temperature; Boyle-Mariotte law).
This causes the soft candy to "bloat" as the higher pressure inside pushes the particles outwards. The same thing happens in deep-sea animals

if they are moved closer to the surface or placed in a shallow pond or reservoir. In this case the hydrostatic pressure is reduced as the height of the water column above the animal is reduced.



4. Figure

The jellyfish is a deep-sea fish that also "bloats" when brought to the surface quickly. This experiment demonstrates what would happen to you if you were to dive into a deep sea and ascend.
Psychrolutes marcidus (Wikipedia)

Source from
STEM Learning

SUSTAINABILITY

1. Learn to recycle packaging materials!

STE(A)M-Areas	environmental studies - visual arts - nature studies - selective waste collection

Summary table	
Subjects	sciences - environmental studies - mathematics - Hungarian language and literature - visual arts - games and movement
Topics	Environmental protection. Selective waste collection. Properties of different materials (glass, metal, paper).
Age of students	6-11 years
Lesson/project duration	5×45 minutes 1-2 hours field trip to the local landfill/waste treatment plant
Number of students	10-24 persons
Online learning tools	interactive whiteboard (with interactive applications, animations) - laptop - speaker - projector
Offline learning tools	illustrative pictures - worksheets
21st century competences	communication - collaboration and teamwork - creativity - critical, innovative thinking - problem solving - technological literacy
Learning objectives	helping students to form communities of learners - developing fine motor skills - learning through play - developing auditory skills

Project plan	
The name of the exercise	Learn to recycle packaging materials!
The implementation process	
Arousing interest, preliminary questions	Do you collect waste separately? How can we take care of our environment? Can we recycle metal? Can we recycle paper? Can we recycle plastic? Can we recycle glass? Why is separate waste collection important?
Preparations	Purchase of raw materials • experimental equipment (e.g. beakers; sand; flat, transparent box; ice; heating device; liquids of different densities; kettle; paper towel) • watercolour, paper • instruments for measurements (glass jars of different sizes)

Presentation	The project aims to teach children about the importance and process of recycling in a playful and interactive way. During the programme, participants will learn how to sort and recycle everyday waste correctly. Through a variety of hands-on activities, crafts and illustrative examples, we will help children to become more aware and actively contribute to environmental protection. Our aim is to help children realise, through playful learning, that even small steps can make a big difference in protecting our planet.
Preliminary assumptions	The majority of children have only a basic understanding of recycling and cannot always correctly identify which waste falls into which category. It is also assumed that many children do not perceive the direct impact of recycling on the environment, so it is important to make the connections in a playful way. It is also likely that children will be keen to learn about the topic if we make the process interesting through creative and interactive activities.
Design	It is important for children to learn this information in a playful and interactive way, so that they can develop a deeper understanding and interest. The above information and activities will help to make the project enjoyable and educational for them.
Method of discovery	Let children learn about the recycling process through their own experiences and active participation. For example, during the project, they are given different types of waste, which they have to sort into the appropriate categories (paper, plastic, metal, etc.) and then discuss how they are recycled. In addition, interactive games and experiments (such as building their own "mini recycling system") will help them to discover the environmental and social benefits of recycling for themselves. The aim is to ensure that knowledge is not just acquired by listening, but through active action and problem solving.
Experiences	The children participated enthusiastically and creatively and quickly understood the basics of recycling through the exercise. Building their own system helped them to experience the importance of sorting and recycling waste as a personal experience.
Feedback	According to teachers and parents, the project was not only fun, but also had an important attitude-forming effect that can be reflected in children's everyday lives. The children enjoyed the creative and playful activities and were proud of their mini recycling systems. Many of them noted that they learned many new things during the activity, such as that a simple piece of waste can be turned into a useful object.
Presentatio n materials	The materials that the children will use in the project. Posters, project work products, pictures, mini recycling system.
Results	As a result of the project, children have become more aware of the importance of recycling and have learned the basic principles of proper waste sorting. Through the mini-systems developed during the interactive workshop, they not only learned theoretical but also practical

	they have also acquired skills that they can use at home and at school. The creative activities increased their interest in environmental awareness and encouraged them to think sustainably.
Critical thinking	The project also helped to develop critical thinking skills, as the children had to analyse which waste fell into which category and why. They also had to consider how to give a 'rubbish' object a new function when designing a creative reuse, which encouraged them to think about the context and possible solutions. This enabled them to ask questions and find sustainable solutions based on logical arguments.

Subject links

Visual arts

I. Your own "mini recycling system"

Aim: To teach children the basic steps of recycling and how it works through a craft project of their own.
The activity demonstrates creative ways to sort waste and find new uses for it.

Tools:

- empty cardboard boxes (e.g. shoe boxes) to the waste sorting station.
- coloured papers (different colours for different types of waste: e.g. blue - paper, yellow - plastic, green - glass)
- scissors, glue, coloured markers, stickers
- imitation waste of various kinds (washed yoghurt containers, cardboard, caps, aluminium foil, etc.)
- a larger sheet (cardboard or thick paper) on which the recycling system is assembled
- one or two sample pictures (photos or drawings) of recycling plants or waste sorting machines.

Annex: Learn to recycle packaging materials!

Talk: what is recycling? Why is it important? How does waste sorting work?(Brief explanation by teachers or facilitators).

Questions for children: How do you sort (separate) waste at home? Which waste can be recycled and how?

To give an example: show a picture/poster of a recycling plant and explain what happens to the waste after it is taken away by the waste collectors.

Planning and preparation of materials: children in teams or individually are given a cardboard sheet and "waste samples".

Challenge: Find out and design how you can build sorting stations from your boxes (e.g. with colour coding) and how your mini system will look like. Draw the layout on the cardboard before they start building.

Mini system construction

Making stations: the children cover cardboard boxes with coloured paper and stickers so that each station represents a different type of waste (e.g. blue - paper, yellow - plastic, etc.).
Waste sorting: children sort the "waste samples" (e.g. caps, paper, aluminium foil) and place them in the appropriate boxes.
Designing new features: they have to create a new object or tool, such as a toy or decoration, from a selected type of waste (e.g. caps or cardboard) (Example: caps are used to make a small picture or cardboard to make a pencil holder).

The children show off their mini recycling system to the others.

II. New life for scrap metal!

Children can make a simple object from scrap metal, for example:

1. **Metal cap fridge magnet:** you can decorate the bottom of the cap with drawings or stickers and then stick a magnetic strip on it.
2. **Canned pencil holder:** cans with securely insulated edges can be decorated with coloured paper or paint.
3. **Small decorations from aluminium cans:** cut out simple patterns (hearts, stars, etc.) under adult supervision!

Tools: scrap metal (clean!), coloured paper, markers, glue, magnetic strips, scissors, paints, brushes

III. New life for paper!

1. **Making paper beads for jewellery**
   You can use coloured magazine pages or newspapers to make beads.
   Cut elongated triangle shapes, roll them up tightly and glue the ends!
   String them on a thread or fishing line to make a necklace or bracelet!
2. **Handmade recycled paper**
   Old papers (e.g. notepaper, newspapers) can be shredded and soaked in water to make pulp.
   Smooth over a sieve and dry, you can make your own recycled paper sheets to use for postcards or decorations.
3. **Paper weaving to make a basket**
   You can cut newsprint or old newspapers into strips, then roll them up tightly into "paper fibres".
   You can use these fibres to weave small baskets to hold small items.
4. **Origami of decorations**
   Make origami figures such as cranes, butterflies or stars from coloured or old sheets of paper!
   You can use them to decorate gift wrapping or as home decoration.

5. **Custom gift boxes and envelopes**
   Turn old cardboard boxes or thicker paper into small gift boxes.
   Decorate them with coloured paper or drawings to make them special.
6. **Paper strip pictures (quilling)**
   Cut thin strips of coloured paper and roll them into different shapes (circle, leaf, heart).
   Glue the strips to a board to create a relief effect!
7. **Paper mache figures or ornaments**
   Soak old newspapers and sheets of paper in a flour or glue-based paste to make papier-mâché objects (e.g. masks, bowls or Christmas tree ornaments).
8. **Making a notebook**
   You can cut up clean pages of old paper and use punched holes and yarn to make a simple notebook.
9. **Papercut pictures (papercut art)**
   Using old cardboard or coloured paper, cut out silhouettes (e.g. trees, animals, landscapes).
   By layering them together, you can create 3D effect images.

Science/ play and movement

Why is separate waste collection important?
Showing pictures of bins in different colours. *Annex:* worksheet3

Using different bins
In one part of the room, set up "bins" of coloured baskets or boxes to represent the different types of waste that are sorted.
"Make" different types of waste (laundered rags, clean bottles or utensils made of cardboard or paper):

- paper: newspaper, cardboard box
- plastic: yoghurt cup, PET bottle
- glass: jar, soft drink bottle
- organic: fruit peel, eggshell, bread
- mixed waste: used pencils, chewing gum, clothing

Posted on

- The children are given a waste item in turn and have to decide which "bin" to throw it in.
- Once you have made your decision, we will briefly discuss whether you made the right choice and, if not, why.

Team game: a competition for correct selection

- Preparation: place the waste in a pile on one side of the classroom. The bins (coloured boxes) should be on the other side of the room.
- How the game works:
  1. Divide the children into two teams.

3 Inspired by the information leaflet published by the local sanitation company.

2. One student from each team, one from each team, picks a waste from the pile and takes it to the appropriate coloured bin.
3. The team gets one point if they select correctly.
4. At the end of the game, teams briefly discuss which objects were more difficult to classify.

Creative exercise

Children should draw a poster or make a small sign for their family reminding them of the rules for separate collection.

Excursion

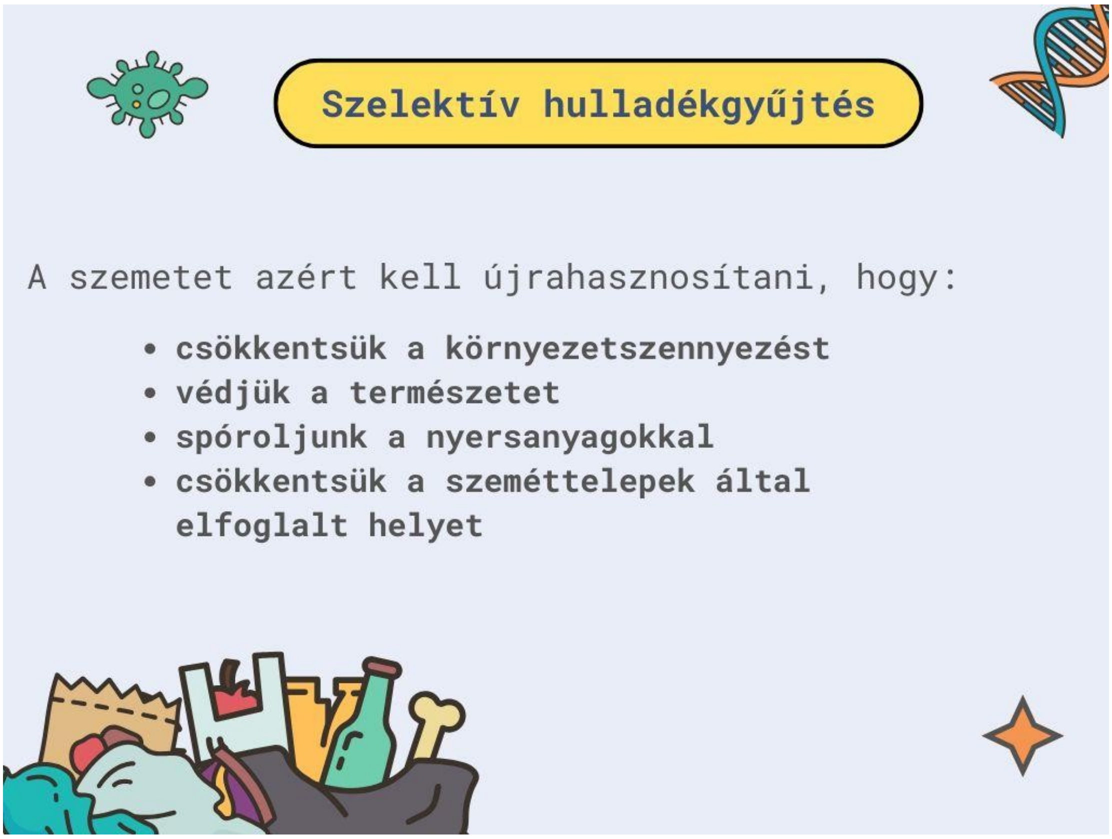
We took the children on a field trip to visit the local waste centre. They showed us how different types of waste are processed and how we can reduce our impact on the environment. The children asked questions and actively participated in the demonstrations. During the trip they learned important lessons about waste pollution prevention and sustainable living. This helped them to become more aware of how to protect their environment. At the end of the programme, it will be more important for the children to be more aware of selective waste collection at home.

Appendix

Links (videos, ideas, activities)

Let's learn to recycle packaging materials (Canva) Worksheet (Canva)
Selective waste collection rules
Selective waste collection (Genially)
Selective waste collection (Genially)
Selectively in the autumn - Fülemüle Zenekar (YouTube)
Kukasuli - The eco-landscapes of Stuffed Fluff and Peas - educational cartoon (YouTube)

Annex: Learn to recycle packaging materials!



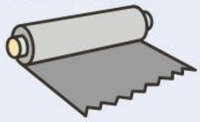
Az üveg, a papír, az aluminium, az acél és a műanyag újrahasznosítható anyagok. Ahhoz, hogy könnyebben újrahasznosítsák, ezeket a hulladékokat különböző színű kukákba gyűjtik.

ÚJRAHASZNOSÍTJUK A FÉMET!

- Az alumínium csomagolóanyagok többségét az üdítőitalos dobozok teszik ki.
- Évente kb. 6 milliárd alumínium dobozt gyártanak a mi üdítőitalaink tárolására.

ÚJRAHASZNOSÍTJUK A FÉMET!

- Az alumíniumot egy bauxit nevű ásványból nyerik. A folyamat rendkívül sok energiát vesz igénybe.
- Az összegyűjtött alumínium csomagolóanyagokat fémlemezekké alakítják át és elküldik a gyáraknak, hogy újabb dobozokat készíthessenek ezekből.
- Az újrahasznosított alumínium előállításához h[illegible]szor kevesebb energia szükséges.



ÚJRAHASZNOSÍTJUK A FÉMET!

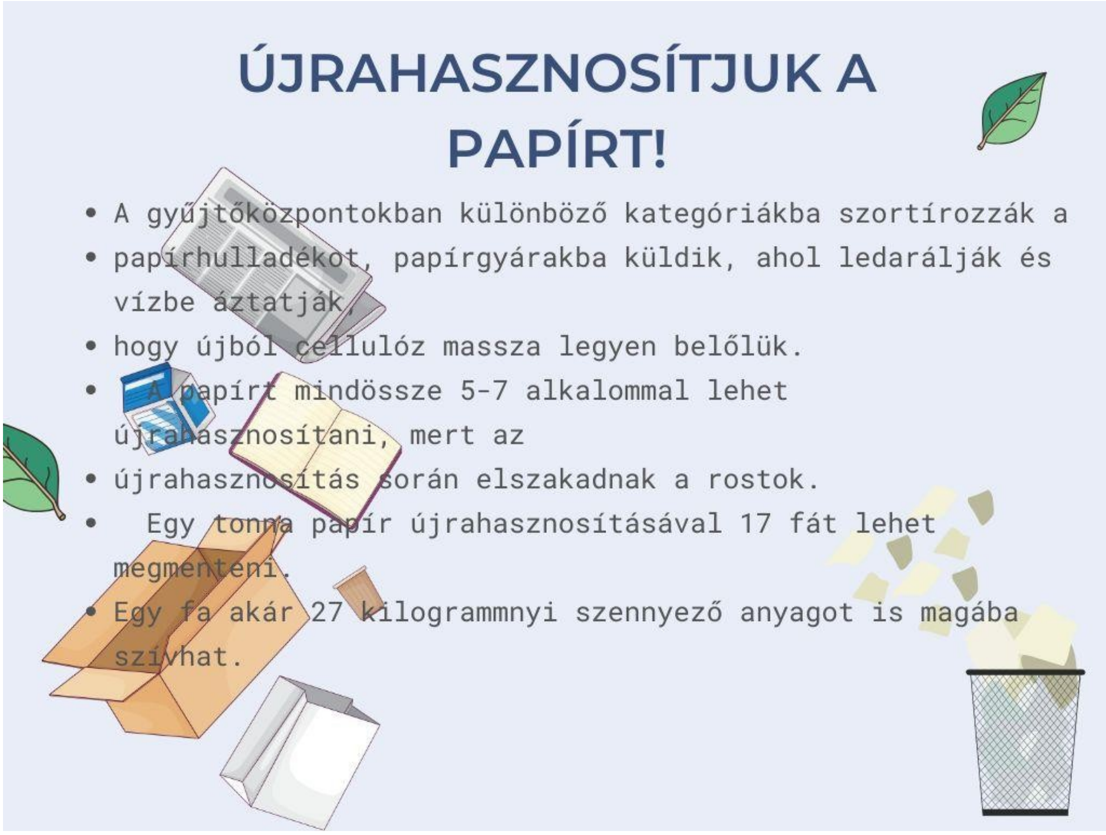
- Az acélt különleges kohókban nyerik, vasércből, kokszból, földpátból és más használtfém darabokból.
- Az acélhulladékot bálákba préselik és a gyárakba küldik, ahol újra acéllá olvasztják.
- Az acél, amit újrahasznosítanak régi autókból, gépekből, konzervdobozokból származik.
- Az az energia amivel egy acéldobozt gyártanak, 4 újrahasznosított acéldoboz gyártására elegendő.

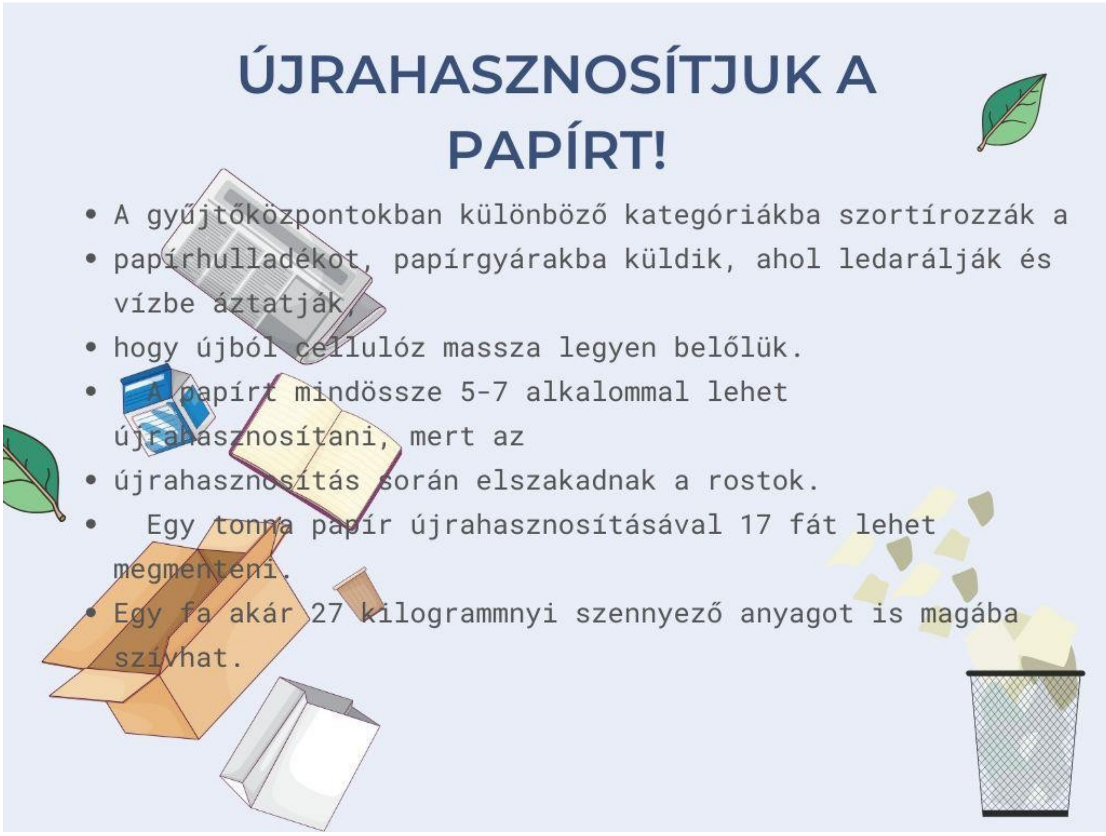
ÚJRAHASZNOSÍTJUK A FÉMET!

Az acél és a fém újrahasznosítása csökkenti a környezetszennyezést és ezáltal megelőzheti a globális felmelegedést!

ÚJRAHASZNOSÍTJUK A PAPÍRT!

- A papírgyártásban használt elsődleges nyersanyagok a fa, valamint a nád és a szalma.
- A nyersanyagokból cellulózt vonnak ki, ami hosszú és erős rostokat
- tartalmaz.
- Nagyon sok élelmiszert csomagolnak papírba vagy kartondobozokba.
- Szintén papírból készülnek a füzetek, könyvek, újságok .


ÚJRAHASZNOSÍTJUK A PAPÍRT!
• A gyűjtőközpontokban különböző kategóriákba szortírozzák a
• papírhulladékot, papírgyárakba küldik, ahol ledarálják és vízbe áztatják,
• hogy újból cellulóz massza legyen belőlük.
• A papírt mindössze 5-7 alkalommal lehet újrahasznosítani, mert az
• újrahasznosítás során elszakadnak a rostok.
• Egy tonna papír újrahasznosításával 17 fát lehet megmenteni.
• Egy fa akár 27 kilogrammnyi szennyező anyagot is magába szívhat.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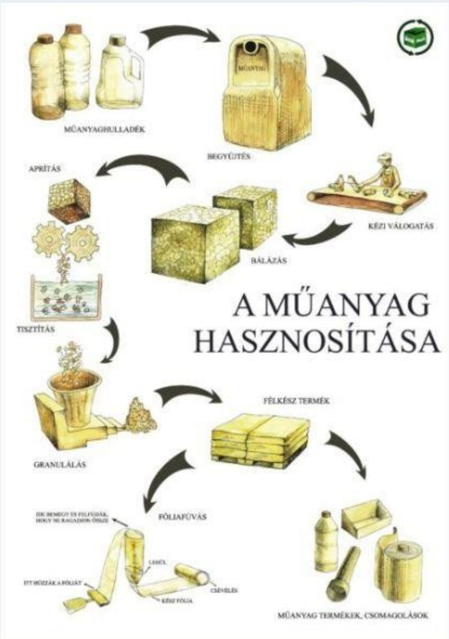
• Egy tonna papír újrahasznosításával 17 fát lehet megmenteni.
• Egy fa akár 27 kilogrammnyi szennyező anyagot is magába szívhat.

ÚJRAHASZNOSÍTJUK A MŰANYAGOT!

- A műanyag termékek kőolajból készülnek, ami egy véges természeti erőforrás.
- Ha eldobjuk ezeket a természetbe, nagyon lassan bomlanak le, több évtized leforgása alatt.
- Az újrahasznosított műanyaghulladékokból nyerik: a plüssállatkák töltelékanyagát, a hálózsák hőszigetelő anyagát, a CD-tartókat, háztartási gépeket.
- Csökken a szemét mennyisége.

ÚJRAHASZNOSÍTJUK A MŰANYAGOT!

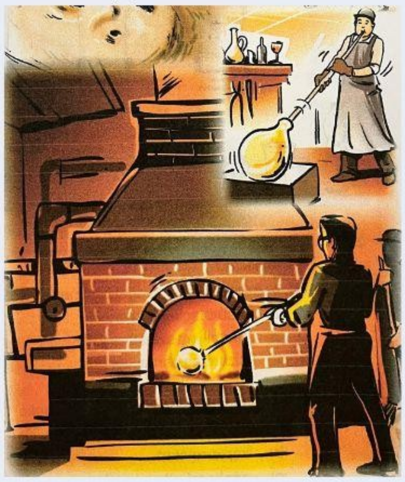


ÚJRAHASZNOSÍTJUK AZ ÜVEGET!

- Az üveg gyártásához felhasznált nyersanyagok: a homok, a szóda, a mész, a földpát.
- Az üvegnek rendkívül hosszú időre van szüksége ahhoz, hogy természetes úton bomoljon le. (több, mint 400 év)

ÚJRAHASZNOSÍTJUK AZ ÜVEGET!

- Ahhoz, hogy alakítható legyen, az üveget megolvasztják (1500 Celsius fok feletti hőmérséklet), formákba öntik és levegővel fújják tele.




ÚJRAHASZNOSÍTJUK AZ ÜVEGET!
ÜVEG-HULLADÉK
BEGYŰJTÉS
TISZTÍTÁS
AZ ÜVEG HASZNOSÍTÁSA
APRÍTÁS
ÜVEG TERMÉKEK, CSOMAGOLÁSOK
SZÍNRE VÁLOGATÁS
BEOLVASZTÁS
FORMÁBA ÖNTÉS


TEGA
öko sepsi
HOGYAN VÁLOGASSUNK?
Szelektív hulladék
Műanyag és fém
• Tiszta műanyag csomagolások
• Fém- és nemfém csomagolóanyagok
• Tiszta nejlonzacskó
• Pillepalack
Taposd laposra!
Papír
• Újságok, folyóiratok,könyvek
• Papír és karton csomagolások
Üveg
• Üvegek
Zöld gyűjtőzsák
Biológiailag lebomló hulladék
• Konyhai hulladék
• Kávézacc, teafilter
• Használt papírtörlő
• Növény, zöldség
Lebomló hulladékok edénye
FIGYELEM! MŰANYAGOT NEM TARTALMAZHAT!
Vegyes hulladék
• Nem újrahasznosítható műanyagok
• Ruhák, cipők
• Személyi higiéniai termékek
• Pelenkák
Vegyes hulladék

Annex: Task sheet

Fefodotlop

We are reusing our esomogolo logos!

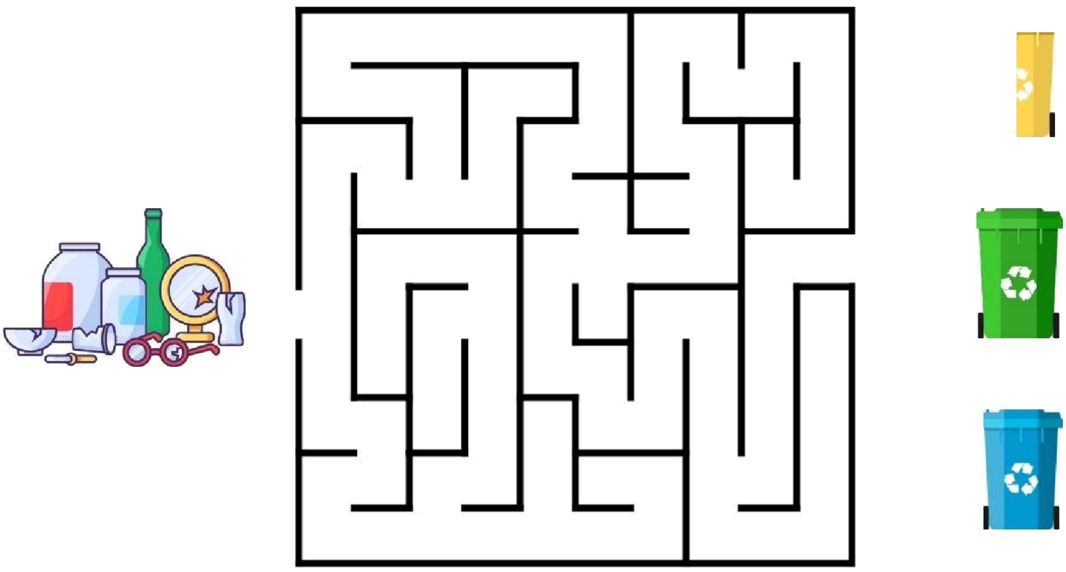
1. Colour the waste trolls in the appropriate colour and add a line to the corresponding clumping material†!

Metal and metal waste

Paper and cardboard

White and tinted glass

2. Találjátok meg az üveg legrövidebb útját a megfelelő szemeteskukához!



5. Which is a better packer from an environmental point of view? Pull bottom!

disposable shaving bag
disposable shaving bag
MULTIMATERAL flaLon
mustard powder bagged milk
non-refillable matter flal'on filtered tea

nylon socks whipped
cream spray bottled
mustard milk carton
returnable bottle of
tea

4. WASTED BiHeo

One person csa2 one place to be listed!

Find someone who,

1. aLi's most soluble materials are collected selectively at home ....
2. who has invested in this year's leLvórt ....
5. akineL has less TV than a snowman o†thon ....
4. who drinks tap water rather than bottled water ....
5. aLi showering, not bathing ....
6. aLi brushing the teeth in steam does not run the water ....
7. who takes care of the trash ....
8. who benefits from energySaving light bulb ....
9. who doesn't buy water/freshener in a useful bottle.....................................
10. ali from compost ....
11. eat more apples than bananas.......................................
12. aLi bicojjol jór iskolóbo...

2. Environmental awareness in literature

STE(A)M-Areas	arts - digital culture - science
Intercultural relations	Comparison of Hungary's wildlife and landscapes with those of other countries.

Summary table	
Subjects	hungarian language and literature - geography - drama - sustainability - biology - digital culture - visual culture
Topics	Environmental education through landscape poems and a fairy tale. Lake Balaton. Great Plain.
Age of students	10-14 years
Lesson/project duration	6×45 minutes
Number of students	10-15 people
Online learning tools	tablet - PC - smartphone - interactive whiteboard - projector
Offline learning tools	paper - pencils - coloured pencils - storybook (Sea Fairies) - props for drama play
21st century competences	communication - cooperation - teamwork - creativity - innovation - critical thinking - problem solving
Learning objectives	critical thinking - knowledge acquisition - cooperative activities - understanding - applicability

Project plan	
The name of the exercise	Environmental awareness in literature
The implementation process	
Arousing interest, preliminary questions	**Theme I** **1.** At the beginning of the lesson I read László Nagy's poem *Balatonparton (On the shores of* Lake Balaton), which describes the wildlife of Lake Balaton in a very atmospheric and vivid way. **2.** Relive your own experiences of Lake Balaton with a little chat. **3.** What is the mood of the poem? The rhythm? **4.** What creatures are in the poem? **5.** Philosophy for children: what would you ask Balaton? Children ask questions, which we write down and summarise. **Theme II** Gábor Lipták:Seaweed Fairies

Theme III

Sándor Petőfi: The Lowlands

Preparations

Form groups of 3-4 people. Research work based on real questions, followed by a presentation. Include your own answers to questions that are not real.

Questions on Theme I

Real questions

(history, location, external features, wildlife, tourism, environment)

How old are you?
How big are you?
How deep are you?
How can we look after you? What do you eat, who feeds you?
What sports and leisure activities do you do? Which tree is your best friend?
What kind of birds are you home to? What fish do you have inside?
What aquatic plants do you have? Why do they call you "the Hungarian sea"?
What hills and mountains surround you? On which side of you is your water shallower?
What colours do you have?
Which of the towns and cities around you are the most beautiful?

Not real questions

(their aim is to arouse interest, experience personal involvement) What have you seen in your life?
Who do you know?
Who are your friends?
Do you like people? Do you like storms?
Do you like the light, the sun?
What is your favourite season?
What is your favourite colour? Do you consider yourself beautiful?
Does it hurt when they skate on you? How does it feel to look at the sky all day? Who do you talk to?
Are you proud of yourself?
Do you feel safe in the hills? You're stagnant: what's it like to stand in one place all day? Do you envy the rivers for their busy life?
Are you the brother of the mirror?
Do you prefer the night or the day? How does it feel when you are cold?
When a boat glides over you, is it like being stroked?

Presentation

Presentations to each other. Discussion of opinions, arguments.

Experiences

Why do we need to take care of Lake Balaton, the Great Plain and other geographical areas in Hungary?
If we get to know and love a particular landmark, we will take better care of it. By protecting them, we can create a sustainable future.

Presentation materials

Making a presentation.
Presentation of a drama play. Presentation of poetry clips.

Critical thinking

Theme III

1. We are dealing with Sándor Petőfi's poem *The Great Plain*, which describes the wildlife of the Great Plain in a very atmospheric and vivid way. After the reading, we will watch a Youtube video about the poem.
2. My own experiences in the lowlands, who has been there? We compare it with the landscape of Balaton, Hungary.
3. What is the mood of the poem? The rhythm of the poem?
4. What are the feelings of the lyrical self towards the landscape?
5. What creatures are in the poem?
6. Philosophy for children: what would you ask the Great Plain? The children ask questions similar to the one on Lake Balaton, which we write down and summarise.
7. In pairs, they search the internet for one of the real questions and share the answers with their peers. The non-genuine ones can be answered by anyone who wants to.
8. We divide the poem into as many parts as there are pupils.
9. We make a poetry clip. The short poem is recited in a location of your choice in the school or schoolyard and recorded by telephone.
10. The clip will be edited, shown and uploaded to the internet.

Through the project, landscapes and their creatures are brought closer to the students through learning, experiencing and personal contact. They will take care of natural values!

Subject links

Natural science

Lake Balaton wildlife (flora and fauna)
Characteristics of the Great Plain

Literature and drama

Theme II

1. Let's read Gábor Lipták's story "*Sea Fairies*"!
2. The content of the story is briefly discussed. It's like an origins story: how did the seaweed of Lake Balaton originate? It is both happy and sad. Who were the characters? Where and when did it take place? In Lake Balaton, sometime very long ago, perhaps at the beginning of time, in summer, at the full moon. What was the palace like (shells, moss)?
What was the environment like (shell bowls, silk seaweed cloth, moss carpets, wave blankets, wave shelters, seaweed curtains)? What were the actions (eating, dancing, escaping, secret revelry, making music, cursing)?
What made the girls expose themselves (not noticing that it was morning, not closing their father's curtains for the night)?
What transformation has taken place (from fairy girls to seaweed)?
3. Dramatisation. Assigning roles, characterising characters together, who is who?

	Main characters: the water king, his daughters, the fairies The palace staff: catfish chopper, crab fisherman, toothfish, swift eels, carp keepers, catfish catchers. The participants of the fun: crickets, fireflies, reed buntings, frogs, waterfowl, reed buntings, lizardlings. Narrators' texts are scheduled. **4.** 2-3 good readers read the story and the characters involved act out their roles in a silent play. The old king says or reads the curse himself at the end. Through the dramatisation, they identify with the lake's wildlife, and become aware of the fact that Lake Balaton is a living creature. In this way they will also take care of it.
Digital culture	Making a presentation, poetry clip.
Geography	Lake Balaton. Great Plain.
Visual culture	Group members who like to draw can draw a picture of the topic and include it in the presentation.
Appendix	**Links, resources** Judit Halász: Balatonparton (YouTube) Sándor Petőfi: The Great Plain Poetry Festival: The Great Plain (6th class of Bozzay Pál Primary School) (Facebook) Gábor Lipták 1968. Budapest.

3. Save the Earth!

STE(A)M-Areas	natural sciences - computer sciences - engineering - arts
Intercultural relations	There are huge differences in the way energy is produced and consumed in different countries and regions of the world.

Summary table	
Subjects	physics - biology - geography - chemistry - sustainability - digital culture - visual culture
Topics	Greenhouse effect. Ozone hole. CO_2 sources. Ecological footprint. Recycling. Air. Climate change. Global warming.
Age of students	12-18 years
Lesson/project duration	4×45 minutes
Number of students	15-25 people
Online learning tools	tablet - PC - smartphone - interactive whiteboard - projector
Offline learning tools	For experiments, recyclable materials found in households.
21st century competences	communication - cooperation - teamwork - creativity - innovation - critical thinking - problem solving - environmental awareness
Learning objectives	understanding - awareness - confidence - knowledge transfer - measurable results - applicability

Project plan	
The name of the exercise	Save the Earth!

The implementation process

Arousing interest, preliminary questions	**1. greenhouse effect** • This is the greenhouse effect. • Greenhouse gases and global warming. • Rising water levels in the Arctic, sea and ocean, use of fossil fuels. • Reducing greenhouse gas use and emissions. • Eliminating the use of free gas sprays, reducing the emission of ozone-depleting chemicals. electric car promotion???? • The greenhouse effect raises air temperatures (climate change!).

	2. ozone hole • Ozone hole situation map. • The consequences of a thinning ozone layer.
Preparations	**CO_2 sources** • Natural ones, such as volcanic eruptions, respiration of living organisms, natural forest fires, decomposition of dead matter from plants and animals. • Unnatural, like industry, cars, oil, coal. (Global average temperatures have been rising since 1900. This is because since 1900 humans have increased their CO_2 production and disrupted natural CO_2 production).
Presentation	**1. Experiment** • Before the day of the experiment, open one of the two mineral water bottles to allow the gas to escape. On the day of the experiment, pour the contents of each mineral water bottle into the glass bottles. Students should note that one bottle contains gas and the other does not. Record the starting temperatures of the two thermometers in the workbook. The bottles are sealed and placed under strong light or in sunlight on sunny days. The thermometers should be placed inside the cylinders through the stopper. Set the experiment aside for a short time. End of the experiment: the experiment ends when the difference in temperature between the two thermometers is about 1.5 °C (after about 10-15 minutes). At this point, the students record the temperature of each bottle and will return to draw a conclusion after the two subsequent tasks. • A simpler version of the experiment is to leave one thermometer in the air and place one in a glass bottle to compare the temperature difference and demonstrate the greenhouse effect, but in this case the effect of CO_2 is not shown. **2. Experiment 1:** The role of CO_2 • Ingredients: 2 test tubes with stoppers, lime water, pipette or syringe • On the day of the experiment, take CO_2 gas from an opened mineral water bottle into one of the test tubes by shaking the bottle. Then seal the test tube hermetically! Do the same, but with a bottle opened the day before in front of the second test tube. This will be the control tube. Close the test tube in the same way as the first one! • Using a pipette or syringe, add a little lime water to the test tube, then quickly close it and shake it! You should observe that the water in one of the test tubes becomes cloudy. Tell the students that lime water is known to detect the presence of CO_2. • The presence of carbon dioxide caused the temperature in one of the cylinders to rise. Carbon dioxide is called a greenhouse gas. On Earth, the atmosphere plays the role of the bottle that traps greenhouse gases and influences temperatures. Greenhouse gases have an advantage: without the atmosphere and the carbon dioxide trapped in it, the average temperature of the Earth would be too low to allow life as we know it. However, as the amount of carbon dioxide in the atmosphere increases, the global temperature of the Earth increases.

3. Experiment 1: Impact of climate change on ice melt

- On Earth, ice is found in two areas: on land and in water. If global temperatures rise and the ice melts, where will it go?
- Ingredients:
  - 2 identical transparent glass jars
  - sufficient ice cubes
  - optional: food colouring for better visibility
  - placing a heavy object in one of the glass jars representing the continent
  - a felt-tip pen, a piece of paper and glue, ruler, etc. to mark the water level of each tank
- Pour water into the two glass jars (this water represents the oceans). Put ice cubes in one of the two glass jars to represent the ice sheet. Dip a heavy object (representing the continent) into the other container and place ice cubes on top (these represent ice fields such as glaciers.
- Mark the water level after the ice cubes have melted! (Does the water level rise or not?)

4. Experiment

Make your own cleaning products to minimise chemical pollution!
[20 DIY Natural Cleaning Recipes, Tips and Hacks that Actually Work! (YouTube)]

Preliminary assumptions

Greenhouse gases pollute the air.
Fossil fuels are high CO_2 emitters. Should we use renewable energy sources?
Is the ecological footprint of renewable energy production smaller?
The average temperature of the Earth should not increase by more than 2°C.

Experiences

Conclusion: the global average temperature increase has serious consequences for the Earth. It is disrupting the climate and affecting ecosystems. Humanity is also responsible for pollution, which also has a serious impact on ecosystems.

Result of experiment 1: CO_2 is trapped in the atmosphere as if it were in a bottle. As the amount of CO_2 in the atmosphere increases, the planet gets warmer.

Result of experiment 3: Ice placed in water melts very quickly (in a few minutes), while ice placed on a "continent" melts much more slowly (in a few hours). This observation can help us understand the fragility of ice sheets that melt faster than ice on land.

Conclusions

The increase in global average temperatures has serious consequences for the Earth. It is disrupting the climate and affecting ecosystems. Humanity is also responsible for pollution, which also has a serious impact on ecosystems. The good news is that we are all human and we can still change the direction we choose!

Presentation materials

Project work

What can we do to increase biodiversity and cleaner air?

- Construction of a Rovarhotel

  [Build An Insect Hotel In 4 Steps (YouTube)]

- Construction of a worm hotel

  [Science Crafts for Kids: Build a Worm Hotel]

- Planting flowers, plants, vegetables, beekeeping?
- Measure the CO2 level in the air by opening the classroom windows
- What plants should be placed in the classroom to make the air cleaner?
- Photosynthesis

Results

The consequences of sea level rise (Climate Change - Sea Level Rise [OCE]).
The consequences of rising sea levels could be catastrophic in the Netherlands if the country does not take this into account and build facilities to protect its cities.By 2100, ocean levels could rise by 1-2 metres. However, other countries do not have the same means of protection. In these cases, we can expect some people to have to leave their countries.
Consequences for man and nature (Conséquences sur l'homme et sur la nature).
The impact of climate change on the Earth (Images of Change - Cape Cod's Ever-Changing Coast 1984-2020 [NASA]).

Critical thinking

School research.
Survey (statistics) on who in the upper school consumes what kind of food (home-grown, vegetarian, home-baked bread, etc.), how much local produce they use (no transport costs), how they collect rubbish (selective), what means of transport they use to get to school.
Research into the school's energy and water consumption (water meter, electricity meter, gas meter readings every month?).

Subject links

Natural science

Air composition

Pie chart of the percentage distribution of ingredients.
Experiment: consequence of oxygen deficiency.
Ingredients: candle, matches, jar.

Air properties (experiments)

- Can it be compressed?

  Ingredients: syringe.

- No pressure?

  Ingredients: glass beaker, cardboard.

- State of matter? The movement of its particles? (Brownian motion)

  Ingredients: deodorant.

Hungarian language

Sayings and proverbs about air

- *He speaks into the air.* One interpretation is that it means that someone is explaining in vain and no one is listening. The expression refers to the fact that the person's words disappear into thin air, as if they had never been spoken. If, for example, a mother asks her son to do the same thing day after day, but he does not do what she asks, the mother

	can say "I see I'm talking into the air" because his son won't listen. The other interpretation is that someone is saying useless or false things, there is no basis for his claims. If, for example, someone is spouting all sorts of made-up lies, someone else may rightly advise his friend "don't listen to him, he's talking out of his ass". • *Don't spoil the air in here!* Go away, we don't want to see you. • *The coast is clear.* No danger, no one here. • *It looks like air.* It doesn't look at anyone, it sees someone as non-existent. • *It relies on air.* He makes unrealizable, imaginary plans, or his actions have no solid basis in reality. You cannot build a castle in the air.
Digital culture	Where is air in digital materials, e.g. in LearningApps? The composition of air (LearningApps).
Biology	**Ecosystems** Weather And Climate What are the major climate zones of the world? Climate (Britannica Kids) **Terrestrial ecosystems** Land food webs multimedia activity (OCE) **Ocean ecosystems** "Ocean Food Webs" Multimedia Activity (OCE) **Experiment** The behaviour of deep-sea organisms when they are brought close to the surface (hydrostatic pressure). Ingredients: syringe, marshmallows. **Food chain** Within ecosystems, interdependence is best described as a food chain. A food chain is a sequence of organisms, each of which depends on the next as a source of food. For example, there are animals that eat plants and then these animals are eaten by other animals. Make a food chain! **Biodiversity** (The diversity of living organisms) Biodiversity plays an important role in healthy ecosystems. This applies to all the varieties of life on Earth (bio= life, diversity= diversity), the communities they form and the ecosystems in which they live. There are three levels of biodiversity: 1. diversity of genes 2. diversity of different species 3. diversity of different ecosystems. What is Biodiversity?
Visual culture	Make your own recycled items or collect what we use at home that can be recycled!
Geography/Sustainability	**The impacts of climate change** • Melting glaciers: Google Earth Timelapse.

Satellite images of the beautiful, fragile Earth (art) Climate belts

- They contain different ecosystems.
- For more on climate belts, see Climate (Britannica Kids).

Observing the Earth

- Images (Google Spreadsheets).
- What happened between the two pictures? What changes did you notice? Do you think they are natural changes?

Glaciers are melting and sea levels are rising.
Extreme events are becoming more frequent: like the heatwaves and drought in California pictured. The consequences are significant for biodiversity - some organisms lose their habitat or die (fires, cyclones, floods...) - but also for people (people lose their homes, die...) or agriculture.
Increasing pollution is causing health problems for humans, animals and plants.
Ecosystems are being destroyed, such as forests that are being sacrificed to build cities or plantations.

Ecological footprint

- Create your own ecological footprint!
- Dip your foot in green paint on cardboard or wrapping paper and write on it how you could reduce your ecological footprint!
- Rapid climate change is affecting the whole planet, but we can make a difference, even if only in small steps!

The ecological footprint is the value that expresses the consumption of energy, food, water, building materials and other resources by a person, a family, a city, a facility, at a given level of development, that is necessary to sustain itself and absorb the waste it produces.

Zero pollution

Pollution is dangerous for our health and the environment. It is the biggest environmental cause of disease and even death. Pollution is also a major cause of biodiversity loss, making it difficult to keep ecosystems clean and healthy. Zero pollution is a plan to reduce air, water and soil pollution to levels that no longer threaten ecosystems.
Zero Pollution Action Plan (European Commission)

Recycling

Recycling is the process of collecting materials such as used paper, glass, etc. that would otherwise be thrown in the trash and, after a little processing and shaping, making them into usable new objects. Recycling gives new life

	old things and waste, and can benefit the community and the environment. [The Environment - Recycling]
Appendix	Thematic lesson plans, sample projects (Sustainability Week)

TONE AND LIGHT

1. Crafty instruments

STE(A)M-Areas	physics - mathematics - engineering - music - biology - technology
Intercultural relations	Musical styles. Making and using musical instruments. Musical affinity.

Summary table	
Subjects	physics
Topics	Phonetics, hearing.
Age of students	6-20 years
Lesson/project duration	8×45 min
Number of students	15-20 people
Online learning tools	Éva Oláh:Let's play music as physics or let's play physics as music Oláh Éva Mária - Stonawski Tamás 2024. STEM and STE(A)M pedagogy in physics education. *Physics Review*. 2024/5. Physics textbook
Offline learning tools	Dr. Anett Nagy 2010. Musical instruments from "nowhere". *Nukleon*. III/56. Tamás Stonawski 2019. Mozaik Publishers.
21st century competences	critical thinking - creativity - collaboration - communication - technological literacy - flexibility - leadership - initiative - productivity
Learning objectives	gaining scientific knowledge - deepening understanding of the subject (phonetics, ear and hearing) - helping to build learning communities - developing manual skills - developing abstraction - learning through play

Project plan	
The name of the exercise	Crafty instruments
The implementation process	
Question	What types of wind instruments are known (wedge, reed, funnel)? How old are the instruments? Do you need to know basic maths and proportions to play music? Which of our organs help us to hear? What are the high and low notes? Who are the champions of hearing in the animal kingdom? Does our hearing range change with age? What do we mean by "music"? What are standing waves?

What is the tempered scale? Do birds have hearing?
How can variable frequency be extracted from wind instruments?

Inspiration

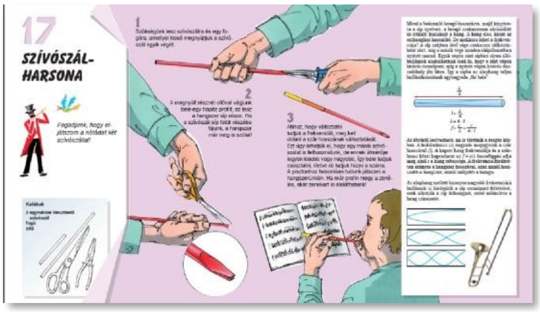
Collecting ideas from students.
After working in groups, a joint discussion. Incorporating your own ideas and innovations into the project.

Preparation

Purchase of raw materials (straws, pliers, KPE pipe, saw blade, drill, sandpaper, PET bottles, cork stoppers, insulation tape).
Making "musical instruments".
Choosing pieces of music.

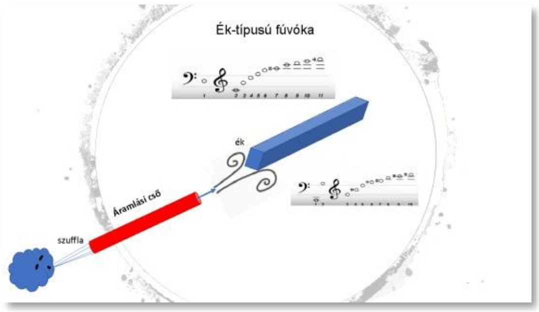
Presentation

- **Sound generator "hearing test"**
- **Doppler effect**
- **Wavelength and frequency of musical instruments**

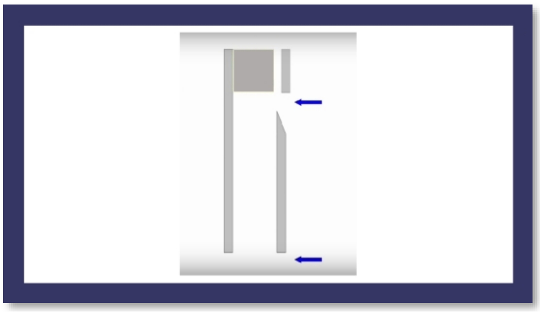


1. Figure

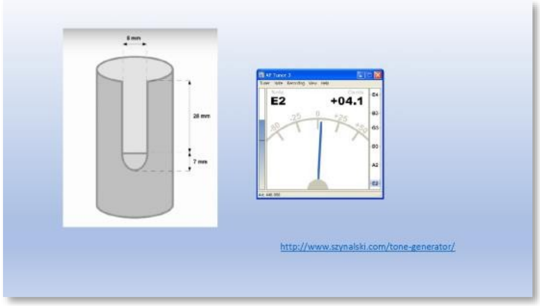
c=λ· f (where c is the speed of propagation of the sound wave in a given medium, λ is the length of the sound wave and f is the frequency of the sound). Even with basic mathematics, it is clear that there is an inverse proportionality between wavelength and frequency at a constant propagation speed.
In practice, this means that at longer wavelengths (longer air column, higher water column), the frequency is lower, which results in a lower musical sound.



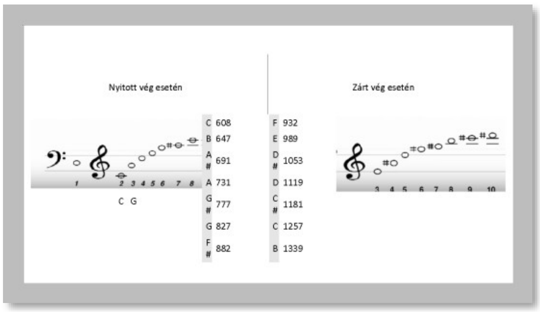
2. Figure



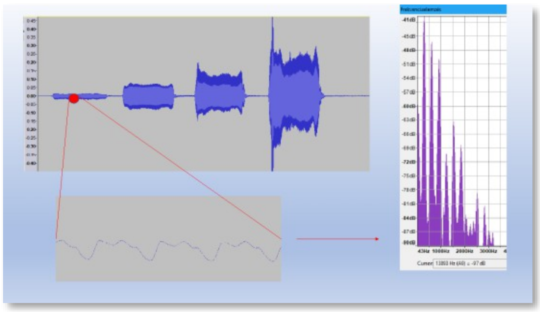
3. Figure



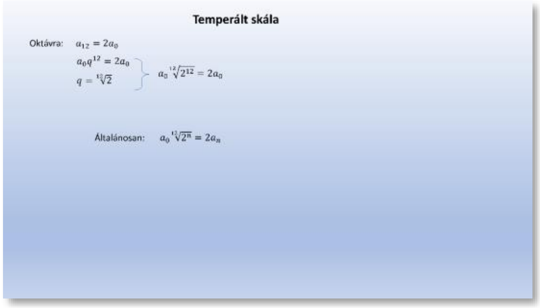
4. Figure



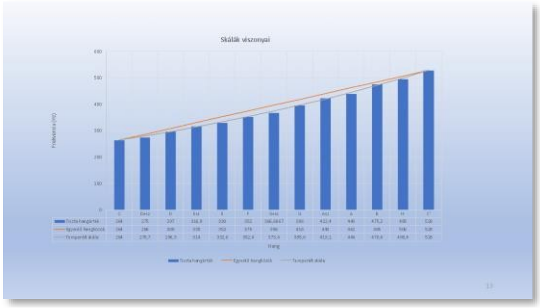
5. Figure



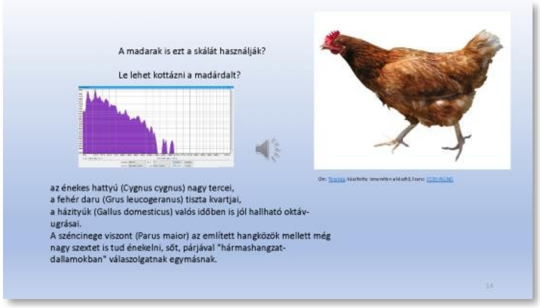
6. Figure



7. Figure

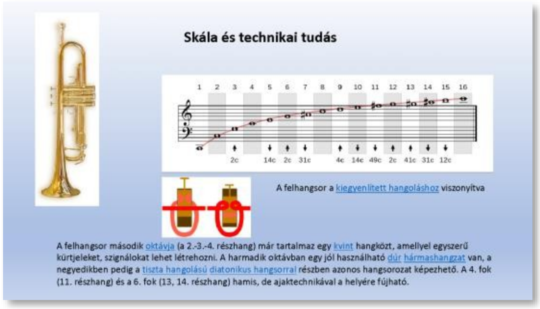


8. Figure



9. Figure

10. Figure



11. Figure

12. Figure

Forecasts	We cannot hear in a vacuum. The waves are reflected, they add up. The octave is twice the frequency. Periodic pressure differences produce sounds.
Design	Using household waste to make musical instruments and using these instruments to gain a deeper, more visual understanding of certain chapters of physics.
Discovery	The project is about using a discovery method to teach students about the laws of physics, and the hands-on mind-on method results in a deeper understanding and more lasting knowledge.
Knowledge sharing	Students compare their results with their preliminary guesses and formulate their experiences.
Reflections	Why are the preliminary suspicions and the experienced ones the same or different? Why don't the instruments sound? What could be improved in the construction of instruments?
Presentation	In small groups, they perform simple pieces of music with their own instruments, explaining the principles of their operation.
Productum	Different instruments. Documents. Video.
Redesign	Look for the faults that affect the way instruments make sounds.
Stations	
Natural science	Science involves thinking, observing, experimenting. It is important to formulate preliminary assumptions and share experiences. Tools: instruments, tablet, PC, notebook, pen
Research	Physics • discovering the basic phonetic relationships, determining the relationship between frequency and wavelength, • discovering connections through independent experimentation, • making sounds, observing pitch and pitch, • mastering wave concepts. Tools: instruments, books, tablet, computer, wave model.
Technology	Electronic devices: computer, tablet, smartphone, interactive whiteboard, digital camera. Tools at home: straw, pliers, plastic tubes, PET bottles, saw blade, drill, glue, tape, ruler, sandpaper.
Technical	Technical tools: pliers, saw, markers, pen, ruler, scissors, file.
Art and design	Art and design tools: glue, scissors, coloured paper. Music: playing instruments, making frequency changers.

Mathematics	Maths tools: calculator, ruler. Introducing fractions, proportional division of given lengths, calculating quantities from linear and inverse relationships.
Presentation	Tools: pen, sketch paper.
Experiences	After the project, you and the students will evaluate the project together, discuss your experiences and further ideas and plans. Recognise the links between the disciplines, formulate connections.
Appendix	**Video from** Homemade Instruments - How to make a PVC pipe overtone flute (YouTube) **Links** Funnel mouth instruments Ajaccio instruments Tamás Handbauer: Synthesis of trumpet sound a one-dimensional acoustic based on model **Summary** Discuss, confirm or refute predictions, preliminary questions. **Group work** Distribute preparation tasks in groups of 2-3 people. Dividing each task into groups. Preparation of the product (instrument, PPT, DOCX) in small groups. **Experiments** The vibration of the air makes an audible sound. Sounds follow mathematical rules. Finding ratios at different pitches.

2. Music Physics

STE(A)M-Areas	physics - mathematics - engineering - music - biology - technology
Intercultural relations	Musical styles. Making and using musical instruments. Musical affinity.

Summary table	
Subjects	physics
Topics	Phonetics. Astronomy. Particle physics.
Age of students	6-20 years
Lesson/project duration	8×45 min
Number of students	15-20 people
Online learning tools	Éva Mária Oláh: The Music of the Microcosm (YouTube) Éva Oláh: Music as physics or physics as music (YouTube) Kepler: Harmonices Mundi (YouTube) Kepler and the Music of the Spheres (YouTube)
Offline learning tools	Éva Oláh 2013. The music of the micro-world, or playing with strings. In András Juhász - Tamás Tél (eds.): *The meeting of physics, mathematics and art in education and research*. Budapest. 141-146. Éva Mária Oláh 2018. *Teaching particle physics in secondary schools. PhD thesis. Part III (Teaching the micro-world by musical analogies)*. Dr. Anett Nagy 2010. Musical instruments from "nowhere". *Nukleon*. III/56.
21st century competences	critical thinking - creativity - collaboration - communication - technological literacy - flexibility - leadership - initiative - productivity
Learning objectives	gaining scientific knowledge - deepening understanding of a subject (phonetics, astronomy) - helping to build learning communities - developing manual skills - developing abstraction - learning through play

Project plan	
The name of the exercise	Music Physics
The implementation process	
Question	What is called the music of the spheres? How long have we known musical instruments? Do you need basic maths skills to play music? What determines whether someone has a musical ear? Which of our organs help us hear?

		Can physicists play instruments? What are high and low notes? Who are the champions of hearing in the animal kingdom? Does our hearing range change with age? What do we mean by "music"? How do celestial bodies move? Particle physics or string theory? What are standing waves? What is the difference between a geocentric and a heliocentric world view? Do planets make sounds as they move? If planets made sounds as they moved, could they be heard in space? Does the pitch depend on the distance from the Sun? Does the sound range depend on the shape of the elliptical orbit?
	Inspiration	Collecting ideas from students. After working in groups, a joint discussion. Incorporating your own ideas and innovations into the project.
	Preparation	Purchase of materials (straws, pliers, paper rolls, jars, Coke bottles, wine glasses, plastic tubes, PET bottles, coloured cardboard, scissors, glue, coloured markers, rulers, string, wooden spoons, balloons, cans, wall slides, larynxes). Making "musical instruments". Drawing rainbow music. Choosing pieces of music.
	Presentation	**• Sound generator "hearing test"** **• Kepler: Introducing the Harmony of Worlds** **• Kepler's laws** **• Solar system model** **• The relationship between speed and frequency** **• Doppler effect** **• Musical larynx** In this chapter, we will use musical analogies to show that the planets of the Solar System move in their orbits according to Kepler's laws. Their distance from the Sun, the size of their orbits, their shape (eccentricity) and the resulting change in velocity determine the sounds that can be associated with their motion, so that we can use sound theory to better understand and explore the wonderful system in which our Earth is found. The farther a planet is from the Sun, the longer its period, i.e. the lower its frequency (rotational speed). In other words, the planet that is furthest away has the lowest frequency, and if we relate this to the frequencies of musical notes, then a low frequency means a low tone. As an example, we can show how the pitch of the sound is changed by manually rotating the so-called "stink pipe", which is one of the kitchen fittings, at varying speeds. Higher speeds are associated with higher frequencies, which result in higher sound output. The planets of the solar system, with the exception of Venus, orbit the Sun in elliptical orbits that differ from the circle in different ways, so that their distance from the Sun varies. The magnitude of the gravitational force acting on them also varies, which can only be

can be balanced by the planet moving faster or slower. This causes our planets to play different 'tunes' as they orbit the Sun. Students check the relationship between frequency and pitch by playing several instruments of their own making. Soda bottles filled with varying amounts of water are blown, plastic tubes cut to different sizes are tapped, and wavelengths and frequencies are determined by measuring the water and air columns. Through hands-on activities, involving students in artistic connections, they can gain more experiential and lasting knowledge.

1. Elementary parts, description of superstrings

Watching a video, discussing what you have seen.

2. Demonstrating the difference between longitudinal and transverse waves with a "straw wave machine"

Place straws on a long adhesive tape at evenly spaced intervals, perpendicular to the tape.
For an even better result, balls of clay can be placed at the end of the straws to make the periodic process last longer.

3. Wavelength and frequency of musical instruments

$c=\lambda \cdot f$ (where c is the speed of propagation of the sound wave in a given medium, λ is the length of the sound wave, and f is the frequency of the sound).
there is proportionality. In practice, this means that at longer wavelengths (longer air column, higher water column), the frequency is lower, which results in a lower musical sound.

4. Demonstration of standing waves on guitar

In the case of the guitar, the presentation of standing waves to produce basic and overtones. For wind instruments, by holding down the holes, we can change the wavelength and consequently the frequency.

5. "Music" tubes

The PVC pipes are sawn into pieces of the given lengths according to the table in Dr. Anett Nagy's article, and the ends are sanded. The rainbow sheet music (Pinterest) is marked with the same colour as the specific colours for the given notes.
By tapping the tubes against the palm of your hand, you get musical sounds by vibrating the air column in the tubes.

6. Paper cylinder "xylophone"

Paper rolls of aluminium foil are cut into different sizes, tied together with string, and sounded with a drumstick (wooden spoon) to vibrate the air column.

7. Mason jar "instrument"

You can collect different sizes of jars, but 1 litre jars are best. Different heights (digital tuner

), we mark the height of the water level with coloured stripes, as in the previous colour code. We make it sound with a wooden spoon, and by tapping the glass we also vibrate the water column inside.

8. PET bottle "instrument"

With this instrument, too, musical sounds are made by hitting the column of water with a wooden spoon (making it vibrate).

9. Coke bottle "instrument"

We pour water into traditional plastic soft drink bottles. We mark the water heights with coloured paper strips according to the colour code, so that you can pour the water out after use and next time it's easier to "tune".

10. Glass "organ"

By selecting the right glass wine glasses of different sizes and shapes, water is filled to a certain height and adjusted to the required musical notes using an online tuning whistle. The finger is slightly lubricated and the mouth of the glass is "stroked" in a circular motion, causing the finger to slide and sometimes to stick. This uneven friction causes the water columns in the cups to vibrate.

11. Straw "horn"

Plastic straws are flattened using pliers to make a whistle. Use the attached video to cut the ends to the shape you want. By blowing the straw, you get different pitches depending on the length (cut shorter and shorter with scissors). Here you can also see that by vibrating the air column, the shorter the straw (shorter the wavelength), the higher the pitch (higher the frequency).

12. Tin can "drum"

Cut and sand the tops off cans and attach a rubber band cut from a balloon and stretched with string to one of the openings. By vibrating the membrane (with a wooden rod), the air inside it is made to vibrate, producing a sound. We cannot tune the drum precisely, we use it as a rhythm instrument while playing music.

Forecasts	We cannot hear in a vacuum. The waves are reflected, they add up. Planets have no sound because of the lack of medium. The difference between the rotation and orbit of celestial bodies.
Design	Using household waste to make musical instruments and using these instruments to gain a deeper, more visual understanding of certain chapters of physics.
Discovery	The project is about using a discovery method to teach students about the laws of physics, and the hands-on mind-on method results in a deeper understanding and more lasting knowledge.
Knowledge sharing	Students compare their results with their preliminary guesses and formulate their experiences.

Reflections	Why are the preliminary suspicions and the experienced ones the same or different? Why do the instruments not sound? What could be improved in the construction of instruments?
Presentation	In small groups, t h e y perform simple pieces of music with their own instruments, explaining the principles of their operation.
Productum	Different instruments. Rainbow music. Documents. Video.
Redesign	Look for the faults that affect the way instruments make sounds.
Stations	
Natural science	Science involves thinking, observing, experimenting. It is important to formulate preliminary assumptions and share experiences. Matching the movement of the planets with sounds. Tools: musical instruments, tablet, PC, notebook, pen.
Research	Physics: • To learn and understand Kepler's laws of planetary motion. • An introduction to the dynamics of circular motion and the force of gravity. • The nature of mass attraction. • Discovering basic phonetic relationships, determining the relationship between frequency and wavelength. • Exploring connections through independent experimentation. • Making sounds, observing pitch and pitch. • Mastering wave theory concepts. Tools: instruments, books, tablet, computer, wave model.
Technology	Electronic devices: computer, tablet, smartphone, interactive whiteboard, digital camera. Tools in the home: straws, pliers, paper rolls, various bottles, cups, plastic tubes, PET bottles, coloured cardboard, scissors, glue, tape, coloured markers, rulers, string, wooden spoons, balloons, tins, wall tiles, laths, plasticine, plasticine, coloured paper.
Technical	Technical tools: pliers, saw, markers, pen, ruler, scissors, file.
Art and design	Art and design tools: glue, scissors, coloured paper. Music: notation of musical sounds, recognition of intervals, playing musical instruments. How can sound be represented? Turn sound ON (Pinterest) Spirituality (Pinterest) Frequency Painting: Ouroboros Cymatics - sound waves and vibration (Pinterest)

	Landfill Harmonic - the "Recycled Orchestra" Landfill Harmonic - the "Recycled Orchestra" (YouTube) There is a symphonic orchestra in Paraguay (Recycled Orchestra of Cateura), who made instruments out of garbage and performed with them in Los Angeles. A documentary film follows their lives. Landfill Harmonic Official Trailer 1 (2016) - Documentary (YouTube) Teaser of the upcoming documentary film "Landfill Harmonic" (YouTube)
Mathematics	Maths tools: calculator, ruler. Introducing fractions, proportional division of given lengths, calculating quantities from linear and inverse relationships.
Presentation	Tools: pen, sketch paper.
Appendix	**Video from** Music of the microcosm (YouTube) Éva Oláh: Music as physics or music as physics (YouTube) Kepler and the Music of the Spheres (YouTube) Street artist playing Hallelujah with crystal glasses (YouTube) The straw trick - How to make a whistle straw (YouTube) **Links** Dr. Anett Nagy 2010. Musical instruments from "nowhere". *Nukleon*. III/56. **Summary** Discuss, confirm or refute predictions, preliminary questions. **Group work** Distribute preparation tasks in groups of 2-3 people. Dividing each task into groups. Preparation of the product (instrument, PPT, DOCX) in small groups. **Experiments** Higher speeds result in higher sound. Air vibration produces an audible sound. Sounds follow mathematical rules.

3. Sounds - Noise and noise pollution

STE(A)M-Areas	maths - physics - biology - geography - computing - technology - art/music

Summary table	
Subjects	mathematics - physics - biology - geography - computer science - engineering - art - drawing
Topics	Sound, noise, noise pollution.
Age of students	12-14 years
Lesson/project duration	4×45 min project plan
Number of students	20-25 people
Online learning tools	Andrea Gróf - István Gärtner - Lászlóné Leitner - Mária Pető:Noise Pollution - Teaching aid The relationship between noise pollution and wave phenomena Multiple-choice exercises PhET simulator Péter Márkus: Noise protection (hearing)
Offline learning tools	Experimental equipment, simple materials from which to make measuring instruments. Tablet, PC, smartphone (with different audio applications), interactive whiteboard, projector. Textbooks (7-10), example books, reference books.
21st century competences	critical thinking - creativity - cooperation and communication - technical skills - initiative - creative work
Learning objectives	Introduction to the tools of scientific cognition-research, setting up and presenting simple research projects. Developing manual work skills, abstracting skills through playful learning and group work, and cooperative and communication skills. Developing a deeper understanding and knowledge of a given topic (phonetics, noise pollution). To do this, we are looking for answers to the following questions: how are sounds made? How are sounds created? What is the difference between ultrasound and infrasound? What are ultrasound and infrasound? The topics to be covered: • Noise pollution, noise nuisance • "Useful and useless" sounds • How can we protect ourselves against noise pollution?

Project plan	
The name of the exercise	Sounds - noise and noise pollution 1. Sounds in everyday life 2. "In a hundred years' time, we will have more problems with noise than with infectious diseases..." Robert Koch (German bacteriologist) 3. I'm making a mess. Noise pollution
The implementation process	
Arousing interest, preliminary questions	What questions we are trying to answer: • What sounds can you identify from the following recordings? What could be the source of the sounds in the previous cases (short sound clips without pictures)? • How are sounds made? What about noise? • Very loud sounds are usually distracting. Why? • How do animals "communicate", hear? • Why can you hear the movement of mosquito wings but not the flapping of butterfly wings, even if you see both at the same time? • Does our hearing range change with age? Why?
Preparations	Purchase of materials: straws, tweezers, rubber b a n d s , Bluetooth mobile phone, plastic bottles, coloured cardboard, scissors, glue, coloured felt-tip pens, rulers, string, balloons, metal strings, loudspeakers; phone apps, map of the municipality.
Processing and presentation of the topic	To learn about the sources of sound and noise in our environment and their impact on it, to study, measure, observe and process the effects on people and the environment. The topics to be presented: • **Sounds in everyday life** • **Noise. Noise pollution** • **"Useful and useless" sounds** **1. How can we create sounds?** **Introduction, repetition/system** **a)** E.g.: Do you recognise the instrument/instrument that made these sounds? By hitting or rubbing a solid body, or by blowing air into a cylindrical tube. Dabo - Tales of Goapan (Official Video) Handpan & Didgeridoo (YouTube) Crystal harp meditation (YouTube) Discover the Aeolian Drone Flutes at Singing Tree Flutes! (YouTube) Sela SE 203 Harmony Handpan F# Hijaz Stainless Steel (YouTube) Acme 446 Cuckoo Bird Call Whistle (YouTube) Bonus: Demo Waterphone (YouTube) Bolf Kalimbas: The kalimba story - When the forest is playing (YouTube) **b)** As you speak, place your palm gently on the back of your neck. (Slight vibration... Why?)

c) Stretch an elastic cord or a metal string between two fixed drawing pins, then blade it first with your finger and then with a blade. What do you notice? (You can hear the sound and see the vibration of the string.)

Introductory experiment

a) The "talking" balloon

You will need a small, half inflated balloon. How to work. Let the air out of the balloon slowly, gradually, while you keep shaping (opening, closing) the "neck" of the balloon with your fingers. How does the balloon "work"? What do you notice when air flows out of the balloon slowly or very quickly? What might be the physical explanation for the phenomenon you observe? How could you put this into practice?

The spread of sound. Watch the animations/simulations below and draw conclusions about the propagation, characteristics and perception of sound. PhET simulator

Compare the observations of the balloon experiment with what you learned in biology class (lungs, vocalization, vocal cords). What does the sound you hear depend on?

b) "Salt and rock" - the "visible voice"

For the experiment, you will need a balloon, a jar of rubber, a 2 litre (empty) plastic bottle, fine salt, scissors, a Bluetooth-enabled smartphone with internet connection, a small speaker.

How to use: cut the plastic bottle with a pair of scissors about 13-16 cm from the cap, then take the cap off the bottle and stretch a piece of the balloon (you can also use another elastic sheet or membrane) over it. You can fix the balloon to the "mouth" of the bottle with a rubber band or a tightly wound string.

Place the open part of the prepared bottle over the speaker, then connect your smartphone to the speaker. Sprinkle the fine salt over the stretched flexible membrane. Play rock music on your phone at varying volumes.

Pl. AC/DC - Highway to Hell (YouTube) The Doors - Break On Through (YouTube)

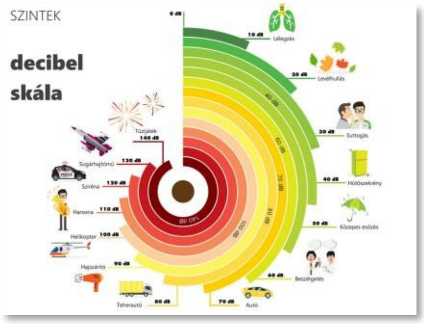
What do you observe? What is the tool you have made similar to? What lessons have you learned about it? Remember and tell us what you know about hearing.

c) How well can you hear the sounds?

Open the Physics Toolbox Sensor Suite app on your smartphone. From the app menu, select "Sound Generator", then "Sine Wave".

Slowly vary the frequency of the sound from the lowest to the highest, while listening for the frequency from which you hear the sounds and the upper limit of your hearing (the highest frequency). Carry out the measurement in class and compare the results. Why might there be differences? Does the range of frequencies you hear change when you turn the volume up to maximum? How do you explain the results? What conclusions can you draw from the experiments?

If you had done the above experiments with instruments, which instrument would you have used?



1. Figure

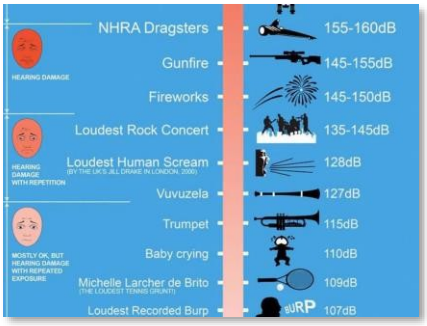


Figure 2.

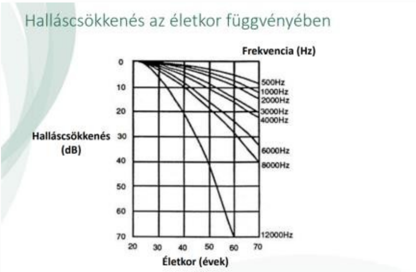
Posted on

Make a short presentation (video or presentation to show the class at the end of the topic).

Conclusions

Not all mechanical waves that reach our ears are perceived as sound, only those between about 20 and 20000 Hz. Very low frequency (infrasound) or very high frequency (ultrasound) waves are not audible.

The sensitivity of the ear to sound is not the same for all people and is age-dependent (Figure 3).



3. Figure

Voice - interesting facts from around the world

4. Figure 1. Singing Ringing Tree, Burnley
[The Singing Ringing Tree, Burnley, Lancashire, England (YouTube)]

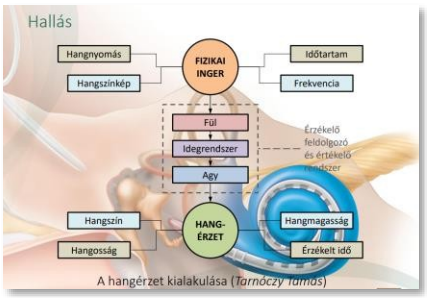
5. Figure 1. Singing Christmas Tree in Zurich
[The Singing Christmas Tree Zurich (YouTube) The Singing Christmas Tree in Zurich (YouTube)]

6. Figure 1. Aeolus Acoustic Wind Pavilion
[Aeolus at The Eden Project - Acustic Wind Pavilion (YouTube)]

Why are the above examples special? Have you seen or heard of similar structures, buildings or natural phenomena?

2. Application - biology/anatomy

The brain uses the differences in the timing and intensity of the sounds perceived by the two ears to determine the direction of the sound coming to it and the location of the sound source.



7. Figure

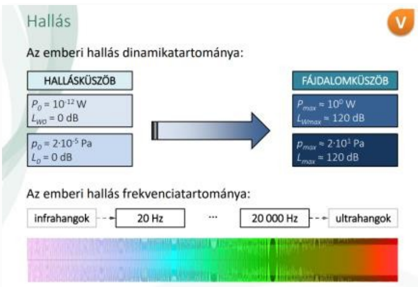


Figure 8.

In medicine, ultrasound imaging is based on the phenomenon of sound reflection, which allows images of internal organs to be visualised on a display connected to the device.

Figure 9.

Figure 10.

Posted on

In small groups, discuss the practical applications and make short (5-8 slides) presentations about them.

Acoustics/music

In large auditoriums, sound can reverberate off the walls several times, creating a mixture of sounds that can be heard even when the original sound source is no longer emitting sound; this phenomenon is called reverberation (the persistence of sound in acoustics after it has been created). To avoid this, auditoriums are specially designed, with seats and floors covered with velvet material that absorbs sound.

3. The noise

Noise is caused by the non-periodic vibrations of sound sources. Because the frequency of these vibrations is constantly changing, noise has no fixed height. Loud noises are disturbing, so we try to cover our ears (e.g. the sound of an earthquake: The sound of the Japanese earthquake [Videa]).

Have you ever heard of such a thing? Can you recognize the sound if you can't see the source?

Music for earthquakes (2011) (excerpt) (SoundCloud)
Strange sounds (Source: European Space Agency [SoundCloud]) The scary sound of Earth's magnetic field (SoundCloud)
The sound of the wind from space (SoundCloud)

Have you ever listened to this? How do you explain it?

The loudest animal in the world is the blue whale, which can emit sounds up to 188 dB.

11. Figure

Tone of voice, like fingerprints, is a unique characteristic of each individual. This is used by a number of security devices that use the tone of voice as a "voice print". The more harmonics in a sound (richer the sound spectrum), the more melodious it is. It is enough to hear a sound to recognise the instrument that created it.

During a rock concert, the loudness can reach 115 dB. Too loud sounds can cause pain. The pain threshold is the volume at which pain is felt in the ear. Sustained loud sounds (above 90 to 95 dB) can cause hearing loss.

12. Figure

I'm going crazy

The damaging effects of noise depend on its intensity, pitch, duration, temporal distribution, gender and age, individual hearing sensitivity, etc.
The adverse effects of noise pollution: weakening or deterioration of the hearing organ as a result; cumulative adverse effects on the brain and nervous system (those who live in a long-term noise-polluted environment are at increased risk of heart attacks and damage to the nervous system).

13. Figure

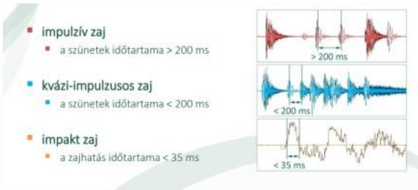


Figure 14.

Examples of such effects for sustained, prolonged noise levels:

- 40-60 dB: mild disturbances: loss of concentration, increased feeling of fatigue
- 65-75 dB: mild vegetative disturbances: blood pressure problems, increased metabolism, etc.
- Above 75 dB: hearing loss is noticeable, headaches, insomnia, tinnitus are common, low frequencies are difficult or impossible to hear, sometimes even higher frequencies are difficult to hear 120-130 decibels permanent hearing loss

Medical observations have shown that physiological damage caused by noise is only detectable after a long period of time, when it is difficult to establish a link between noise and damage. Noise-induced permanent hearing loss cannot be cured, prevention is the key.

Figure 15.

Task (in groups of 2-3)

Map your city, your residential areas and then mark the noisiest and quietest districts/places on a map. Find the sources of noise that cause the most noise pollution. Present your results to the class in the form of a poster or a presentation!

How can you measure noise levels to make the presentation credible? For example, you can use these apps you can download on your smartphone:

a) Physics Toolbox Sensor Suite
b) Sound Meter - Noise meter (Android and iPhone mobile)
c) Decibel Meter - Measure the sound around you with ease

Posted on

Observe the impact of environmental noise pollution on the animals in the area where you live (document it and show it to your peers, if available).

Planning/ research

Digital measurement methods for determining noise levels.
Methods of noise reduction.
Sound insulation options; solutions for everyday life.

Exploratory questions/ research topics

How is a sonic boom created? Is it a one-off, momentary phenomenon or does it accompany the aircraft continuously?
Can the pilot of the plane hear the sonic boom? How can you hear the sound of a bat or a dolphin?

Presentation materials

Making a poster - Noise, noise pollution

Find a clever, eye-catching title for the poster! Size: A1 or A0 - scientific poster type.

Ideas for the poster

- Self-made photos, videos, drawings of noise sources.
- How can we reduce noise pollution: at home, in the classroom, in our environment, in nature, etc.?
- How does noise affect restful sleep/learning?
- What role does vegetation play in reducing noise pollution?
- Rock concert and noise pollution etc.
- The harmful effects of noise on health.
- How noisy is the city/town where you live? Noise map of your neighbourhood.

	Presentation/Canva presentation/poster or video in class, in which the ways of noise pollution and noise generation are presented and explained to the students.
Results	Studies in PDF or Word format; PPT, Prezi, Canva or video presentations, posters.

Subject links

Natural science	Physics: mechanical waves, sound, earthquakes; properties of matter; sources of waves, ways to reduce noise pollution, solutions. Research: exploring connections through independent experimentation. Sound production, observation of pitch, pitch, pitch, auditory sensitivity. Experimental demonstrations to deepen knowledge. Recognition of noise and noise pollution. Reducing noise pollution in everyday life. Biology: the physiology of hearing; sounds and noises in the animal kingdom; how do animals communicate?
Geography	Earthquake generation and accompanying noise. Sounds in the universe, waves created by solar activity. Map - sources of noise where we live, earth stations.
Appendix	**Theoretical background and collection of videos** Greatest Classic Rock Songs Of All Time | Best Classic Rock Songs Playlist (YouTube) The sound of the Japanese earthquake (Video) Learning Resources (NASA) Vibrations **Points of interest** The Singing Ringing Tree, Burnley, Lancashire, England (YouTube) Discover the Aeolian Drone Flutes at Singing Tree Flutes! (YouTube) Aeolus at The Eden Project - Acustic Wind Pavilion (YouTube) Music for earthquakes (2011) (excerpt) (SoundCloud) **Art** Noise pollution drawing / Stop noise pollution drawing / Noise pollution poster (YouTube) 12 special instruments with unique, magical sounds **Phone apps for measurement** Sound Meter Decibel Meter **Source of images** Miklós Márkus: Noise protection (Sound and vibration) Singing Christmas Tree Zurich at Werdmühleplatz Aeolus Acoustic Wind Pavilion (Wikipedia) Miklós Márkus: Noise and vibration protection (Hearing) 4D Ultrasound Diagnostic Centre Golden Clinic NOAA Photo Library, sanc0112 Pixnio The impact of noise on health

4. Noise and noise pollution

STE(A)M-Areas	maths - physics - biology - geography - computing - technology - art/music

Summary table	
Subjects	mathematics - physics - biology - geography - computer science - engineering - art - drawing
Topics	Sound, noise, noise pollution.
Age of students	15-18 years
Lesson/project duration	4×45 minutes Project plan
Number of students	20-25 people
Online learning tools	Andrea Gróf - István Gärtner - Lászlóné Leitner - Mária Pető:Noise Pollution - Teaching aid The relationship between noise pollution and wave phenomena Multiple-choice exercises Juhász András - Tasnádi Péter - Wiener Csilla - Gócz Éva 2021. *physics Teaching in secondary schools II.* PhET simulator Péter Márkus: Noise protection (hearing)
Offline learning tools	Experimental equipment, simple materials from which to make measuring instruments. Tablet, PC, smartphone with various audio applications, interactive whiteboard, projector. Textbooks (9-11), example books, reference books.
21st century competences	critical thinking - creativity - cooperation and communication - technical skills - initiative - creative work
Learning objectives	Introduction to the tools of scientific cognition-research, setting up and presenting simple research projects. Developing manual work skills, abstracting skills through playful learning and group work, and cooperative and communication skills. Developing a deeper understanding and knowledge of a given topic (phonetics, noise pollution). We are looking for answers to the following questions: What is the difference between sound and noise? Ultra and infrasound, what do they mean? Can sounds be made "visible"? The topics to be covered: • Noise pollution, noise nuisance • Noise and society • How can we protect ourselves against noise pollution?

Project plan

The name of the exercise

Noise and noise pollution

1. "In a hundred years' time, we will have more problems with noise than with infectious diseases..." Robert Koch (German bacteriologist)
2. I'm making a mess. Noise pollution
3. Disorder and social development

The implementation process

Arousing interest, preliminary questions

What questions we are trying to answer:

- What sounds can you identify from the following recordings? What could be the source of the sounds in the previous cases (short sound clips without pictures)?
- How are sounds made? What about noise?
- Very loud sounds are usually distracting. Why?
- How do animals "communicate", hear?
- Does our hearing range change with age? Why?

Preparations

Purchase of materials: plastic wrap, Bluetooth mobile phone, plastic bottles, scissors, glue, coloured markers, ruler, string, balloon, metal string, loudspeaker; phone apps, map of the municipality.

Processing and presentation of the topic

To learn about the sources of sound and noise in our environment and their impact on it, to study, measure, observe and process the effects on people and the environment.

The topics to be presented:

- **Noise. Noise pollution**
- **"Useful and useless" sounds**

1. How can we create sounds?

Introduction, repetition/system

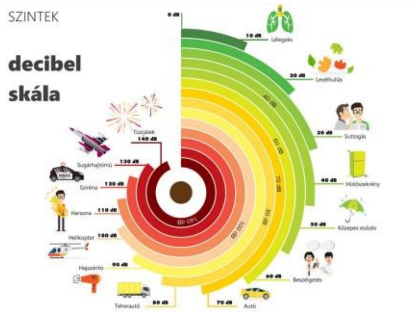
a) E.g.: Do you recognise the instrument/instrument that made these sounds? By hitting or rubbing a solid body, or by blowing air into a cylindrical tube.
Dabo - Tales of Goapan (Official Video) Handpan & Didgeridoo (YouTube)
Crystal harp meditation (YouTube)
Discover the Aeolian Drone Flutes at Singing Tree Flutes! (YouTube) Sela SE 203 Harmony Handpan F# Hijaz Stainless Steel (YouTube) Acme 446 Cuckoo Bird Call Whistle (YouTube)
Bonus: Demo Waterphone (YouTube)
Bolf Kalimbas: The kalimba story - When the forest is playing (YouTube)

The spread of sound. Watch the animations/simulations below and draw conclusions about the propagation, characteristics and perception of sound. PhET simulator

b) "Sand and rock music" - the "visible voice"
For the experiment, you will need a balloon, a jar of rubber, a 2 litre (empty) plastic bottle, fine-grained sand or salt,

scissors, a smartphone with Bluetooth and internet connection, a small speaker.
How to use: cut the plastic bottle with a pair of scissors about 13-16 cm from the cap, then take the cap off the bottle and stretch a piece of the balloon (you can also use another elastic sheet or membrane) over it. You can fix the balloon to the "mouth" of the bottle with a rubber band or a tightly wound string.
Place the open part of the bottle over the speaker, then connect your smartphone to the speaker. Sprinkle the fine salt over the stretched-out flexible membrane. On your phone, play rock music at varying volumes.
You can also do the experiment by stretching a piece of flexible film (a cut-up balloon) over a picture frame and then sprinkling fine-grained sand on top. Place the speaker under the flexible sheet and turn on the music.
Pl. AC/DC - Highway to Hell (YouTube) The Doors - Break On Through (YouTube)

c) How well can you hear the sounds?
Open the Physics Toolbox Sensor Suite app on your smartphone. From the app menu, select "Sound Generator", then "Sine Wave".
Slowly vary the frequency of the sound from the lowest to the highest, while listening for the frequency from which you hear the sounds and the upper limit of your hearing (the highest frequency). Carry out the measurement in class and compare the results. Why might there be differences? Does the range of frequencies you hear change when you turn the volume up to maximum? How do you explain the results? What conclusions can you draw from the experiments?



1. Figure

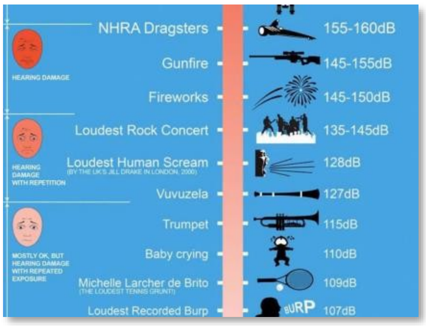
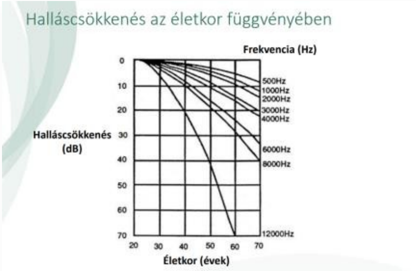


Figure 2.

Posted on
Make a short presentation (video or presentation to show the class at the end of the topic).

Conclusions
Not all mechanical waves that reach our ears are perceived as sound, only those between about 20 and 20000 Hz. Very low frequency (infrasound) or very high frequency (ultrasound) waves are not audible.

The sensitivity of the ear to sound is not the same for all people and is age-dependent (Figure 3).



3. Figure

Sound propagation - interesting facts from around the world

4. Figure 1. Singing Ringing Tree, Burnley
[The Singing Ringing Tree, Burnley, Lancashire, England (YouTube)]

5. Figure 1. Aeolus Acoustic Wind Pavilion
[Aeolus at The Eden Project - Acustic Wind Pavilion (YouTube)]

Posted on

In small groups, discuss the practical applications of sound waves and prepare short (5-8 slides) presentations on them (medical, technical, etc.).

2. The noise

Noise is caused by the non-periodic vibrations of sound sources. Because the frequency of these vibrations is constantly changing, noise has no fixed height. Loud noises are disturbing, so we try to cover our ears (e.g. the sound of an earthquake: The sound of the Japanese earthquake [Videa]).

Have you ever heard of such a thing? Can you recognize the sound if you can't see the source? For example: do you recognise what made that sound? Music for earthquakes (2011) (excerpt) (SoundCloud)

Strange sounds (Source: European Space Agency [SoundCloud]) The scary sound of Earth's magnetic field (SoundCloud)
The sound of the wind from space (SoundCloud)

During a rock concert, the loudness can reach 115 dB. Too loud sounds can cause pain. The pain threshold is the volume at which pain is felt in the ear. Sustained loud sounds (above 90-95 dB) can cause hearing loss.

6. Figure

I'm going crazy

The damaging effects of noise depend on its intensity, the pitch of the sound, its duration, its temporal distribution, the sex and age of the person, individual hearing sensitivity, etc.
Consequence: weakening and deterioration of the auditory system as a result; cumulative adverse effects on the brain and nervous system (those who live in a permanently noise-polluted environment are at increased risk of heart attacks and damage to the nervous system).

7. Figure

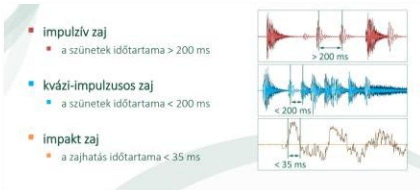


Figure 8.

Posted on

Look for information on the effects of prolonged noise and sounds on people!

Medical observations have shown that physiological damage caused by noise is only detectable after a long period of time, when it is difficult to establish a link between noise and damage. Noise-induced permanent hearing loss cannot be cured, prevention is the key.

Figure 9.

3. Disaster - industrial development, the relationship between human societies

The main sources of noise pollution from transport sources (road, rail or air) are related to economic activities (EU report: Environmental noise in Europe - 2020).

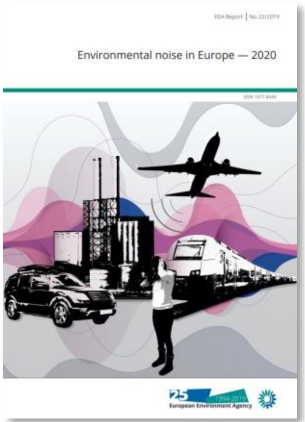


Figure 10.

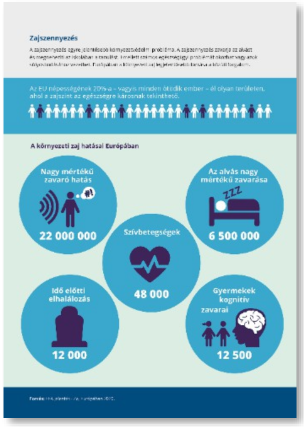


Figure 11.

Comparative study (countries with different levels of industrial development)

What conclusions can you draw from the graphs (social, economic characteristics - noise pollution)?

Noise pollution in Romania and Austria:

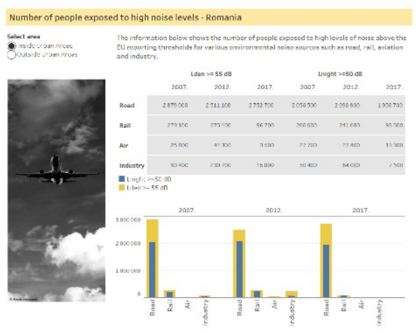


Figure 12.

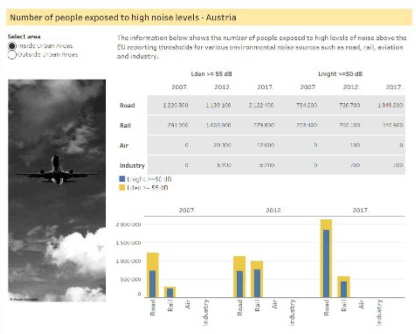


Figure 13

Additional explanation to the interpretation of the graphs: noise exposure to the population is monitored on the basis of two reporting thresholds: one is the all-day noise indicator (Lden, or day-night noise indicator), which measures "nuisance" noise levels, and the other is the night-time noise indicator (Lnight, or night-time noise indicator), which measures sleep disturbance (EU directives).

Quiet areas in Europe - The environment unaffected by noise pollution.

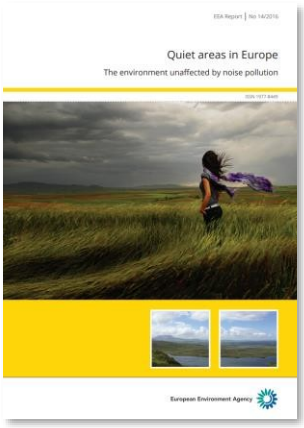


Figure 14.

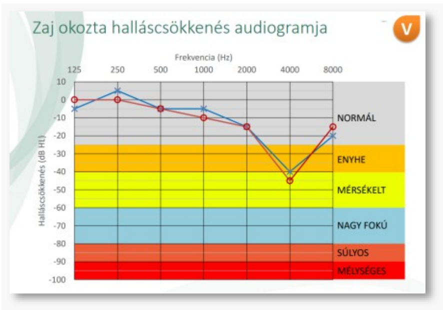


Figure 15.

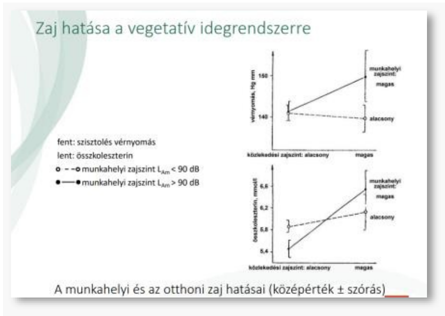
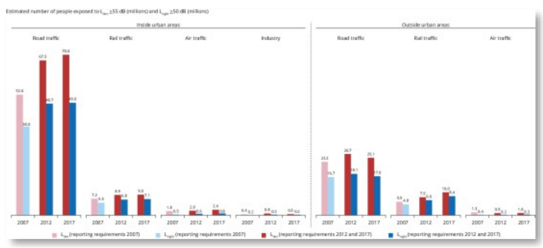


Figure 16



17. Figure

Task (in groups of 2-3)

Map your city, your residential areas and then mark the noisiest and quietest districts/places on a map. Find the noise sources that cause the most noise pollution. Present your results to the class in the form of a poster or a presentation!

How can you measure noise levels to make the presentation credible? For example, you can use these apps you can download on your smartphone:

a) Physics Toolbox Sensor Suite
b) Sound Meter - Noise meter (Android and iPhone mobile)
c) Decibel Meter - Measure the sound around you with ease

Sources of noise pollution: airports, road and rail traffic, wind turbines, construction sites, heavy machinery, open/closed industrial noise sources, metalworking, outdoor concerts, etc.

What is Noise Pollution?| Sources of Noise Pollution| Letstute (YouTube).

18. Figure

Based on a European survey (Environmental noise in Europe - 2020): measurements show that road transport is the main source of noise pollution.

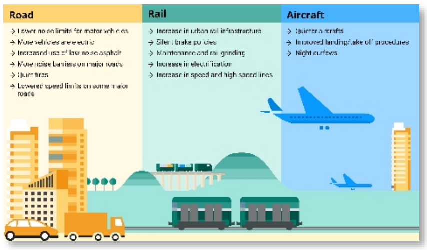
- 65% of Europe's population is exposed to noise levels of 55 dB per day - causing sleep disturbance.
- 17% of Europe's population is exposed to an average noise level of 65 dB, which is already causing detectable damage.
- 1.4% of the European population is exposed to noise levels above 75 dB, which is above the health limit.

Options for reducing noise pollution (active, passive):

- the elimination of noise sources,
- reducing noise already near the noise source,
- soundproofing of workplaces,
- design and use of special protective equipment, sound absorbing procedures/devices.

Acoustics/music

In large auditoriums, sound can reverberate off the walls several times, creating a mixture of sounds that can be heard even when the original sound source is no longer emitting sound; this phenomenon is called reverberation (the persistence of sound in acoustics after it has been created). To avoid this, auditoriums are specially designed, with seats and floors covered with velvet material that absorbs sound.



19. Figure

Figure 20.

How can we protect ourselves and our environment from noise pollution caused by industrial and economic activities?

Ideas Exchange

Suggest solutions that would help to reduce noise pollution in your immediate environment (classroom, school, housing estate, train station, motorway, etc.).

Solutions currently in use in the world

a) Sound barriers along roadsides and sound reflecting surface

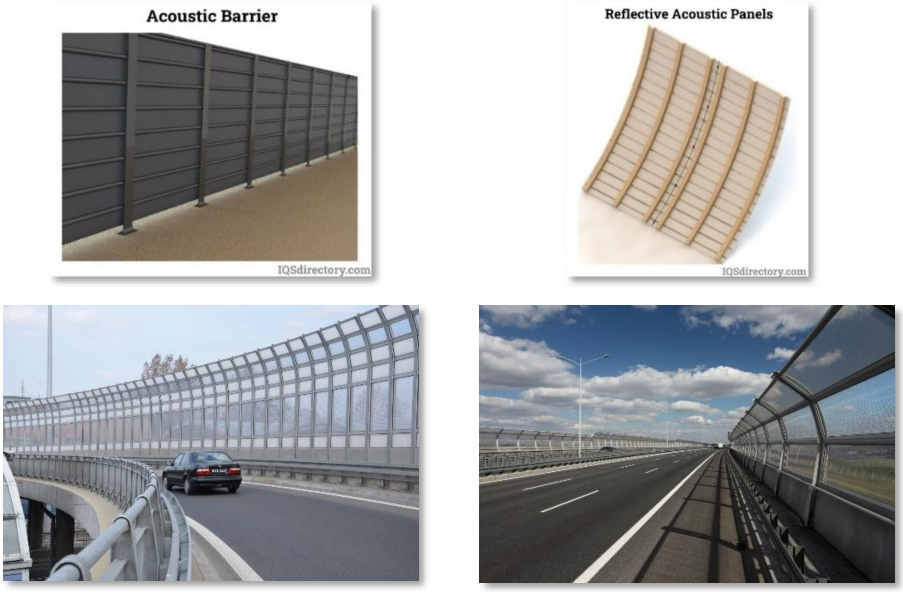


Figure 21.

b) Helmet swallowing solutions

Figure 22.

c) Natural noise reduction

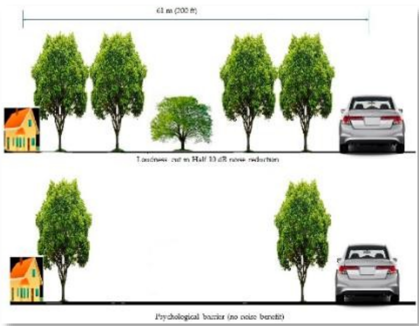


Figure 23.

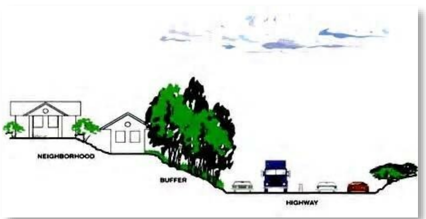
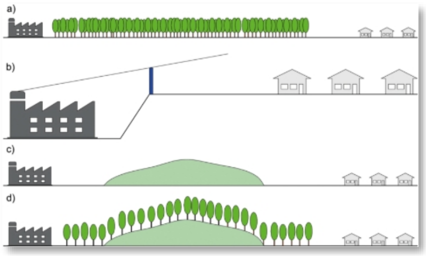


Figure 24



25. Figure

Noise pollution and wildlife

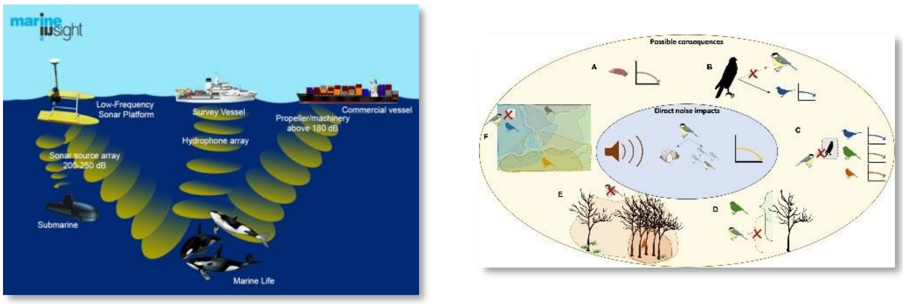
Sustained strong sound effects, noise affects not only humans but also animals. It can alter communication between animals, alter the routes of migratory birds, and reduce the reproduction and survival of animals.

"For animals, the perception of different sounds is key to their survival, their hearing is usually much more refined and sensitive than humans', so they are more responsive to noise. The effects of noise can also cause hearing loss in animals directly, as well as indirectly affecting their behaviour, reproduction and feeding."

[EMLA Foundation for Environmental Education: industrial and legal, technical the prevention and reduction of transport noiseand economic instruments for]

26. Figure

[Technology for a Peaceful Ocean: How Hanwha Ocean is Innovating to Reduce Underwater Noise (YouTube)]



27. Figure

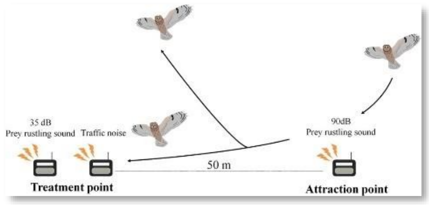


Figure 28.

Posted on

Have you encountered the cases described above? Where?
Observe the impact of environmental noise pollution on the animals in the area where you live (document it and show it to your peers, if available).

Planning/ research	The relationship between sound, noise and human society. Why are noise levels in our environment increasing? Measurement methods to determine noise levels. Methods to reduce noise. Background noise measurement. Measuring sound speed and volume. Examination of the dependence of loudness, loudness level on distance. Sound insulation options; solutions in everyday life.
Exploratory questions/ research topics	How is a sonic boom created? Can the pilot of the plane hear the sonic boom? How are fauna and flora affected by increasing loudness and noise?
Presentation materials	**Making a poster - Noise, noise pollution** Find a clever, eye-catching title for the poster! Size: A1 or A0 - scientific poster type. **Ideas for the poster** • Self-made photos, videos, drawings of noise sources. • How do they work, how effective are they? • How can we reduce noise pollution: in the classroom, in our environment, in nature, etc.? • How does noise affect restful sleep? • What role does vegetation play in reducing noise pollution? • Rock concert and noise pollution etc. • The harmful effects of noise on health. • How noisy is the city/town where you live? Noise map of your neighbourhood. Presentation/Canva presentation/poster or video in class, in which the ways of noise pollution and noise generation are presented and explained to the students.
Results	Studies in PDF or Word format; PPT, Prezi, Canva or video presentations, posters.

Subject links

Natural science	Physics: mechanical waves, sound, earthquakes; properties of matter; sources of waves, ways to reduce noise pollution, solutions. Research: exploring connections through independent research tasks. Sound production, pitch, pitch observation, loudness, auditory sensitivity. Recognition of noise and noise pollution. Reducing noise pollution in everyday life.
Geography	Earthquakes: the generation of sound waves and noise when tectonic plates move. Discussion of economic geography, population geography: the relationship between industrial development and noise.
Mathematics/ physics	Simple problems using logarithms, ratios, powers. Graph making and interpretation.
Appendix	**Theoretical Background and Videos** The Sound of the Japanese Earthquake (Video) Safety Engineer Lectures Learning Resources (NASA) Noise Control Products: Features and Benefits What is Noise Pollution?| Sources of Noise Pollution| Letstute (YouTube) Sela SE 203 Harmony Handpan F# Hijaz Stainless Steel (YouTube) Vibrations **Points of interest** Discover the Aeolian Drone Flutes at Singing Tree Flutes! (YouTube) Aeolus at The Eden Project - Acustic Wind Pavilion (YouTube) Underwater noise pollution has a significant impact on lives of marine animals theNoise from road and rail traffic increases the Alzheimer's disease risk of (Qubit) Music for earthquakes (2011) (excerpt) (Soundcloud) **Art** Noise Pollution Drawing/ Stop Noise Pollution Drawing/ Noise Pollution Poster (YouTube) 12 special instruments with unique, magical sounds **Phone apps for measurement** Physics Toolbox Sensor Suite Sound Meter - Sound Level Meter (Android and iPhone mobile) Decibel Meter - Measure the sound around you with ease Sound Meter **Summary** EU documents and directives on the subject Noise pollution is a major problem for both human health and the environment (EEA) **Source of images** Miklós Márkus: Noise Protection (Vibration and Acoustics) Aeolus Acoustic Wind Pavilion (Wikipedia)

Pixnio
Miklós Márkus:Noise and vibration protection
(Hearing) The impact of noise on health
Noise (EEA)
SOER 2020 Report Chapter 11 on environmental noise Do we notice the noise around us?
Values based on health guidelines (Viktor Balázsi 2021. *The impact of noise on health*.)
Noise Barrier Singapore: The Best Option for a Peaceful Environment
MD Ohiduzzaman - Okan Sirin - Emad Kassem - Judith L. Rochat: State-of- the-Art Review on Sustainable Design and Construction of Quieter Pavements - Part 1: Traffic Noise Measurement and Abatement Techniques Fig 4 - uploaded by Hossein Mehravaran
Figure - available from: Current Pollution Reports Infographic: Underwater Noise From Ships
Noise Rigorous Pollution Ocean
How chronic anthropogenic noise can affect wildlife communities Traffic noise reduces foraging efficiency in wild owls

5. Discover the light!

STE(A)M-Areas	natural sciences - technology - engineering - mathematics

Summary table	
Subjects	physics - mathematics - digital culture
Topics	Reflection, refraction, refractive index, colour formation, colour spectrum, angle calculations, wavelength, frequency, speed of light.
Age of students	10-18 years
Lesson/project duration	3×45 minutes
Number of students	20-25 people
Online learning tools	PhET simulations (light spectrum and refraction), tutorial videos Colour palette, colour mixing Color conversion RGB to CMYK colour conversion
Offline learning tools	prism - mirror - 1-2 laser pointers or flashlights - 3 glasses - oil - water - 1 transparent plastic sheet - 3 transparent plastic bowls - paper - marker pen
21st century competences	communication - cooperation - teamwork - creativity - innovation - critical thinking - problem solving
Learning objectives	Understanding the physical properties of light. Developing the use of digital tools in the learning process.

Project plan	
The name of the exercise	Discover the light!
The implementation process	
	I. Introductory lesson: Reflection and refraction of light
Arousing interest, preliminary questions	Why does the light break? How are colours created? How does the direction of light change as it passes through different materials? What does the refraction of light depend on?
Preparations	Equipment: prism, mirror, 1-2 laser pointers or flashlights, 3 glasses, oil, water, 1 transparent plastic sheet, 3 transparent plastic bowls, paper, preparation of marker pen.
Presentation	Forming groups (3-5 people), assigning tasks. Students carry out experiments based on the annex.

	Aim: to get students interested in refraction and related phenomena.
Preliminary assumptions	Aim: to activate students' prior knowledge and make them think about the reasons behind the phenomenon. Open questions for students to answer in experiments.
Method of discovery	Students actively and independently discover phenomena through experimentation. Description of how the experiments are carried out Measurement accuracy: e.g. measuring the angle of incidence and refraction with a protractor. Recording observations: e.g. making notes, diagrams of the path of light.
Experiences, knowledge sharing	Students compare their results with their preliminary guesses and formulate their experiences. What was unexpected or surprising for them?
Feedback	Joint evaluation: what worked well in the experiments? What problems or challenges did you encounter? What would they do differently next time?
Presentatio n materials	Notes, measurement results, photos of the experiments. Results of data collection in the form of tables or graphs.
Results	Experiments have found that light is refracted differently in different materials (e.g. more in water than in air). Using prisms, students created a colour spectrum and understood that colours come from the different refraction of light at different wavelengths. In the study of optical illusions, they have seen how refraction changes the apparent shape or position of objects.
Critical thinking	Why is knowledge of refraction important in engineering? Why does light refract differently on different materials? How can refraction be used in everyday life (e.g. spectacle lenses, microscopes, telescopes)?
Presentation	10-minute presentation per group: introduction: what have you studied? Presentation of the experiment: tools, layout, steps. Results: what have you experienced and what conclusions do you draw? What were their most interesting or unexpected observations? The presentation is complemented by visual material (e.g. diagrams, photographs).
Productum	Posters or digital presentations: summarise the experiments, results and conclusions of the group. Videos: experiments in progress, recording refraction phenomena. Model: a simple optical model (e.g. with prisms or mirrors) that illustrates the phenomena being studied. Notes and data: notes and calculations related to the experiments carried out and shared with the class.

	II. The colour spectrum and the origin of colours
Arousing interest, preliminary questions	Why does a prism split white light into different colours? What determines what colour we see reflected from a given material? How does light behave in contact with different materials?
Preparations	Prism, blue and green colour filters, other colour filters, coloured paper, flashlight, laptop.
Presentation	The teacher briefly demonstrates (using a prism) that white light is made up of colours of different wavelengths. This can be demonstrated using a prism, where white light is broken down into colours. The principle of how colours are created (the wavelength of light determines the colour) is highlighted. The demonstration can include a video or picture of the colour spectrum.
Preliminary assumptions	Is white light really a set of colours? If so, how can these colours be distinguished? What colours do students expect when white light is refracted through a prism (red, orange, lemon yellow, etc.)? Do you think that the order of the colours will always be the same? Why?
Method of discovery	**1. Conduct experiments** Students use prisms to break white light into colours. They experiment with colour filters to see which colours disappear or remain. They try to create different colour combinations by combining coloured paper and colour filters. **2. Recording observations** Describe the order of the colours (e.g. red, orange, yellow...). Document how each colour filter changes the spectrum.
Experiences, knowledge sharing	Students will recognise that a prism diffracts light because different wavelengths of light refract light differently. They understand that colour filters only transmit certain wavelengths of light. They discover how mixing colours can lead to new shades.
Feedback	Which experiment was the most spectacular? Why? Why do some colour filters work differently than expected? How can understanding how colours are created be applied in everyday life?
Presentation materials	Photos of the colour spectrum created by the prism. Notes and drawings of the experimental set-up and results. Graphs illustrating the effect of colour filters on the spectrum of light.
Results	The students understood the principle of the colour spectrum and experienced the practical application of refraction. They have identified how different wavelengths of light refract differently.

	They learned how to manipulate the appearance of colours using colour filters and different light sources.
Critical thinking	How is the colour spectrum used in modern technologies such as monitors, projectors or theatre lighting design? Why are different wavelengths of light needed in scientific research (e.g. spectroscopy, medical imaging)? How does the perception of colour vary across cultures and environmental conditions?
Presentation	Group presentation Demonstration of experimental set-up (e.g. how the prism-light source combination was set up). Share photos, drawings and notes on the results. Explaining the colour spectrum and showing the effect of colour filters. Making a poster or digital presentation: summarising the results with striking visual elements.
Productum	Photos or drawings of the experiments and results. A colour scale diagram showing the effect of colour filters on the spectrum of light. A short video or slide presentation summarising the experiments and lessons learned. A common blackboard on which each group records the observations and conclusions of their experiments.
	III. Mathematics and physics of colours
Arousing interest, preliminary questions	The teacher shows a colourful rainbow picture and asks the question: "Why do we see the rainbow in different colours?"
Preparations	Before the lesson, the teacher prepares the necessary equipment: RGB LEDs, colour filters, prism, computer colour simulator. Download the Physics Toolbox Sensor Suite colour generator app.
Presentation	The teacher explains that colours represent different wavelengths of light (e.g. red: 620-750 nm). A brief introduction to RGB and CMYK colour models: how can colours be mixed in different proportions? Examples: colour spectrum images, colour mixing models
Preliminary assumptions	How are colours created? Why do we see different colours? How is wavelength related to colour perception? What primary colours are needed to create other colours? How can primary colours (e.g. red, green, blue) be mixed to create new colours?
Method of discovery	Experiments 1. Mixing coloured lights with RGB LEDs: watch how white light is created. 2. Effect of colour filters on different coloured lights: which colours are transmitted or absorbed? 3. Examination of graphic colour models using computer simulation (e.g. online RGB simulator).

Experiences, knowledge sharing	Students observe that with the RGB model, the white colour is created by mixing the three primary colours. In the CMYK model, the black colour is a combination of pigments. Different colour filters absorb light at a certain wavelength and only let the colour of the filter pass through.
Feedback	Which colour model was the easiest to understand? What difficulties were encountered in the colour mixing experiments? How can this knowledge be used in everyday life (e.g. printing, digital design)?
Presentatio n materials	Notes on colour wavelengths and how colour models work. Photos of experimental results (e.g. RGB, CMYK colour mixing, effect of colour filters). Colour mixing tables and graphs.
Results	Students understand that the differences in the wavelengths of colours make up the colour spectrum. Be able to explain the basics of RGB and CMYK colour models. They recognise how these models can be used in digital technology and printing.
Critical thinking	How do we use colour in industry and technology (e.g. monitors, printers)? How does the biological function of the eye affect colour perception? Why are different colour models needed in practice?
Presentation	Presentation of graphs, colour charts and notes. Brief description of online colour model simulations.
Productum	A colour scale or colour mixing table based on experimental results. Notes on the experiments, diagrams of how the colour models work.

Subject links

Natural science	Physics: • Reflection, refraction, colour formation. • Demonstration of refraction with a prism. • The nature of light (wave and particle properties). Demonstration of refraction using prisms, reflection using mirrors. • Colour spectrum formation, wavelength and frequency relationship.
Digital culture	Data collection results in the form of tables or graphs. Use online optical simulations to model refraction and colour spectrum.
Mathematics	Refracted angle calculation: perform simple geometric calculations to determine the angle of incidence and refraction of light. Study RGB colour model, calculate the mixing ratio of colours.
Appendix	*Annex: I. introductory lesson* Tasks of the groups *Annex: lesson II* 1. Presentation 2. Tasks of the groups *Annex: lesson III*

Annex: introductory lesson

Group work:

1. Group 2: Investigating refraction using water and glass Aim: To observe the difference in refraction between water and glass. **Experiment procedure:**

1. Put clean water in a glass beaker and an empty glass next to it.
2. Position the light source (flashlight or laser pointer) so that it shines at an angle into the glasses.
3. Observe how light is refracted in an empty glass (refractive index of glass) and how it is refracted in a glass full of water.
4. Make a note of which material bends light and to what extent.

2. Group 3: Refraction by angles (glass prism)

Aim: To study the angle of refraction caused by a prism at different angles of incidence.

Experiment procedure:

1. Place a prism on the white sheet of paper.
2. Point a flashlight at different angles (30°, 45°, 60°) to one side of the prism.
3. Notice how the direction and angle of refraction changes inside and outside the prism.
4. Note the angular values and the direction of the light (e.g. draw it).

Discussion:

- What angle was the light bending inside the prism?
- How does the amount of refraction change with increasing angle of incidence?

3. Group 2: Effect of refractive index on different materials

Aim: To compare the refractive index of different materials (e.g. water, oil, plastic).

Experiment procedure:

1. Place three transparent bowls: one with water, one with oil and one with a transparent plastic sheet.
2. Illuminate the materials obliquely with a laser pointer or a flashlight.
3. Notice how the direction of refraction of light changes in materials.
4. Note the results: which material bends light the most?

Discussion:

- Which of these materials would have the highest refractive index?
- How can these materials be used in optical devices?

4. Group 2: Creating optical illusions by refraction

Aim: To observe how refraction creates optical illusions.

Experiment procedure:

1. Draw a simple pattern (e.g. a straight line) on a piece of white paper.
2. Place a glass beaker of water over the drawing and see how the shape of the line changes when you look at it from different angles.
3. Repeat the experiment with another shape (e.g. an arrow) and see how it bends or disappears.
4. Note the angle from which the illusion is most spectacular.

Discussion:

- Why does the pattern change shape?
- How is refraction used to create optical illusions or special effects?

Annex: lesson II

A) Presentation

The aim of the tutorial is to help students understand that the formation of colours is based on the wavelength of light and that differences between colours are due to changes in this property. Simple examples and visual demonstrations are used throughout the explanation to help students' attention and understanding.

Learning about the wavelength of light and the formation of colours

1. What does wavelength mean?
   - The wavelength of light is the distance between successive peaks of light waves.
   - The unit of measurement is the nanometre (nm).
   - The wavelength of the light determines the visible colour: longer wavelengths produce a red tint, shorter ones blue or violet.

2. The range of visible light:
   - The light perceived by the human eye is between 380 nm (violet) and 750 nm (red).
   - The spectrum of colours can be thought of as a rainbow, where the following colours appear in order: red, orange, yellow, green, blue, indigo, violet (ROYGBIV).

Simple examples of the relationship between wavelength and colour

1. Using prisms to show the colour spectrum:
   - Place a white light source (flashlight) on a prism and show how it breaks white light into a spectrum of colours.
   - Explanation:
     - The prism refracts the light, and as different wavelengths of light are refracted differently, the colours are split.
     - Red light (longer wavelengths) is less refracted, while violet (shorter wavelengths) is more bent.
2. An example from everyday life:
   - Rainbow: a rainbow is created by water droplets floating in the air, which act like a prism: refracting and diffracting light.
   - The role of the visible light spectrum: this is how white light from the sun is broken down into colours when it passes through water droplets.
3. LEDs and colours:
   - Show LED's (e.g. red, green, blue light sources) and explain that each LED emits light at a particular wavelength.
   - Example: a red LED operates at a wavelength between about 620-750 nm, while a blue LED operates at about 450-495 nm.

B) Group work

1. **Group 3:** Creating a colour spectrum using prisms

Aim: To break white light into colours and observe the order of the colours.

Task:

1. Set up a prism so that the white light from the flashlight passes through it.
2. Move the prism so that the colours projected onto the white sheet of paper are clearly visible.
3. Make a note of the order in which the colours appear (red, orange, yellow, green, blue, indigo, violet).

Documentation: draw a diagram of the arrangement of colours exiting the prism.

2. Group 2: Effect of colour filters on the spectrum of light
Aim: To study how colour filters change the white light and colour spectrum.
Task:

1. Place a red colour filter in front of the light source and direct the light onto the prism.
2. Notice what colours appear on the sheet of paper behind the prism.
3. Repeat with other colour filters (e.g. blue, green) and note the changes.

Documentation: make notes on how each colour filter affected the appearance of the colours.

3. Group 3: Mixing colours using colour filters
Aim: To discover how colours mix and create new shades.
Task:

1. Place two colour filters behind each other (e.g. red and blue) in front of the light source.
2. Notice how new colours are created and note the shades.
3. Experiment with combining different colour filters and try to predict the outcome.
4. Additive colour mixing with CD tokens - how to do the experiment Additive colour mixing with CD tokens (YouTube)

Documentation: prepare a table with the results of the mixed colours.

4. Group 2: RGB, CMYK colour models: mixing pigments Color conversion
RGB to CMYK colour conversion
Task:

1. Make a colour mixing table based on the colours you get.
2. See what happens when all three primary colours are mixed (→ black).

Annex: lesson III

Detailed group work descriptions

1. **Group 2:** RGB colour model - Mixing of coloured lights
   1. Turn on the RGB LEDs and point them at a white sheet of paper.
   2. Investigate how white light is produced when all three colours are lit at the same time.
   3. Document how the colours change when only two are combined (e.g. red+ green → yellow).
   4. Note down what colours are produced at different ratios.

2. **Group 2:** CMYK colour model - Mixing pigments
   1. Prepare a table of mixing ratios (e.g. 50% cyan+ 50% magenta→ purple).
   2. Mix different proportions of the three primary colours (cyan, magenta, yellow).
   3. Test what happens when black pigment is added.
   4. Create a colour palette based on the colours you get.

3. **Group 2:** Wavelengths and colour filters
   1. They test the wavelengths of light transmitted by the red colour filter.
   2. Combine the colour filters (e.g. green + blue → cyan) and observe how the spectrum changes.
   3. Make notes of which wavelengths appear or disappear when filters are used.

4. **Group 2:** Wavelengths and spectrum
   1. Place a white light in front of a prism and adjust it so that the colour spectrum is projected onto the wall or paper.
   2. Make a note of which colours appear and in what order.
   3. Draw a diagram showing how the refraction of light varies as a function of wavelength.

6. Building a spectroscope. Interpreting the information carried by light

STE(A)M-Areas	physics - computer science - chemistry - technology - art
Interdisciplinary links	The topic can also be approached from the perspective of the history of science and technological development. Through their own experience, students will learn about achievements that have been essential to our social and technological development. Students interpret the information they receive, which is transformed into data that leads them to further knowledge through informatics.

Summary table

Subjects	physics - computer science - technology - chemistry
Topics	To know and understand the information carried by light and its components.
Age of students	15-20 years
Lesson/project duration	4×45 minutes
Number of students	4-20 people divided into smaller groups (e.g. groups of 4)
Online learning tools	Following the procedure described below, students will build their own spectroscope using gas discharge tubes to observe the line spectra of each excited gas. The history of the development of the line spectrum is explained, linking the lesson to the development of the atomic models studied in chemistry. We take photographs and then try to identify the chemical composition of the gas according to the lines of the spectrum captured.
Offline learning tools	Gergely Dálya 2021. *Introduction to Astronomy (From Atoms to Galaxies)*. Károly Simonyi 2011. *The cultural history of physics*.
21st century competences	Creativity - Manual dexterity - Problem solving - Experiential learning - Recognising the links between information - Using information technology - Cooperative skills - Working in a team
Learning objectives	Learning by doing, building an experimental tool from which information/data can be processed with scientific rigour. Deeper understanding of a given part of the curriculum. Forming learning groups, developing image processing skills. Developing abstract thinking.

Project plan

The name of the exercise	Building a spectroscope Interpreting the information carried by light

The implementation process

I. Building theoretical knowledge

Theoretical background

The lesson is structured around 3 main themes.

1. Evolution of atomic models: to describe the atomic models from the beginning (Thomson) to the currently accepted (Bohr-Sommerfeld) model (Dálya 2021). Students should formulate a logical path that leads them through the gaps of each atomic model to the insight that explains the creation of the line spectrum. This chain of thought is guided and guided by the teacher on the basis of his knowledge of the history of science (Simonyi 2011).

2. Description of the line graph

a) Balmer series

b) Application of Balmer formula to hydrogen atom - determination of line frequencies

c) Learning about line spacing, characteristic patterns (e.g. doublets)

3. Diffraction of light

a) Optical slit, description of the operation of the grating

b) Using a CD disc as an optical lattice

II. Building a spectroscope

Preparation

To make a spectroscope, you need some basic materials, which you should prepare before the lesson. The following equipment will be needed per group:

- scissors
- tape adhesive
- black duct tape
- glue gun
- black spray paint (matt)
- scalpel or sharp knife
- CD disc
- cylindrical box of chips
- inner roll of kitchen towels

Realisation

If you are working in teams of 4, divide the tasks as follows:

- 1 person uses a sharp scalpel to carefully cut a thin 2.5cm slit in the metal bottom of the chip box - this will serve as an optical slot.
- 1 person cuts a circle from the CD disc the same size as the bottom of the chip box as shown in Figure 1. This is then inserted into the open half of the box, tilted at an angle of about 30°.
- 1 person cuts the inner roll of the paper towel at a 15° angle (Figure 1).
- 1 person glues the device together as shown in Figure 2, making sure that there is no gap where light can enter (except for the optical gap cut at the first point), which can be easily eliminated with black electrical tape.

Check that your spectroscope is working properly!
After the final check, spray with black matt paint and leave to dry until the next session (optional).

1. Figure

2. Figure

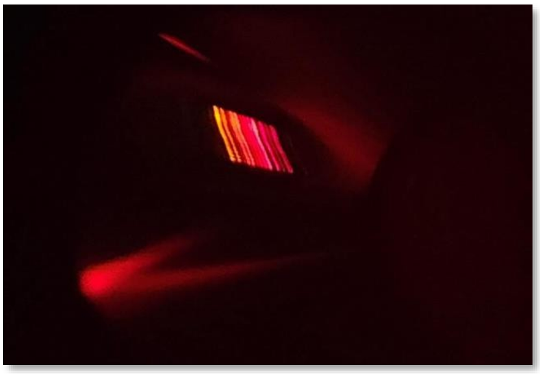
Hypothesis	If your instrument is well built, you will see the spectrum of the Sun's light when you look into the paper towel roll and turn the optical slit towards the light. If we turn the same towards a gas-filled fluorescent tube, we will only see specific spectral lines.
Plan	The plan is to take a photo of the spectra of the different gas discharge tubes in the school's laboratory in the next session, and then analyse it with a Python program.
Discovery	The second session aims to give students a sense of how we can use everyday tools to gain important information and knowledge about the world around us. If done with care and attention to detail, this can result in digitisable data (photographs) that can be scientifically analysed.
	III. Taking photos
Plan	In the third session, the aim is to take pictures of the different gas-filled pipes.
Realisation	There are many aspects to consider when taking photos. As far as the composition of the group is concerned, it is good to be aware of the students' knowledge of photography. This will help us to know what our options are. However, the easiest and most obvious way is to take photos with a mobile phone. When creating the conditions, make sure that the room is as dark as possible to avoid the effects of sunlight. This typically shows u p in photographs as distracting glare and diffusion. Alternatively, gas discharge pipes can be significant

a continuum superimposed on the contours of the scene. Any such effect will make image processing more difficult later on.
You should also make sure that the lines in the photos are as vertical as possible. This can be done when taking the photo, but software post-processing is also perfectly fine.

Project product

At the end of the activity, the students have a colour image of their own making, which is a fingerprint of the excited gas under investigation. If the school kit included a hydrogen-filled discharge tube, they can also assign a wavelength to each spectral line, making the image somewhat of a reference and using it as a calibration for the other photos.

3. Figure 1. The hydrogen alpha (red 656 nm, 1.89 eV) and beta (blue 486 nm, 2.56 eV) lines



4. Figure 1. A part of the excited neon spectrum

IV. Evaluation of photos

Plan

The aim is to identify the colour lines in the photos taken in the third session and to process them in software.

Realisation

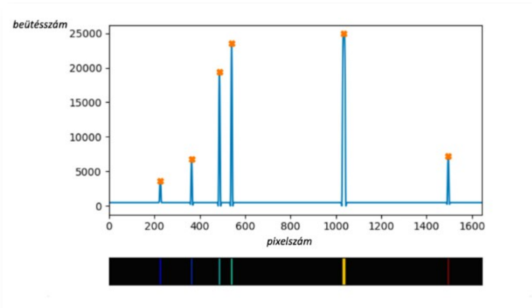
We need to make students aware that a photo is only of real value to us if we transform the data it contains into meaningful information.
In order to extract information from these spectra, we need a program to analyse them. The plan is that the program will process the image by plotting an intensity curve from the spectrum, looking for peaks.
When a reference image is scanned, the program creates ratios from the distances between vertices and saves them to a database. When it reads in an image that we have created, it compares the ratios with its database and then returns the name of the gas whose reference spectrum is most similar to that spectrum, so that some

can tell, within error limits, which gas is the source of the spectrum we are looking at.

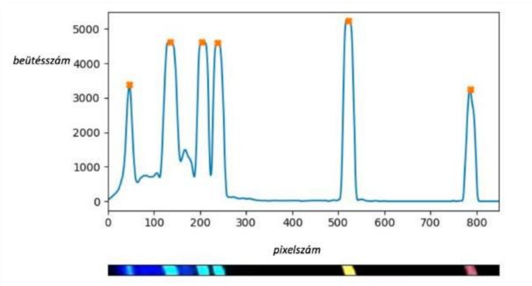
To help you process the images, I have included a Python program (written jointly with my students) that works as follows:

- First, the program scans the image, converts it to shades of grey and then blurs it a little to filter out noise and minor errors from the photos you take yourself.
- It then sums the pixel-by-pixel values along the x-axis to draw an intensity curve. On this curve, the program searches for the peaks.

As a result, the program generates the following figures:



5. Figure 1. Reference spectrum of helium



6. Figure 1. Our spectrum of helium

In the two figures above, students can observe the similarity between the reference spectrum and the spectrum we have created. However, they should be made aware that this program is only suitable for pattern recognition. It cannot assign specific wavelengths to individual lines.

If you don't want to use the included programme, there is another option that may be of interest to students and teacher. In this case, we will use the nowadays so popular educational tool, artificial intelligence. It can also be instructive for students to try to explain to ChatGPT, for example, what they want to know about the picture. ChatGPT has the programming skills to write a program to process the photos. However! It is very important and instructive that we cannot avoid algorithmic thinking. Explaining in detail what we want to do is a way of developing students' thinking and the need to look at a problem from a clear, top-down perspective.

Experiences

After the sessions, students can set themselves further ideas and goals. They can discuss how they can be implemented and we should also draw their attention to their everyday applicability. In which areas of life is the information gained from spectroscopy used.

Python program

```
import cv2
import numpy as np
import matplotlib.pyplot as plt from
scipy.signal import find_peaks

def ratio():
     ratios= []

     for i in peaks:
          ratios.append((int(i)/sum(peaks)) * 100) print(ratios)

def add_to_database():
     global ratios

     file = open("source.txt", "a", encoding= "UTF8") name=

     input("Specify the source image in the reference image
gas name: ")
     print(name, end= " ", file=file)

     for i in ratios:
          print(i, end= " ", file=file)
     print()

img= cv2.imread('Photo/higany/higanynet1.png')

gray= cv2.cvtColor(img, cv2.COLOR_BGR2GRAY) blur =
cv2.GaussianBlur(gray, (3,3), 0)

fig, (ax1, ax2) = plt.subplots(2, 1, gridspec_kw={'height_ratios':
[3, 1]})

intensities= np.sum(blur, axis= 0)

peaks, _= find_peaks(intensities, prominence=img.shape[1],
distance=img.shape[1] / 100)

print(should)

ratio()
'''add_to_database()''''
ax1.plot(intensities)
ax1.plot(peaks, intensities[peaks], "X") ax1.set_xlim([0,

img.shape[1]]) ax2.imshow(cv2.cvtColor(img,

cv2.COLOR_BGR2RGB))

ax2.set_xticks([])
ax2.set_yticks([])

plt.show()
```

Interdisciplinary link

Digital culture	The fourth activity can be introduced in a digital culture lesson, as it introduces students to a simplified form of image processing.
Appendix	**Sources** Gergely Dálya 2021. *Introduction to Astronomy (From Atoms to Galaxies)*. Károly Simonyi 2011. *The cultural history of physics*. Akadémiai Kiadó.

7. Celebrations and traditions of light - The symbolism of light in different cultures

STE(A)M-Areas	science - technology - engineering - art - mathematics
Intercultural relations	The symbolic and practical role of light in different cultures and their celebrations.

Summary table	
Subjects	history - geography - natural sciences - mathematics - visual culture - digital culture - foreign languages - religion and ethics
Topics	Cultural relations, sustainability, art and design, interculturality, global learning. The different cultural roles of light through an interactive exhibition.
Age of students	10-14 years
Lesson/project duration	90-minute lesson+ 4×45-minute project work
Number of students	20-25 people
Online learning tools	Quizizz, Kahoot: end of lesson test Canva: designing a lantern Teams: share related material, tasks Padlet: share research results and images
Offline learning tools	Coloured paper, scissors, glue, candles/LED lights, laptop/projector for the presentation, pictures and videos of the holidays. Pictures and texts in printed form. Candles and LED lights for decoration.
21st century competences	communication - cooperation - teamwork - creativity - innovation - critical thinking - problem solving
Learning objectives	Understanding the symbolic and practical significance of light in the celebrations of different cultures. Develop creative skills in making traditional objects. Develop communication and cooperation skills. Develop students' intercultural sensitivity and global awareness. Students appreciate the interconnection of science and technology with cultural traditions.

Project plan	
The name of the exercise	Celebrations and traditions of light - The symbolism of light in different cultures

The implementation process

	I. Introductory lesson: light holidays and traditions (90 min)
Arousing interest, preliminary questions	Ask the students, "Can you think of a holiday where light plays an important role?" A brief introduction to Diwali, Hanukkah, Christmas and the Chinese Lantern Festival with pictures and videos.
Preparations	The teacher prepares the necessary materials: coloured paper, scissors, glue, candles, candles or simple lantern making materials. Selection of videos and pictures of holidays.
Presentation	Students are divided into 4 groups, each group gets a celebration. A short research is done within the groups (e.g. the origin of the Diwali, the symbolism of Hanukkah, etc.). The groups design their own lantern or candle ornament based on the symbolism of the holiday.
Method of discovery	Students make lanterns or candle ornaments. During the process of creation, the teacher briefly explains the role of light in science (e.g. mixing of colours, chemical process of burning a candle).
Experiences, knowledge sharing	Each group presents its lantern and briefly explains the meaning and symbolism of the holiday. The others can ask questions.
Feedback, evaluation	Reflection: which holiday did you like best and why? What did they learn about the role of light? The teacher summarizes what was learned, points out common motifs (good vs. evil, light as hope).
Presentatio n materials	Presentation including pictures, short videos, descriptions and questions about the holidays.
Results	Creative works by students (lanterns/candle ornaments). Understanding the differences and similarities between holidays. Teamwork experience.
Critical thinking	Reflection questions What do the presented holidays have in common? How do the holidays show that the symbolic meaning of light is universal? Why is it important to depict the struggle between good and evil through the symbolism of light?
Presentation	Group presentations: each group gives a short presentation on the symbolism of the chosen holiday and their own creation (lantern, candle ornament or digital design). Interactive sharing: other groups can ask questions, e.g. "What materials did you use?" "Why is this holiday important in the culture?"
Productum	Handmade lanterns/candle ornaments: students' own creative creations that reflect the symbolism of the holidays. Digital products: digital posters or lighting designs using Canva or other design applications. Reflection in writing: each group writes a short summary of the holiday they have worked on.

	II Draft Interactive Exhibition "Light in World Cultures" (4× 45 min)
Arousing interest, preliminary questions	The teacher briefly explains the role of light in different cultures (with pictures, videos, examples).Ask the students: "How can light be related to people's lives, beliefs or celebrations around the world?"
Preparations	Grouping, assigning cultures (e.g. India - Diwali, China - Chinese lantern festival, Jewish tradition - Hanukkah, Christianity - Christmas). Providing tools: paper, inks, digital tools.
Presentation	The teacher briefly explains the purpose of the exhibition and the importance of light in different cultures (e.g. Diwali, Hanukkah, Christmas, Chinese lantern festival). Motivational questions. **Exhibition preparation** The groups research the light-related traditions of their chosen culture and prepare a short presentation. Create interactive elements: lanterns, candle holders, digital displays. Decorating and designing stations. **Organising the exhibition** Each group sets up its own station. Visitors (students, teachers, parents) can tour the stations and take part in interactive activities (e.g. lantern making, quiz).
Method of discovery	Through their own research, students will discover the symbolic, historical and scientific role of light in the culture they are studying. Making interactive elements (e.g. lanterns, candle holders) in a creative and experimental way.
Experiences, knowledge sharing	Students experience different aspects of the role of light (cultural, religious, scientific). Creative work: using craft techniques to make lanterns and decorations. Communication: presentation of the completed stations and interaction with visitors.
Feedback	Shared reflection: which stop was the most interesting and why? Teacher summarizes the lessons of the exhibition.
Presentation materials	Physical creations: lanterns, candle ornaments, unique decorations. Digital presentations (PowerPoint, Canva) for a short presentation of the culture and the celebration. Interactive quizzes (Kahoot) for visitors, presenting what they have learned in a playful way.
Results	Each group will create its own station, showcasing the culture and celebrations they are researching. Visitors will gain insight into the universal role of light and learn about the differences and similarities between cultures.
Critical thinking	Discuss questions "Why is light important in the holidays?" Students compare the similarities and differences in the way cultures use light.

Presentation	Each group gives a short presentation of the theme and creative work of their station. In the interactive part of the exhibition, visitors can also try out their creations (e.g. making paper lanterns).
Productum	Handmade objects (lanterns, candles). Digital materials (e.g. presentations, pictures, videos). Interactive games or quizzes at the stations.
Subject links	
Natural science	Optical phenomena (light reflection, refraction). Chemical processes of candle burning.
History	Exploring the origins and historical context of the different light festivals. Presentation of religious and cultural traditions.
Geography	The geographical location of the festivals of light: in which cultures and countries are they celebrated?
Digital culture	Designing with digital tools (e.g. using Canva to digitally design lanterns). Online research on holidays.
Visual culture	Traditional handicraft techniques (e.g. making lanterns, candle ornaments). Symbolism of colours and shapes in different cultures.
Mathematics	Designing symmetry and geometric shapes for lamps. Calculating proportions and dimensions in craft work.
Appendix	*Annex: Introductory session (90-minute lesson)* Tasks of the groups The group work process *Annex: Project lessons (3×45 min)* Organisational tasks

Annex: Introductory session

Group work objective: groups should learn about their assigned holiday of light and produce a creative product that illustrates the symbolism of the holiday. The groups will share their work with the class in a short presentation.

Group work process:

1. Forming groups: the class is divided into 4 groups, each group is given a task related to a particular light festival:

- Diwali (India)
- **Hanukkah** (Jewish tradition)
- **Christmas** (Christian tradition)
- **Chinese Lantern Festival**

2. Allocation of tasks within groups: the group members share the following tasks:

- **research:** gathering information on the origins, meaning and symbols of the holiday.
- **Craft project:** design and make a traditional object (e.g. lantern, candle ornament) related to the holiday.
- **Preparing a presentation:** preparing the presentation material.

3. Tasks for the group:

- **Research tasks:**
  - What is the origin and history of the holiday?
  - What is the role of light in the holiday?
  - How does the symbolism of the holiday relate to light?
- **Creative exercises:**
  - **Diya group:** make an oil lamp (diya) decorated with coloured paints.
    How to Make Oil Lamps: How to Make Diwali Oil Lamps
  - **Hanukkah group:** make a simple menorah model using candles or draw it digitally.
    Ideas: Eight Unique Menorahs Made of Bread, Candy, and More (Pinterest)
  - **Christmas group:** create a candle ornament or design a Christmas light garland out of paper or other materials.
    Ideas: easiest DIY ideas for Christmas from the blog! (Pinterest)
  - **Chinese lantern group:** make colourful paper lanterns inspired by Chinese traditions.
    Ideas: DIY lanterns Crafts Perfect for this Season (Pinterest)
- **Presentation tasks:**
  - Put together a 2-3 minute presentation that includes:
    - A brief history of the holiday.
    - The symbolism of light in a given culture.
    - Presentation of the artwork created by the group and its meaning.

4. Creative products: physical lanterns, candle ornaments or digital designs.

Annex: Project work - Designing an exhibition (4×45 min)

The proposed breakdown of the project work is as follows:

1. Lesson 2: Topic introduction and research Duration: 45 minutes
Content:
- The teacher explains the role of light in different cultures (15 minutes).
- Forming groups, assigning tasks.
- Students start researching the topic they have been given (20-25 minutes).

Aim: To learn about holidays through research.

2. Lesson: Creative design
Duration: 45 minutes
Content:
- Groups design stations and interactive elements to be created (e.g. lanterns, candles, digital materials).
- Preparation of tools and raw materials.
- The making of creative products.

Goal: Design and prepare the visual and interactive elements of the stations.

3. Lesson 2: Creating and building stations
Duration: 45 minutes
Content:
- Students will continue and finish making lanterns, decorations, presentations and other items.
- Setting up and testing the stations.

Aim: Visualisation of the stations and practical preparation for the demonstration.

4. Lesson 2: Exhibition management Duration: 45 minutes
Content:
- Presentation of the stations: the groups present their theme and their creative creations to visitors (classmates, other classes, parents).
- Conduct interactive activities (e.g. lantern making, quizzes).
- Reflection: joint evaluation, discussion of the lessons learned from the exhibition.

Aim: Students show what they have learned and share their creative results.

Total: 3-4 hours
The number of hours can be flexibly adapted to the pace of the students, the level of interactivity and the visibility of the exhibition.

Topics:

1. **Diwali (India):**
    - Presentation material: pictures and videos of the Indian festival of light.
    - Creative product: an oil lamp (diya) made and painted by the group members.
    - Interactive activity: visitors can try decorating their own lantern.

2. **Hanukkah (Jewish tradition):**
    - Presentation material: short digital presentation on the history of the menorah.
    - Creative product: simple menorah model with candles.
    - Interactive activity: lighting candles while telling a story.

3. **Christmas:**
   - Presentation material: a presentation on the symbolism and tradition of lights.
   - Creative product: Christmas lights or candle ornaments.
   - Interactive activity: visitors can make decorations from different materials.

4. **Chinese lantern festival:**
   - Presentation material: pictures and videos of the festival's colourful lanterns.
   - Creative product: traditional Chinese lanterns made of paper.
   - Interactive activity: visitors make their own lanterns.

1. Clear the air!

STE(A)M-Areas	maths - physics - biology - art - sport - sustainability

Summary table	
Subjects	maths - physics - biology - chemistry - geography - sport - foreign language - digital culture - engineering - sustainability - meteorology
Topics	Air pollution is the biggest health threat in Europe. Polluted air makes many people sick. 10 times as many people die from air pollution-related diseases as there are car accidents. Children are most at risk. Polluted air causes heart disease and lung disease.
Age of students	8-10 years
Lesson/project duration	4×45 minutes
Number of students	10-30 people
Teaching tools	Tools for lessons: interactive whiteboard, notebook or paper, pencil. Tablets can also be used for the lesson if you want to work in groups or in other ways.
Lesson content	During the lessons, students learn about outdoor and indoor air pollution activities and factors. They will learn about the health consequences of air pollution. They learn what we can do to reduce air pollution. They will learn about good ventilation techniques and then apply the knowledge they have acquired in creative or exploratory activities or extend their knowledge in personalised ways.
21st century competences	communication - cooperation - teamwork - creativity - innovation - critical thinking - problem solving
Learning objectives	-

Project plan	
The name of the exercise	Clear the air!
The implementation process	
Arousing interest, preliminary questions	What makes the air polluted? What is smog? What is acid rain? How can air pollution be reduced? Indoor and outdoor air pollution?

		Why delete a port? How to delete a port correctly? Why ventilate?
	Ideas Exchange	I came to today's class with a very important word. This word marks one of the most important things in our lives. Take out your notebooks and write down the word that I have in mind. I wonder who guessed what I meant. We will find out the answer with an online exercise: one of the most important things in our lives (LearningApps) Answer: health. After the answer, we'll see who guessed the most important word!
	Presentation	Causes of air pollution (LearningApps) Reducing air pollution - How can we improve air pollution? (LearningApps) The online exercises can be found in Clean Air (Padlet)
	Background knowledge	**Smog:** A dense haze of smoke, mostly in large cities. **Acid rain:** polluted air mixes with precipitation, making it toxic. Acid rain is formed and infiltrates into the soil, poisoning plants and the animals that consume them. It also damages buildings. **Smoking:** cigarette smoke contains nearly 4,800 chemicals, some of which are carcinogenic, in addition to tar and nicotine. People who do not smoke, and only inhale the smoke, are called passive smokers. It is as harmful to you as smoking. The harmful effects of smoking include: headaches, coughing, cardiovascular disease, respiratory diseases, asthma, lung cancer, and premature birth in pregnant women. **Photosynthesis:** humans and animals breathe in oxygen and breathe out carbon dioxide. We can't use the carbon dioxide we exhale, but plants can! In return, they produce oxygen, which is essential for human survival. **Mould fungus:** Mould can easily appear in damp, humid homes. Breathing them in can cause respiratory illness, hay fever and asthma. Mould must be got rid of at all costs! This often involves dehumidifying the room and destroying the mould colonies. Make sure you ventilate frequently! **Dust:** Dust, animal hairs, dust mites settle very easily on curtains, textiles, carpets, sofas. Dust, carpets, carpets, carpets, furniture, sofas, rugs, etc., are immediately released into the air whenever they are touched. **Chemical pollution -** Cleaning products, cosmetics, air fresheners, paints, glues and even electrical appliances, as well as candles and incense can release a host of chemicals into the air that can put our health at risk. Great care must be taken not to mix chemicals, as this can create a very dangerous and highly toxic mixture!

Pet dander: A lot of dust, bacteria and viruses are released into the air through pet dander.

Air pollution: air pollution is the biggest health risk in Europe. In Europe, air pollution is the biggest cause of illness in Europe. More than 10 times as many people die from air pollution-related illnesses as there are car accidents. Children are most at risk. Polluted air causes heart disease, lung disease.

Design

What can we do about air pollution?
Tick the box to indicate what you can contribute to!

___Avoid using the car!
___Get around by bike or on foot!
___Let's heat with car tyres, plastic waste!
___Use a car to get around, it's faster!
___For longer trips, take the train or other public transport!
___If you can, heat with geothermal energy, district heating!

Checking what you have learned

Mark the true statements with an X!

___Air pollution is very harmful to humans, causing serious diseases.
___We are not responsible for air pollution.
___We can do a lot to reduce air pollution.
___Particulate matter, exhaust fumes from cars, burning waste are very harmful to the air.
___Acid rain is not harmful to wildlife.
___The meaning of smog is: a haze of smoke. It is more common in large cities.
___Air pollutants are carried in precipitation, damaging soil and plants.

Experiences

Indoor air pollution
Which ones do you meet in your environment?

Figure 1.

Mould fungus

What should be done to eliminate mould?

Figure 2.

Project work

Optional tasks

1. Make a quiz of what you have learned so far!
2. Make a poster to reduce air pollution! Raise awareness of harmful air pollutants!
3. Make a list of how we can improve air cleanliness! Write these golden rules on a large drawing board and hang it on the classroom wall.
4. Collect environmentally friendly cleaning products! Get help from the internet! Describe some of them (what can we use them for, ingredients, etc.)
5. Kutakodj! Which are the most polluted countries? Which are the least polluted? Which are the most polluted cities in Hungary? Where is the best air quality?
6. Search the internet to find out which houseplants to plant for better air! Collect the names and pictures of the plants. Make a presentation!

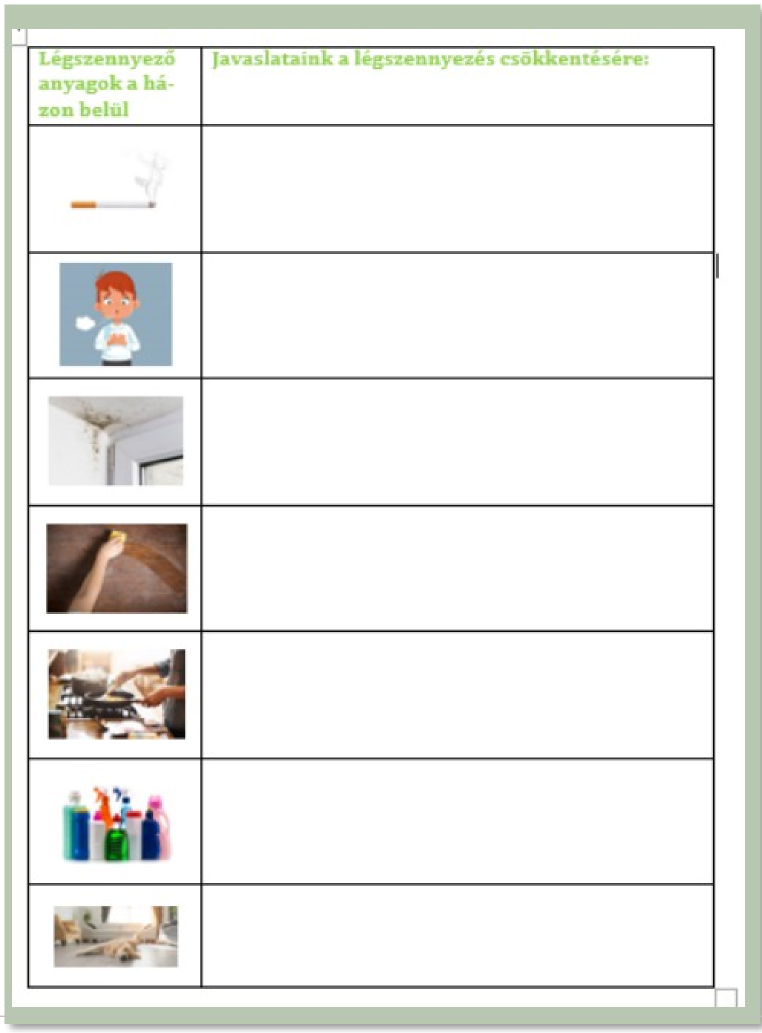
Results

Solutions to reduce indoor pollution

Figure 3.

- Match the pictures with the description! Find out which are the most polluting factors! [Causes of air pollution (LearningApps)]
- Was there anything you hadn't thought of?
- What do you call the thick haze of smoke that is most common in big cities (smog)?

	• Why is it developing in larger cities (more cars, more industrial facilities)? • Did you know that contaminated air can also leach into the soil? I wonder how? The picture helps... The polluted air mixes with the precipitation, making it toxic. This is when acid rain is formed and seeps into the soil, poisoning plants and the animals that eat them. It also damages buildings. • How do you think we can reduce air pollution? What can we change? • Which of the following sentences are correct? How can we improve air pollution? (LeariningApps)
Critical thinking	**Fill in the table, make suggestions!**



Légszennyező anyagok a ház belül	Javaslataink a légszennyezés csökkentésére:

Subject links

Natural science	What do you think are the things that put our health at risk? (Listen to individual opinions.) I have made a puzzle for you. Put the picture out and find out what is the most dangerous thing for our health! Air pollution puzzle.

	Digital culture	Digital devices: tablet, smartphone, projector, laptop, projector.
	Annexes	Accessories.

Figure 4 Smog

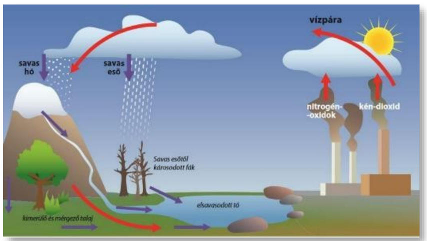


Figure 5 Acid rain

Figure 6 Photosynthesis

Figure 7 Animal pollution

	Appendix	**Source from** [Clear the air!]

2. For cleaner air

STE(A)M-Areas	maths - physics - biology - art - sport - sustainability

Summary table	
Subjects	mathematics - physics - biology - chemistry - geography - sport - digital culture - engineering - sustainability - meteorology
Topics	Air composition, air pollution, livable environment.
Age of students	11-14 years
Lesson/project duration	3×45 minutes
Number of students	15-25 people
Online learning tools	tablet - laptop - phone - interactive whiteboard - projector
Offline learning tools	-
21st century competences	communication - cooperation - teamwork - creativity - innovation - critical thinking - problem solving
Learning objectives	raising awareness of global problems - acquiring scientific knowledge - carrying out research

Project plan	
The name of the exercise	For cleaner air
The implementation process	
Arousing interest, preliminary questions	What does it mean to have dirty air? Is there life without air? Is there life on the Moon? Can we talk without air? What can we do to make the air cleaner?
Preparations	Students are shown pictures of air pollutants in a presentation. An 8-minute short film on air composition and pollutants. Meanwhile, students describe the main problems of air pollution based on what they have heard in the short film. Group formation: pupils draw from different pictures and those who draw pictures on the same topic are put into a group. Discuss the groups' tasks.

Sayings, proverbs cards to make:

- *He speaks into the air.* One interpretation is that it means that someone is explaining in vain and no one is listening. The expression refers to the fact that the person's words disappear into thin air, as if they had never been spoken. If, for example, a mother asks her son to do the same thing day after day, but he does not do what she asks, the mother may say, "I see, I'm talking into the air" because her son does not listen. The other interpretation is that someone is saying useless or false things, there is no basis for their claims. If, for example, someone is spouting all sorts of made-up lies, someone else may rightly advise his friend "don't listen to him, he's talking out of his ass".
- *Don't spoil the air in here!* Go away, we don't want to see you.
- *The coast is clear.* No danger, no one here.
- *It looks like air.* It doesn't look at anyone, it sees someone as non-existent.
- *It relies on air.* He makes unrealizable, imaginary plans, or his actions have no solid basis in reality. You cannot build a castle in the air.

Presentation

Experiment - Detecting the presence and absence of oxygen

Tools: candle, lighter, glass cylinder.

What is oxygen essential for?

Figure 1.

Figure 2

Figure 3.

Figure 4

Figure 5.

Figure 6

Figure 7.

Figure 8

Preliminary assumptions

Common thinking

What would cause

lack of oxygen, lack of air, cleaner air, the polluted air?

Design

During the project, students learn about the composition of the air and air pollutants. By the end of the second lesson, posters will be produced to raise awareness of the harmful effects of air pollution.
During the lessons, we learn about the composition of the air and the effects of air pollutants. We will examine and discuss individual and community responsibilities and preventive options. We argue for the importance of clean air.

Method of discovery

What do the following pictures remind you of?

List the following forms of air pollution.

Figure 9.

Figure 10.

Figure 11.

Figure 12

Experiences

Detection of airborne particulate matter

Visual inspection of the dust on the leaves of a plant brought to class/home for a week and drawing a conclusion. Observation of dust grains 'dancing' in the light of sunlight through a curtain slit.

Presentation materials

Testimonials: give a testimonial about the implementation!

Critical thinking

Air Patrol
In groups, plan what you can do to improve air quality!

Intézkedési terv

- az allergén növények eltávolítása a teremből/iskolából/otthonról
- szemléletformáló beszélgetések a kortárscsoportban, családban
- plakátkészítés (plakátkészítési verseny hirdetése az iskolában)
- portalanítás
- zöld felületek növelése az iskolában és otthon
- szelektív hulladékgyűjtés elősegítése
- kozmetikumhasználat mérséklése
- autómentes nap/hét „Közlekedj ÖKOsan!” jeligével

Tevékenység	Felelős	Határidő	Megvalósulás
Portalanítás	Hetes	Péntek 6. óra	👍

Subject links

Natural science

In groups, make a presentation or poster on the following topics.

1. **Group 1: Greenhouse effect**
   Brainstorm: how to put greenhouse gases and global warming on the poster.
2. **Group 2: Artificial sources of pollution**
   Brainstorming session: how to present industrial pollution, agriculture and transport on posters.
3. **Group 1: Ozone Hole**
   Ideas Fair: a poster showing the consequences of ozone depletion.
4. **Group 2: Smog**
   Idea Fair: show the substances responsible for creating smog and outline the consequences on the poster.

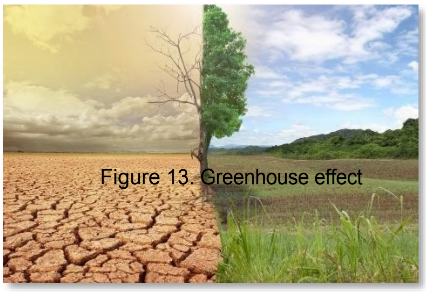


Figure 13. Greenhouse effect


Figure 14. Artificial sources of pollution

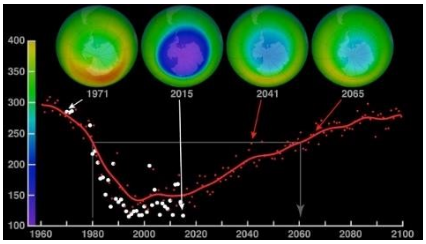


Figure 15. Ozone hole

Figure 16. Smog

Greenhouse effect: many things can be drawn on the poster about global warming, e.g. polar bears in the Arctic, rising sea and ocean levels, use of fossil fuels.

Artificial sources of pollution: in this context, for example, factory chimneys, fertilisers, transport, heating may appear on the poster.

Ozone hole: on this poster it is possible to show e.g. carbon dioxide, ozone, methane, nitrogen oxides.

Smog: This poster may include, for example, a drawing of a smog haze.

Properties of air

Learningapps are shared while solving the assigned task individually. Each pupil is given a task to solve individually during/under the Learningapps joint solution.

[Air composition (LearningApps)]

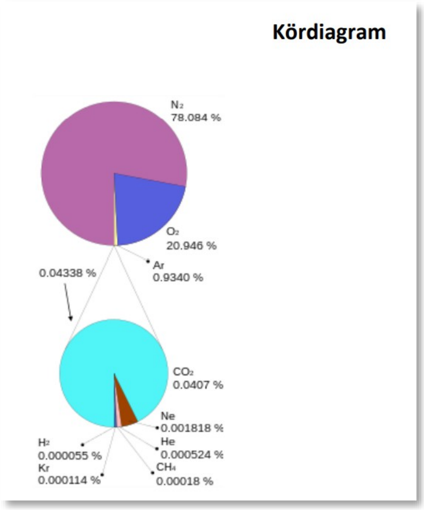
Properties of air (Underline the true statements!)

- colourless, odourless gas
- not compressible (try with a balloon)
- a mixture of different gases
- contains nitrogen
- no pressure
- contains oxygen
- solid in state
- well soluble in water
- poorly soluble in water
- the oxygen it contains feeds the combustion
- not important for living organisms
- may contain dust
- no carbon dioxide
- the quality of the plants is improved
- the greenhouse effect raises air temperatures

Detection of the presence and absence of oxygen by experiment

The students have to guess the experiment based on the tools they see and then draw conclusions after carrying it out.

Hungarian language	Interpretation of air-related sayings and proverbs in frontal class work: interpreting the sayings and proverbs that arise based on the students' ideas and/or interpreting the ones on the board.

	Work in pairs: match the previously cut-out sentences with the explanations. Group work: you have to form the sayings and proverbs from the words you have cut out beforehand, and then find the explanation together.
Digital culture	Digital devices: tablet, PC, smartphone, projector, laptop.
Physical education	Sports equipment: fitness measurement, capacity of the horse.
Geography	Atmospheric processes. Tornadoes, winds. Air pressure. Heights and depths.
Visual culture	Creating a pie chart: printing a pie chart or cutting out piecuts from the chart and assembling them.  Figure 17.
Mathematics	Interpreting pie charts, ratios, percentages.
Appendix	**Sources** Air pollution reduces solar potential in China Less specific emissions, but more cars? What is the truth? Shocker: 99 percent of people lose two years of their lives to air pollution Air pollution effects This is the greenhouse effects It's OK to have a diesel car, just don't breathe the smoke! Ozone hole situation picture Smog is getting worse - here is the alert, traffic restrictions Smog Air (Wikipedia) **Video from** Pollutants in the atmosphere and air (YouTube)

3. For the air of the future!

STE(A)M-Areas	maths - physics - biology - art - sport - sustainability

Summary table	
Subjects	maths - physics - chemistry - biology - geography - sport - digital culture • sustainability - engineering - meteorology - foreign language - art
Topics	Air pollution is one of Europe's biggest environmental challenges, with serious health and economic consequences. Hundreds of thousands of deaths are directly linked to air pollution every year, while it also causes economic damage through loss of working capacity and strain on health systems.
Age of students	14-18 years
Lesson/project duration	4×45 minutes
Number of students	10-30 people
Teaching tools	projector - interactive whiteboard - notebook - pencil - interactive maps - simulations and models - videos and animations - experimental tools - pots - cotton wool discs - candles - glass - coloured paper tools - tablets
Lesson content	Air pollution is one of the biggest health risks in Europe, causing heart and lung disease and premature death, especially among children. Polluted air causes ten times more deaths than car accidents, which is why source reduction and conscious environmental protection are of paramount importance. Students can learn about the causes and effects of air pollution and find personal solutions to the problem through practical examples.
21st century competences	communication - cooperation - teamwork - creativity - innovation - critical thinking - problem solving
Learning objectives	learning about global issues - environmental education

Project plan	
The name of the exercise	For the air of the future!
The implementation process	
Enquiry arouse, preliminary Questions	Imagine that the air you breathe is not only fresh and clean, but also affects our health and shapes our future. We happens when the air is polluted? How it affects our planet

and all our lives? Why is it important to act now to make the air of the future cleaner and healthier?

Preliminary questions

1. How do you think air quality affects our health?
2. Why is it dangerous to have harmful substances in the air?
3. How will air pollution-related diseases affect future generations?
4. Why is it important to act today for clean air?
5. What can we do to improve air quality?

Ideas Exchange

How can we teach people why clean air is important and how they can protect themselves from air pollution?
Why is it important to prepare the next generation now to care for the environment?

Presentation

"The Air We Breathe" - 2019 The Air We Breathe (YouTube)
"Before the Flood" - 2016
Before the Flood Full Movie National Geographic (YouTube)

Background knowledge

1. Basic physics and chemistry

- Breathing and air composition: it is important for students to know what makes up air (e.g. nitrogen, oxygen, carbon dioxide, other gases) and how pollutants (e.g. carbon monoxide, nitrogen oxides, sulphur dioxide) affect air quality.
- The role of oxygen in living organisms: oxygen is necessary for living things to breathe, so clean air is essential.
- Chemical interactions between air and water: air pollutants can contaminate not only air but also water resources (e.g. acid rain).

2. Sources and effects of pollutants

- Car traffic, industrial emissions: students should learn that industrial activity, cars and households release pollutants into the atmosphere.
- PM2.5 and PM10: The role of fine particles in air pollution, which are microscopic in size and have long-term adverse health effects.
- Greenhouse gases: they need to understand the role of greenhouse gases (such as carbon dioxide and methane), not only in global warming but also in air quality degradation.

3. Health effects

- Air pollution and respiratory diseases: students should be aware that air pollution is closely linked to respiratory diseases such as asthma, bronchitis, lung cancer.
- Cardiovascular effects: polluted air can cause long-term heart disease, stroke.
- Children's sensitivity: students should be aware that children and the elderly are particularly sensitive to air pollution.

4. Climate change and global impacts

- The role of air pollution in climate change: the link between polluted air and global warming. Carbon dioxide, methane and other gases contribute to the greenhouse effect, which leads to global warming.
- Impact of air pollution on climate systems: understand that air pollution affects not only human health but also weather systems (e.g. storms, droughts).

5. Sustainable development and environment

- Green energy and sustainability: it's important to know about sustainable energy sources such as solar, wind and hydro power and their role in keeping the air clean.
- Urban Green Spaces: the role of green spaces in improving air quality, for example by absorbing carbon dioxide from plants.
- Environmental regulations: the school material should include international, national and local environmental regulations aimed at reducing air pollution.

6. Social and economic impacts

- The economic consequences of air pollution: how pollution affects the economy (e.g. increased health costs, reduced productivity).
- The impact of pollution on social inequalities: why are poorer people more exposed to the risks of pollution?

7. Technological solutions

- Filtering systems and air pollution measuring devices: the role of different technologies such as air filters, emission standards and pollutant measuring devices in keeping the air clean.
- Green technology developments: future innovations such as electric cars, sustainable industrial practices and urban green infrastructure.

8. Global examples

- Levels of pollution in different parts of the world: they need to know the levels of air pollution in different parts of the world (e.g. Delhi, Beijing smog) and how local governments are trying to combat it.

Design

What can we do about air pollution?

- *Take public transport or cycle!* Instead of cars, choose public transport, walking or cycling to reduce car emissions!
- *Use an electric vehicle!* Electric cars emit fewer pollutants than conventional petrol or diesel vehicles.
- *Support green energy!* Switch to renewable energy sources (e.g. solar and wind)!
- *Reduce energy use for heating and cooling!*

Setting lower temperatures in winter and summer, and using energy-saving devices can help reduce pollution.

- *Do not burn waste!* Burning waste is a major source of air pollutants.
- *Choose environmentally friendly products!* Buy products that do not contain harmful chemicals and are produced without overburdening the environment.
- *Green your environment!* Plant trees and other plants that help clean the air!
- *Stop wasting water and energy!* Reducing your energy and water consumption also reduces pollution, as their production often results in harmful emissions.
- *Help your local community against pollution!* Get involved and support local environmental programmes!
- *Teach others about the effects of air pollution!* You can help raise awareness through educational activities.

Checking what you have learned

Which statement is true and which is false?

a) The biggest sources of air pollution are industrial activity and transport.

✓ True - Industrial activities (factories, power plants) and transport (cars, trucks, planes) are the biggest sources of air pollution.

b) Polluted air only has a negative effect on adults, children are not sensitive to it.

✗ False - Children are particularly vulnerable to air pollution because their developing respiratory and immune systems put them at greater risk.

c) Cars and vehicles are a major source of carbon dioxide in the air.

✓ True - Cars and other means of transport emit significant amounts of carbon dioxide, which contributes to air pollution and greenhouse gas emissions.

d) Planting trees can help reduce air pollution by producing oxygen and trapping dust.

✓ True - Trees produce oxygen and trap dust, helping to clean the air and reduce carbon dioxide levels.

e) Air purity is not affected by wind and rain.

✗ False - Wind and rain play an important role in cleaning the air, as wind carries pollutants away and rain can wash them away.

f) Choosing to cycle and use public transport reduces air pollution.

✓ True - Cycling and public transport reduce car use, thereby reducing carbon emissions and air pollution.

g) The effects of air pollution include heart disease and lung disease.

✓ True - Air pollution can lead to serious health problems such as heart disease, asthma, COPD (chronic obstructive pulmonary disease) and other respiratory diseases.

	h) Reducing energy use in households has no impact on air pollution. ✗ False - Reducing energy consumption in households, for example by using energy-saving devices, can reduce the burning of fossil fuels, thereby reducing air pollution. i) Wind and solar energy help reduce air pollution because they do not emit harmful substances. ✓ True - Wind and solar power are clean energy sources that produce no pollutants, helping to improve air quality. j) Waste incineration is a major source of air pollution. ✓ True - Waste incineration releases various harmful substances into the air, such as dioxins and other toxic compounds that contribute to air pollution.
Experiences	Experiences at home can help students better understand the effects of air pollution and possible solutions. Some questions t o help students reflect on their own experiences and make connections with their home environment: • What is your experience of air quality in your own environment? • For example: how often do you feel that the air is hard to breathe or that there is smog in the area? • How do you think air pollution affects your quality of life at home? • For example: do you have difficulty breathing, asthma or other respiratory problems? Have you noticed a link between polluted air and your well-being? • What is your family doing to reduce air pollution at home? • For example: do you use energy-saving devices, collect waste separately, do you drive often? • Have you ever paid attention to air quality when you went on holiday? • For example: have you noticed that other places have cleaner or more polluted air? How did you feel when you were in clean air? • Is there anything you or your family could do to reduce air pollution at home or in your neighbourhood? • For example: could you use public transport more, cycle more or avoid driving?
Project work	**Optional tasks** **1. Air pollution and its effects - Image and description** Task: create a poster showing the effects of air pollution on human health, wildlife and the environment. Use pictures, data and short descriptions. Aim: Students will visualise the seriousness of the problem while working creatively.

2. How to reduce air pollution? - Possible solutions Task: make a list of at least 5 ways to reduce air pollution at school, at home or in the city. Include a short justification with the list.
Aim: Students can collect their own ideas and reflect on personal responsibility.

3. Polluted air and health - Role play
Challenge: Imagine a situation where the inhabitants of a city face various health problems due to polluted air. Each person should choose a role (doctor, parent, child, town leader, etc.) and act out how they would try to solve the problem.
Aim: Students practice problem solving and develop empathy through situational play.

4. Measuring air pollution - Experiment
Task: Carry out a simple experiment in which you measure air quality at different points in your home (for example, before and after opening a window, or at different times of the day). Record the measurements and draw conclusions about changes in air quality.
Aim: Students will gain experience of measuring air quality and a better understanding of the effects of air pollution.

5. Car vs. means of transport - Image and statistical comparison Task: make a comparison showing how different means of transport (car, bus, bicycle) affect air quality. Use statistics, graphs and pictures to illustrate the differences.
Aim: Students will gain a better understanding of the impact of their transport choices on the environment.

6. School Air Pollution Action Plan
Task: make a school action plan that includes: how to reduce air pollution in school, what you can do together in the classroom, and what tools can help to ensure cleaner air.
Goal: Students will adopt a collaborative approach and work together to solve problems.

7. A day in the polluted air - Storytelling
Challenge: Write a story about a fictional character who lives in a polluted city in the future. In the story, describe how air quality affects his life, his health and the environment.
Aim: Students will work creatively while imagining future problems and their impacts.

8. Individual responsibility - Air pollution and everyday life
Task: make a diary in which you keep track of how much you can reduce your individual air pollution for a week. Record when and how you help reduce air pollution,

such as public transport, walking, waste management, etc.
Aim: Pupils reflect independently on the impact of their own actions.

Results

1. Air pollution and its effects - Picture and description

Expected result:

- Students will be able to summarise the effects of air pollution on human health, wildlife and the environment, including a visual representation.
- Creative solutions and visual representations help to develop a deeper understanding of the topic.

Measurement:

- Posters will be assessed on the basis of aesthetic and content criteria.
- Observing the proportion of visual and textual elements, measuring the accuracy of information conveyed.

2. How to reduce air pollution? - Possible solutions

Expected result:

- Students will actively think about solutions to reduce air pollution and will be able to give practical advice for everyday life.

Measurement:

- The lists are evaluated on the basis of creativity, realistic solutions and answers to the problem.
- Short, clear justifications for each solution.

3. Polluted air and health - Role play

Expected result:

- Students will practice problem-solving in different roles (doctor, parent, child, city leader, etc.) and understand the health consequences of air pollution.
- They develop empathy while working together to solve problems.

Measurement:

- Evaluate students' empathy and problem-solving skills in role-playing games.
- The quality of group work, the approach to the problem and the elaboration of solutions.

4. Measuring air pollution - Experiment

Expected result:

- Students learn to measure air quality and keep records of the results.
- They will be able to draw conclusions about the effects of polluted air.

Measurement:

- Data collection and documentation of experiments.
- Conclusions drawn from the measurements and interpretation of the results.

5. Car vs. transport - Image and statistical comparison

Expected result:

- Students will understand how transport affects air quality and will be able to use statistics to illustrate the problems.

Measurement:

- Quality of comparative work and accurate use of data.
- Understandability of graphs and statistical charts.

6. School Air Pollution Action Plan

Expected result:

- Students will be able to develop a school-wide action plan with concrete steps to reduce air pollution.

Measurement:

- The detail of the action plan, its feasibility and the innovativeness of the ideas.
- The effectiveness of teamwork.

7. A day in the polluted air - Storytelling

Expected result:

- Pupils will think creatively about the effects of future air pollution and will be able to present the problem in the form of a fictional story.

Measurement:

- To put the story in context and make the problems more visible.
- The coherence of the narrative and the level of creativity.

8. Individual responsibility - Air pollution and everyday life

Expected result:

- Students will be able to reflect independently on the actions taken against air pollution and the impact on their own lives.

Measurement:

- Accurate diary keeping and individual student engagement.
- Getting students active and sharing personal experiences.

Overall results

- Increased awareness: students better understand the effects of air pollution and recognise their own responsibility in tackling the problem.
- Problem-solving skills: students will actively seek solutions and be able to make realistic, practical proposals to reduce air pollution.
- Empathy and creativity: role-playing and creative exercises help develop empathy and problem-solving skills.

Critical thinking	In developing critical thinking, students not only gather and evaluate information, but also develop the ability to analyse problems in a thoughtful way, to consider different perspectives and to develop complex solutions. This is particularly important in the field of air pollution, where the issue has not only scientific but also ethical, economic and social dimensions.

1. Questions for students

- Why do we need to regulate cars and industrial activities to reduce air pollution?
- What alternative solutions are known to alleviate transport problems and why is it important for society to use them?
- How can air pollution be measured and what data can be used to determine the scale of the problem?

Analysis of examples

- We can analyse the steps taken by different countries to reduce air pollution, for example China or Western Europe, and look at why certain measures work or don't work.
- Students can measure and assess the level of air pollution in their own city and understand why there are differences between cities.

2. Scepticism and source criticism

Posted on

Students can compare information on air pollution from different sources. They can analyse data and opinions from different media (scientific articles, news reports, social media) and try to evaluate them, taking into account the credibility of the sources.

Questions for students

- What are credible sources and how can we distinguish reliable information from misleading information?
- How does media coverage influence public opinion on air pollution?

3. Problem solving and alternative perspectives

Questions for students

- How can we reduce air pollution while taking into account economic, social and political aspects?
- How can the transport system be designed to reduce environmental pressures while ensuring people's mobility?
- Why is it important to look at sustainability and long-term solutions to reduce air pollution?

Debates and role-playing

Students can take on different roles (e.g. city leader, environmental activist, transport expert) and organise debates on the best solutions. Considering different points of view helps to develop critical thinking.

4. Ethical decisions

Question for students

- How do we balance individual rights and the interests of the community? What ethical dilemmas are raised by measures to reduce air pollution, such as traffic restrictions?

Posted on

- Students are asked to judge different measures (e.g. banning cars in city centres) from an ethical point of view and explain why they consider them important or problematic.

5. Scientific and social context

Questions for students

- How has the level of air pollution changed over the past decades? What has caused the biggest changes?
- How does air pollution affect different sections of society and why are children and the elderly at greater risk?

Interactive exercise

- Students can analyse statistical data and try to link it to the social impact of air pollution. In this way, they can see the problem not only from a scientific but also from a social perspective.

6. Finding new solutions

Creative exercise

- Students can explore alternative solutions to reduce air pollution that combine technological innovation, social change and individual responsibility.
- The aim of the exercise is to teach students how to approach a problem in different ways and to consider different aspects in order to get the best result.

Subject links

Natural science	What do you think are the things that put our health at risk? (Listen to individual opinions.)
Digital culture	Digital devices: tablet, smartphone, projector, laptop, projector.

4. Vegetation affecting the air estimating ecosystem services

STE(A)M-Areas	maths - physics - biology - art - sport - sustainability

Summary table	
Subjects	maths - physics - biology - chemistry - geography - sport - foreign language - digital culture - engineering - sustainability - meteorology
Topics	Estimating the ecosystem services of vegetation to air.
Age of students	16-18 years
Lesson/project duration	6×45 minutes
Number of students	15-25 people
Online learning tools	tablet - PC - smartphone - interactive whiteboard - projector
Offline learning tools	-
21st century competences	communication - cooperation - teamwork - creativity - innovation - critical thinking - problem solving
Learning objectives	-

Project plan	
The name of the exercise	Estimating the ecosystem services of vegetation to air
The implementation process	
Arousing interest, preliminary questions	Introduce some basic concepts (e.g. service, air, oxygen). Basic concepts.
Preparations	Group formation, division of tasks.
Presentation	The project looks at the effects of vegetation in an area in our environment, such as a school garden, on the air. It will estimate the amount of carbon dioxide absorbed and oxygen released during plant photosynthesis, the amount of water evaporated by plants and the amount of air pollutants sequestered. The estimates are compared with the services provided by an average forest. It gives an index of relative ecosystem services to air for the study area. The project also provides the possibility to map larger areas.

Preliminary thoughts

From around the turn of the century, it became more and more common and widespread that green spaces and trees play an important role. "Don't cut down trees, they produce oxygen!"
But how much? Let's look at the disc showing the age of the tree, the estimated amount of carbon dioxide absorbed and oxygen produced.
The DenziCam mobile app calculates canopy cover from a photo of a canopy and uses it to calculate the amount of carbon dioxide absorbed and oxygen produced in a given forest stand. This not only provides an estimate of the quantities, but also allows for comparison by introducing an index.
You can use it to compare the trees in your garden, or to create a map of your wider environment.

Design

1. Field data collection

Measuring the circumference of trees, counting the number of shrubs, determining the size of the lawn area, filling in the relevant parts of the worksheet.

2. Definition of the leaf cubic metre

Use the worksheet to determine the cubic metres of trees, shrubs and grassland.

1. Feladatlap

A fa kerületének mérése 1-1,5 m magasságban

A fa kora: fa kerülete 1-1,5 m magasan (cm): 2,5 = életkor (év)

vagy (fa kerülete 1-1,5 m magasan (cm) *4): 10 = életkor (év)

sor-szám	fa faja*	kerülete (cm)	a fa kora (év)	lomb-köbméter
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
...				
lombköbméter összege				

1. Table

fa életkora (év)	lombköbméter
10	2
20	9,5
30	24
40	49,5
50	90
60	142,5
70	225

2. Table

cserjék	darab	egység lomb-köbméter	lomb-köbméter
1 m -nél alacsonyabb		1,5	
1 m-nél magasabb		2	
lombköbméter összege			

gyep	felület (m^2)	egység lomb-köbméter	lomb-köbméter
fűnemű dominancia		1,2	
szélesebb levelű, kétszikű dominancia		1,5	
lombköbméter összege			

A növényzet teljes lomköbmétere (fák+cserjék+ gyep)	

Table 3

3. The values of ecosystem services

Calculate quantities based on the cubic metre and the data provided.

2. Feladatlap

A levegőre ható ökoszisztéma-szolgáltatások becsült értékei

	lombköb-méter (m^3)	egy vegetációs időszakra vonatkoztatott egységnyi mérték (kg/m^3)	mennyiség (kg)	a vizsgált terület nagysága (m^2)	1 m^2-re vonatkoz-tatott mennyiség (kg/m^2)
megkötött szén-dioxid		0,59 kg/m^3			
elpárolog-tatott víz		47 kg/m^3			
termelt oxigén		0,65 kg/m^3			
kiszűrt szennyező-anyag		4,5 kg/m^3			

viszonyítás egy hazai átlagos erdőhöz

4. Table

	A = vizsgált terület 1 m^2-re vonatkoz-tatott mennyiség (kg/m^2)	B = erdő 1 m^2-re vonatkoztatott mennyiség (kg/m^2)	A osztva B	az eredmény egész %-ra kerekítve megadva
megkötött szén-dioxid		1,1959 kg/m^2		
elpárolog-tatott víz		94 kg/m^2		
termelt oxigén		1,3175 kg/m^2		
kiszűrt szennyező-anyag		12 kg/m^2		

5. Table

	lombkoronával fedett terület (m^2)	a vizsgált terület nagysága (m^2)	árnyékolt terület %-ban
árnyékolás			

6. Table

4. Average calculation

3. Feladatlap

A %-os értékek átszámítása

viszonyított érték (%)	0-5	6-20	21-40	41-60	61-80	81-100
szolgáltatásindex	0	1	2	3	4	5

	%	index
Szén-dioxidmegkötés-index		
Párologtatási index		
Oxigéntermelés-index		
Szennyezőanyagszűrési index		
Árnyékolási index		
Az indexek összege		
Az indexek átlaga		

7. Table

5. Conversion of % values according to the given table

Feedback	Checking the accuracy of measurements and calculations, checking the completion of worksheets, evaluating the presentation.
Results	Presentation of results, presentation.

Subject links

Digital culture	Digital equipment: computer, laptop, projector.
Visual culture	Art and design supplies.
Mathematics	Mathematical tools.
Languages, primary, story, writing, reading	Accessories.

WORLDWIDE

1. Wonderful Universe

STE(A)M-Areas	mathematics - science - computer science - design
Intercultural relations	The relationship of developed and developed countries to space exploration, the space race between the great powers.

Summary table

Subjects	maths - physics - geography - technology - digital culture - astronomy - sustainability
Topics	The structure of the Universe. Dimensions of the Universe. Spacecraft. Objects in space. Extraterrestrials.
Age of students	10-14 years
Lesson/project duration	6×45 minutes
Number of students	15-20 people
Online learning tools	tablet - PC - smartphone - interactive whiteboard - projector
Offline learning tools	coloured cardboard - scissors - coloured pencils
21st century competences	communication - collaboration - creativity - innovation - critical thinking - problem solving
Learning objectives	cognition - understanding - applicability - extension of knowledge

Project plan

The name of the exercise	Wonderful Universe

The implementation process

Generating interest	A brief history of space exploration: the history of space exploration (YouTube)
Preparations	Exploring space requires different tools: telescopes, satellites, spacecraft, ISS. Pairing exercise: space exploration tools (Wordwall)
Presentation	Distances in Space: Powers of Ten™ (1977) (YouTube) Comparison of the size of the Sun: Les ÉTOILES les plus GRANDES de l'Univers - Comparaison de TAILLE des ÉTOILES (YouTube) Our solar system's planets! Size and distance visualized (YouTube) The sizes of the planets: Got Balls - Planet Size Comparison, 12tune (YouTube)

Preliminary questions	Why are we exploring space? What can be found in space? Objects in space Are there space creatures? Why do we study space?
Design	Design your own habitable planet! Design an alien! (Write a postcard from your imaginary planet to a friend! Tell him/her why it's nice to live there.) Make a (proportional) set of models with the planets of the Solar System!
Method of discovery	Using the tools in your household, carry out the following experiments. • Baking Soda Rocket Baking Soda Rocket • Make a Mars Helicopter from Paper Make a Paper Mars Helicopter • Build your own satellite! Build your own Integral model • Make a comet! How to Make a Comet
Experiences	After you have done the experiments, write down your experiences. • What makes rockets move? • How can a helicopter travel on Mars? • What is the purpose of satellites? • What is the difference between a comet and a meteorite?
Presentation materials	Show each other your experiments, your imaginary space devices, your objects!
Results	Poster. Solar system model. Presentation. Experimental tools.
Critical thinking	Talk about why it is important to know the Universe! Why do we need to take care of our planet Earth? What can we do to protect the Earth, so that it remains habitable for as long as possible? Is there a realistic possibility that humanity could move to another planet?

Subject links

Natural science	Physics: • Gravity Gravity simulation game: NSTMF Lab Gravity Why are satellites not falling out of the sky? Why Don't Satellites Fall Out of the Sky? (YouTube) Why are satellites not falling out of the sky? | NOAA SciJinks - All about weather • Weightlessness Objects in a state of weightlessness

	Alexander Gerst: Small particles and big planets (Flying Classroom) (YouTube) • Comets What are comets? | #74| SPACE EXPLORATION IN ENGLISH
History	The history of space exploration The beginning of space exploration| #5| SPACE EXPLORATION IN HUNGARY The History of Space Exploration: a Timeline
Digital culture	Making presentations and/or posters using computer programs.
Geography, astronomy	Online sky map (Sky map online [skymaponline.net])
Visual culture	Make a drawing of your own spacecraft and the planet you want to live on!
Mathematics	The powers of 10. Conversion between units of measurement (distance, time). Pairs of ratios.
Appendix	***Space Exploration in Hungarian* video series** Where are we in the universe? | #1| SPACE EXPLORATION ON A HIGH (YouTube)

2. Solar physics primer

STE(A)M-Areas	maths - physics - biology - geography - computing - technology - art

Summary table	
Subjects	mathematics - physics - biology - geography - computer science - engineering - art - drawing
Topics	Determining the rotation speed of the Sun using sunspots. Finding the diameter of the Sun.
Age of students	14-18 years
Lesson/project duration	4×45 minutes Project task
Number of students	22-26 persons
Online learning tools	tablet - PC - smartphone (with various astronomy apps) - interactive whiteboard - projector
Offline learning tools	Experimental equipment, simple materials from which to make measuring instruments.
21st century competences	communication - cooperation - teamwork - creativity - innovation - critical thinking - problem solving
Learning objectives	Basic knowledge of solar physics: How does the Sun rotate? Why are there sunspots on the surface of a body? How are they formed? How can the apparent diameter or rotation speed of celestial bodies be determined?

Project plan	
The name of the exercise	Solar physics primer 1. The structure of the Sun. Sunspots 2. Determining the diameter of the Sun 3. Determining the differential rotation rate of the Sun 4. Space weather
The implementation process	
Arousing interest, preliminary questions	How do celestial bodies move in the Solar System? How can these movements be observed and described? Why are there dark spots on the surface of the Sun? Sometimes, the media (newspaper articles, TV news, etc.) warn that telecommunication (internet, mobile) services will be disrupted or even interrupted for short or long periods. What is causing this?
Preparations	Getting acquainted with astronomical, astrophysical databases: SDO, SOHO, Solarmonitoring, Solar Physics Observatory Debrecen, etc.

Presentation	The activities are designed to give students a solid understanding of solar physics and astrophysics, using methods that are accessible to them and that they can repeat at any time in their individual, independent research.

Method of discovery

What could be solar activity (protuberance, sunspots, flares, etc.)?
What is space weather and how does it relate to the weather on Earth? How can you determine the diameter or rotation speed of a solar disk?
How to take a photo of the day?

1. Determining the apparent diameter of the Sun

3. measurement with groups of students in the schoolyard, outdoors.

1. Figure

Tools: a long (approx. 1 m or longer) cardboard or plastic cylinder with a diameter of 10 cm or less, aluminium foil or thin metal sheet (e.g. soda can), matte transparent sheet (tracing paper, white baking paper), pencil, glue/tape, protractor, ruler. Glue the sheet of paper, completely flattened, to one end of the cylinder and the thin metal sheet to the other end, securing both securely. Make a small hole in the middle of the metal sheet with a thin needle.

Principle of measurement: the end of the cylinder with the metal plate is turned towards the Sun, and at the other end, at a given moment (t), the visible image of the solar disk (a darker spot) is drawn on the sheet of paper.
Care must be taken not to look directly into the Sun! If the correct viewing angle has been set (the image of the Sun is clearly visible), the observation cylinder should be kept fixed in this direction. Every 1-2 minutes, draw the visible outline of the solar disk on the sheet of paper as accurately as possible (a thinly sharpened pencil is recommended). At least 6-8 measurements are needed to obtain a more accurate result. In all cases, the time should be recorded (hh:mm:ss).

Data processing

$$\frac{D_N}{d} = \frac{D_{NF}}{L} \Rightarrow D_N = d \cdot \frac{D_{NF}}{L}$$

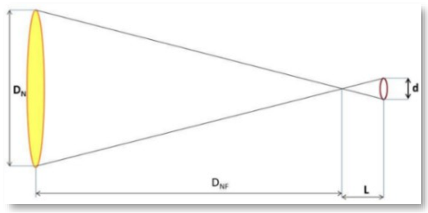


Figure 2.

Nominations

DN is the apparent diameter of the solar disk
d is the diameter of the solar disk on the frosted paper sheet (that we drew) DNF is the Sun-Earth distance, DNF=149600000 km=1,496$\cdot^{108}$ km L is the length of the observation cylinder, e.g. L=1,2 m

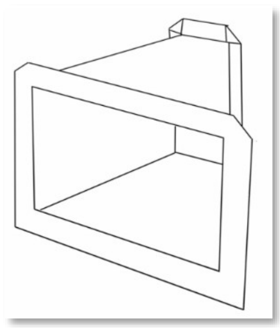
Table

Date	L (m)	d (mm)	DN$\cdot^{105}$ (km)	Average$\cdot^{105}$ (km)

Table 1.

Annex: Student worksheet 1.

Instead of a cylinder, a "needle camera" observation box can be used, with a similar working method. See diagram.



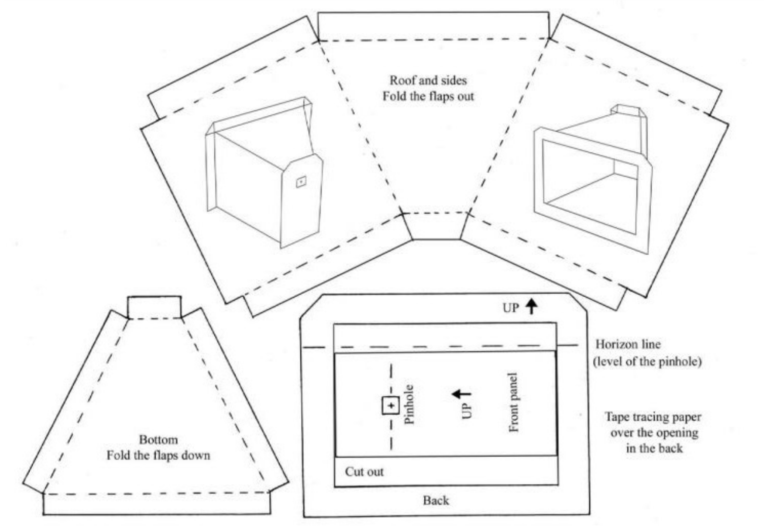


Figure 3. Model developed by Sakari Ekko (Turku) (2007, EAAE Summer School)

Compare the results (apparent diameter of the Sun) with the data in the literature. Evaluate the method of measurement.
Once you have accurately drawn the image of the sun disk on the tracing paper and the corresponding times, measure the length of the arc of the shadow patches and calculate the duration of the movement to determine the speed of movement. What can you say about the resulting velocity?
Give reasons for your answers!

Source:
[Sakari Ekko: Observations with a pinhole camera WS3 9](#)
[Diametro del Sol Camara oscura (YouTube)](#)

Experiences

Daily activities - news in the media about the failure of communication and navigation devices (collecting news, warnings: newspaper articles, short videos, animations from different news portals).
Energy problems around the world. Nuclear fusion as a possible solution... We always see the same side of the Moon, is this also true for the Sun? Why? How can it be justified?

Method of discovery

2. Determining the differential rotation rate of the Sun

Theoretical underpinning
The movement of sunspots on the surface of the sun is uniform and occurs approximately along a circular arc. The equations of uniform circular motion can be used to describe the motion.

$$\alpha=\alpha_o+\omega\cdot\Delta t \qquad (1)$$

$$\omega=\frac{\Delta\alpha}{\Delta t} \qquad (2)$$

(Where ω is the angular velocity, Δα is the change in longitudinal angle, Δt is the time elapsed between two consecutive observations.)

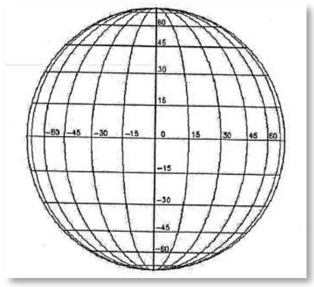
$$T = \frac{2\pi}{\omega} = 2\pi \cdot \frac{\Delta t}{\Delta \alpha} \qquad (3)$$

(Where T is the rotation period.)

$$v = \frac{2\pi R}{T} = \omega \cdot R \qquad (4)$$

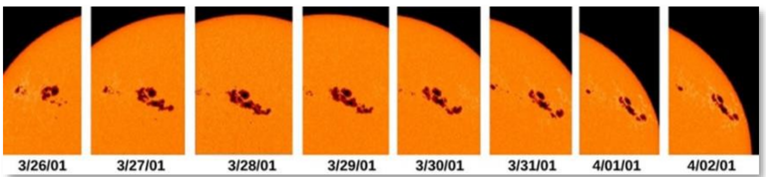
(Where v is the circumferential speed, $R=6.9598\cdot10^{5}$ km, the radius of the Sun.)

- Identify the observable sunspots on the magnetograms obtained (images downloaded from the SDO or other specialist portal database). Choose one that you can follow from its appearance to its disappearance!
- Place the grid foil on the first magnetogram and determine the position/coordinates of the chosen sunspot.



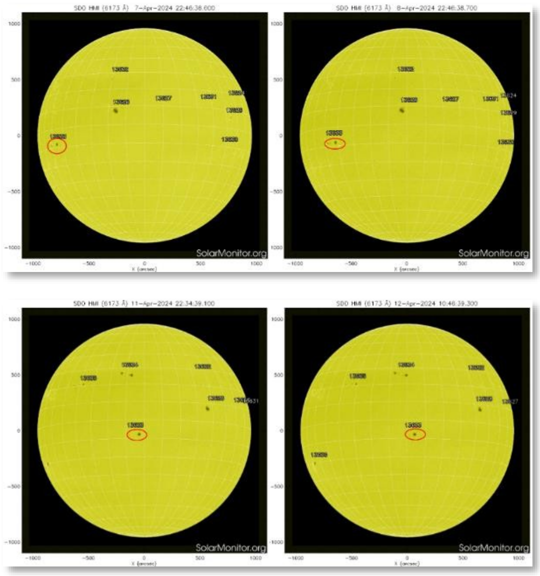
4. Figure

- Write down the sunspot's ID, the time of observation and its coordinates (x, y or β, α) in a table.
- Follow the selected sunspot until it disappears, and each time write down the relevant data! Also note how the size, shape and position of the spot changes over the period under study. Record these in the comment column!
- Based on the data obtained, calculate the distance the spot has moved from day to day and the time elapsed between the two observations. From this, calculate the period and speed of rotation of the Sun.
- Enter the data in a table!



5. Figure

The examples below show how the above method can be applied in a specific case. It is recommended to download at least 10-12 images to follow the movement of a sunspot.



6. Figure

To download Sunspots

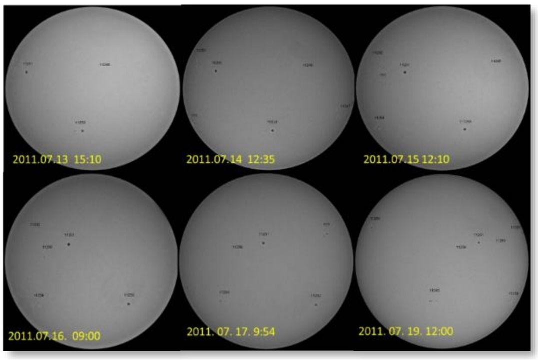
[Quick-Look Debrecen Photoheliographic Data 2014 based on SDO/HMI]
[Soho Science Archive Solar]
[Physics Introduction]

Once you have done the calculations, compare the results obtained for different solar latitudes (x/β) with the data available in the literature. What can you tell us about the Sun's rotation?

In the attached images you can find sunspots from 13-19 July 2011 to do the exercise, but you can also download recent magnetograms from 2024 from the NASA database.

date	date (hh:mm:ss)	width b (degrees)	length a (degrees)	Da (degrees)	Da (rad)	Dt (day)	ω=Δα/Δt (rad/day)	T=2π/ω (day)

Table 2 (expand as you wish)

	 Figure 8. *Annex: Downloaded sunspots 2007, 2014* *Annex: Student worksheet 2. Sunspots (simple)* *Annex: Student worksheet 3. Software analysis (advanced level)*
Feedback	After the sessions, students will be better informed about solar activities, and will have a clearer understanding of basic concepts that will help them navigate the world of everyday media news, but also of the physical and geographical concepts related to solar research. Students understand that simple methods can achieve results in areas that seem out of reach for us. However, to draw final conclusions, it is necessary to compare these results with the literature (reliable sources: NASA, ESA, specialised portals).
Presentation materials	Making posters/presentations, animations 1. Sunspots and space weather 2. Nuclear processes in stars/the Sun 3. ITER - artificial nuclear processes (ITER) 4. A report on the determination of the diameter and motion of the solar disk (images, observations, calculation results) 5. Presentation of solar activities 6. Solar space telescopes, research programmes
Results	Prepared presentation materials (PPT, Canva or Prezi presentation, poster), experimental protocols, which demonstrate the students' knowledge of solar physics and its relation to everyday life.
Critical thinking	What is the relationship (or not) between space weather, sunspots and the weather on Earth? Find answers and arguments to discuss this question! Sunspot Counts Hit Their Highest Level in 9 Years Sunspot regions What is the solar cycle and how does it affect the weather?

Subject links

Natural science	Physics: particle physics, magnetism, radiation, thermodynamics, mechanics, state-of-matter changes, optics, photometric instruments, telescopes. 1. Review and use the concepts of Kepler's laws, celestial mechanics in a new learning situation.

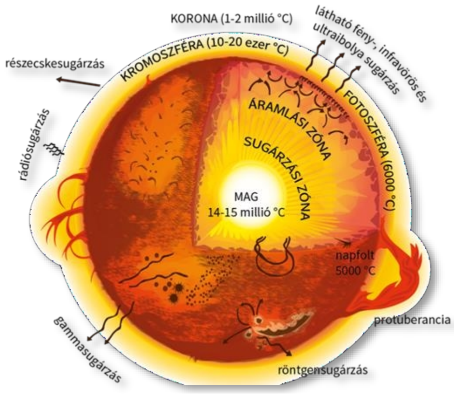


Figure 9.

2. Review and discuss the structure of the Sun using NASA, ESA imagery.
3. Characteristics of the solar surface (temperature, surface features).
Discussion of the laws of thermal motion and radiation, thermodynamics along the structure of the Sun.
Solar Granules at Record High Resolution (YouTube)
4. Nuclear processes in the magma. Flows. Energy transport processes.
Deepening and broadening knowledge of particle physics.
5. Convection currents. Solar dynamo.
6. Magnetic field and radiation.
7. Optics: telescopes, ground and space telescopes; Repetition and practice of imaging methods.

Figure 10. In January 2023, roughly 144 sunspots were observed on the solar disk during the 25th sunspot cycle.

History, science-history

Galileo and the first sunspots

How were the first sunspots observed? What was needed? What made it possible to make the first telescope? Where were the first telescopes made? How have they interpreted their presence on the Sun's surface? What significance did they attach to them?
Galileo first saw sunspots on the solar disk when he began using his telescope, built in 1610, to make astronomical observations and recorded his observations. Other astronomers later recorded the number of spots they observed, making it one of the best documented solar activities. The number of sunspots is an important measure of solar activity, since most of the solar activity is also associated with sunspots.

Digital culture

Digital tools: data processing using JHelioviewer software, or the online platforms Helioviewer.org and SOHO.

Download and use images and databases from NASA/ESA solar physics interfaces.
The Sun (NASA)
Astronomy - The Sun (8 of 16) Sunspots (YouTube) SDO|
Solar Dynamics Observatory (NASA) JHelioviewer -
Explore the Sun
SDO| Dashboard (NASA)

Geography

Solar activity and weather: during the active period of the solar cycle, the amount of radiation from the Sun to Earth increases, affecting the weather and climate of our planet.
What might be the relationship between the number of sunspots and the weather?
During the Little Ice Age, roughly 1645-1715, the so-called Maunder minimum, there were almost no sunspots on the surface of the Sun, what could be the reason for this?

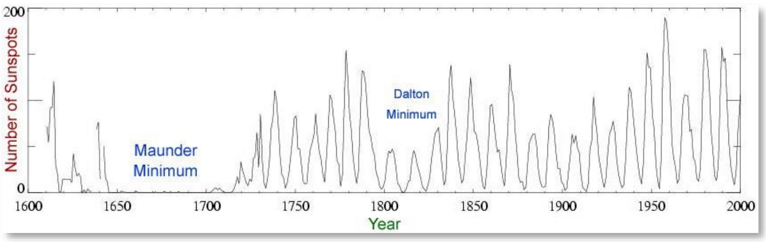


Figure 11. History of Sunspot Observations

Exploring the links between geography and astrophysics. Astronomy - The Sun (10 of 16) Surface Features (YouTube)
The Sun and Sunspots
Sunspots
Geography 9 I. Representing our cosmic environment and habitat (NKP)

Visual culture

Art supplies for poster making (coloured cardboard, paints, glue, coloured markers, etc.), camera.
For example: photojournal - Sun (NASA)
This composite image was taken by Patricio Leon from Santiago, Chile, who photographed the Sun almost every day in January 2023, and then stacked the images to show the progress of sunspots on the solar disk.

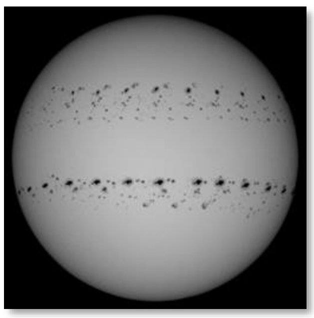


Figure 12.

Mathematics

Task solution

- Simple arithmetic problems for nuclear processes, calculation of rotation speed, rotation period.
- Diameter calculation based on similarity, e.g. for the Sun.

Appendix

Experiments/software
Aladdin Desktop

Theoretical underpinning
ESA/2014/20140701-000040
Solar Superflares once per Century The
solar fire up close
Astronomy GCSE: Topic 10 part 3 Sunspots (YouTube) The
Sunspot Cycle
Mystery of solar cycle illuminated ITER
(Wikipedia)

Ideas
Make Sunspot Cookies!

Images from
SOHO Mission Page
Sunspots
Sunspot regions
Solar Cycle Progression Expedition
to the solar fire
"A panoramic view of the Sun"

Videos
STEMonstrations: Friction (YouTube) WS5
4 Manchas Solares (YouTube) What Are
Sunspots? (YouTube)
The Deepest We Have Ever Seen Into the Sun| SDO 4K (YouTube) NASA|
Solar Cycle (YouTube)

Annex: Student worksheet 1.

Student magazine _ Solar physics- the science of the Sun's solar magnetic properties

1. Pupil's booklet - The sun's latitude and longitude

Device: eqy long (about 1 to vng¡y- longer) knrtoii vary tahun:yag heuger, with a òniérê of hem or- aurials smaller, aluniíiiiuiri foil xøgy vćkony fécnlnp (pld. (e.g., for example, a box with a lid), mat paper (tracing paper, thin shiitepaper, etc.), ceniza, glue stick, nailpaper,

On the one end of the cylinder, the thin metal sheet should be placed, completely unstuck, and on the other end, the thin metal sheet should be placed, both being well1 fixed. The centre of the sheet of wood should be stuck with a x'ékony ńivelàst opró nvilàst.

The principle of znérés:

The x'sky of the cylinder with the metal plate is turned towards the sun, and at the other end of the x'sky, the visible image of the solar disk (a dark spot) is drawn on the paper in a' given t-pillar (bh:rum:ss). lsnpba köm etlenúl nein szBbnd nézui! Once the correct angle of observation has been set, the observation tube should be inserted into this hole. On a sheet of paper, draw 1-2 minute lines of sight of the sun as accurately as possible (thinly sharpened pencil required). A maximum of ß-8 measurements is required to ensure that the result is accurate.

Adatfeldnlgozńs:

$$\frac{D_N}{d} = \frac{D_{NF}}{r} \Rightarrow D_N = d \cdot \frac{D_{NF}}{r}$$

Dø .

Markings:

- the size of the riapkornng lătszólnsos źtmérò;

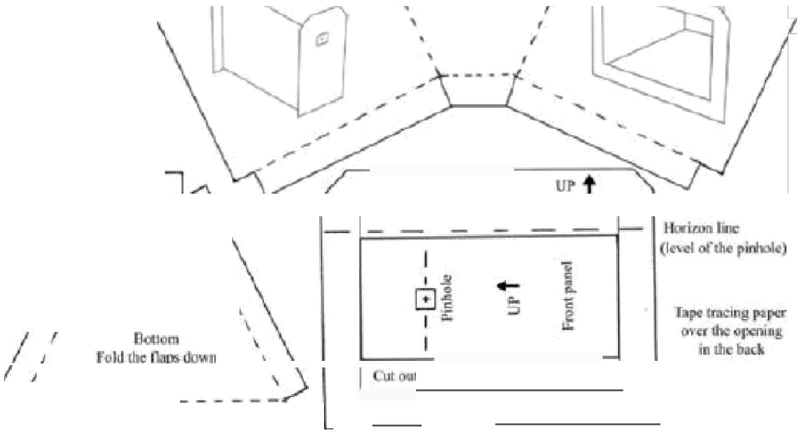
d- the sunrise to sunset on the sheet of paper (this must be drawn very accurately) Mr- the Sun-Earth conjunction: =149ó00000ktn=l,496 l0'kin

L- the weighing lienger liosszn; pld. L=l,2ni

Table

időpont	L (m)	d (mm)	D_N ($\cdot 10^5$	$D_{átlag}$ (km) 10^5

Cylinder can also be lined with a "tiikainerźs" niegfigvelo box. See below:



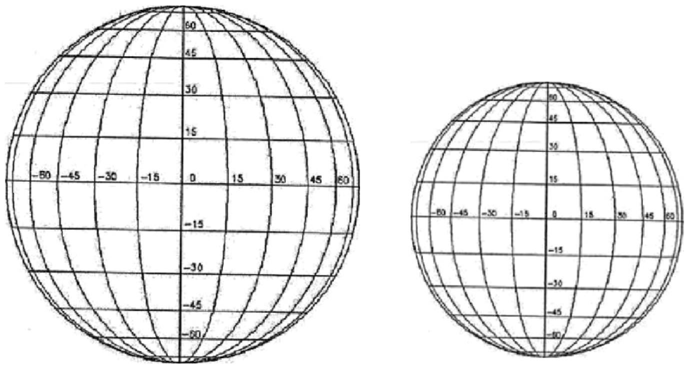
Forrás: Sakari Ekko (Turku) - által kidolgozott modell (2007, EAAE- Summer School)

Annex: Downloaded sunspots 2007, 2014

Sunspots - Student worksheet _ Help **for reading the data.**

28.04.2014-05.15. SDO/ **HMI Continuum (small)**

Sor.	date	idopoint	for.	détum	**időpont**	**Sor.**	date m	**időpont**
1	2014.04. 28.	07:30	7	2014.05. 04.	07:30	13	2til4.05.lO.	07:30
2	2014.04. 29.	07:30	8	2014.OR. 05.	07:30	l4	2014. 05.11.	07:30
3	2014.04.30.	07:30	9	2014.05.06.	07:30	15	2014. 05.12.	07:30
4	2014.05.01.	07:30	iil	2014. G5.07.	07:30	l6	2014.05.13.	07:30
5	2014. 05.02	OR:30	11	2014.05.0ß.	07:30	l7	2014. 05.14.	07:30
6	2014. 05.03	07:30	12	2014.05.09.	07:30	IS	2014.05.15.	07:30



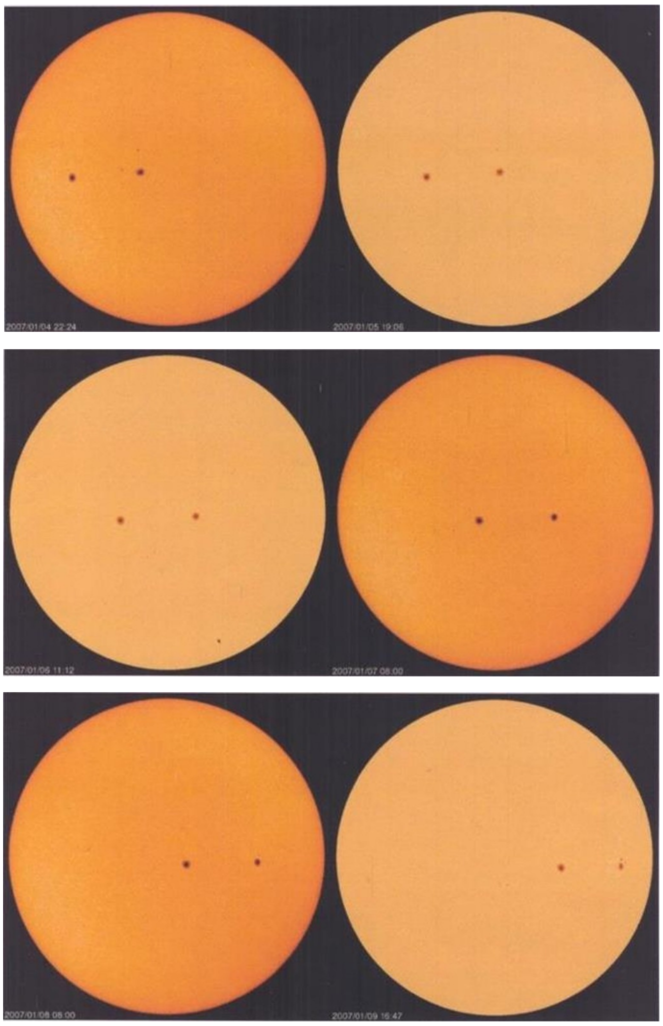
Solar grids, to determine the position of the spots

4-14 January 2007 Solar Equinox (small)

isor.	date m	idiíporit	**Sor.**	d4tum	idiïpont
1	2007. 01. 04.	22:24	7	2007. 01. 10.	D5:37
2	05 OI. 2007.	19:06	S	2007 (II. 11.	02:12
3	2007, 01 OI'.	11:1 2	9	2007, 01. 1 L	14:24
4	2007. 01. 07.	05:00	10	2007. 01. 12.	14:24
5	2tJO7. OI. (IS.	05:Hu	11	2007. Ol. 13.	12: 11
6	2007. 01. 09.	16:47	12	2007. 01. 14.	00.00

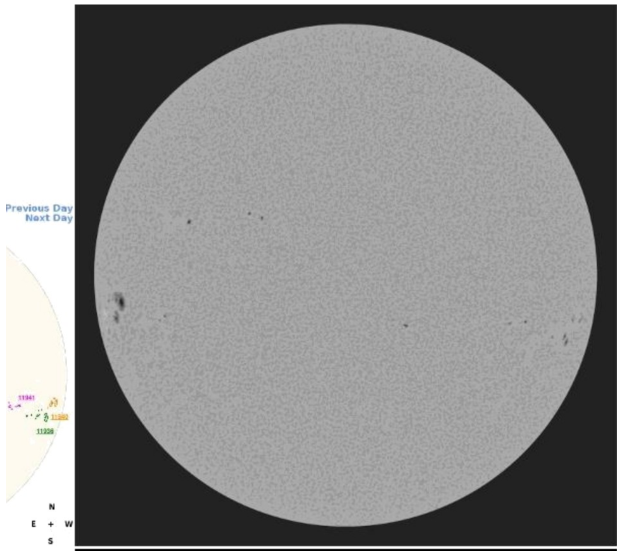
Student worksheet - Data sheet mcllćklct

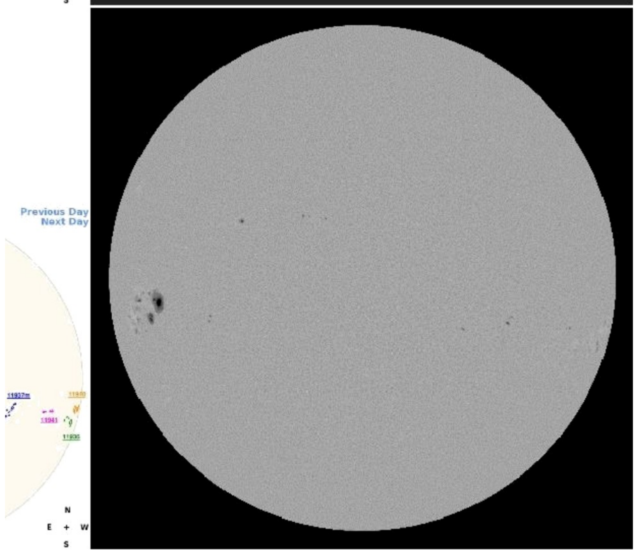
January 4-14, 2007 Spots near solar equinox



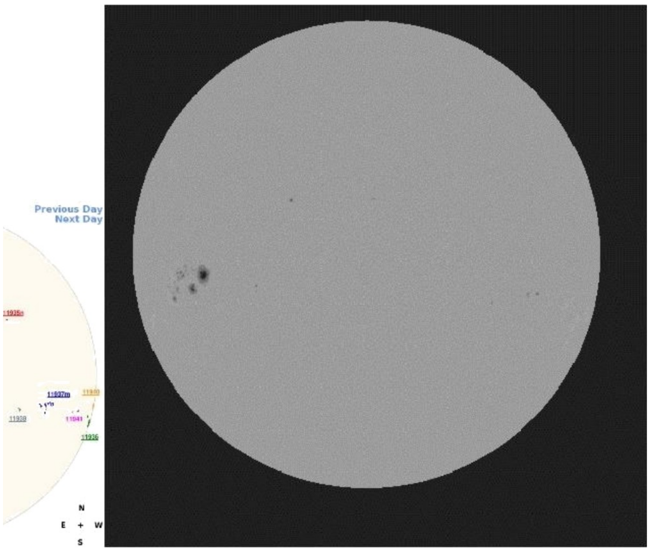
Student worksheet - Data sheet for the

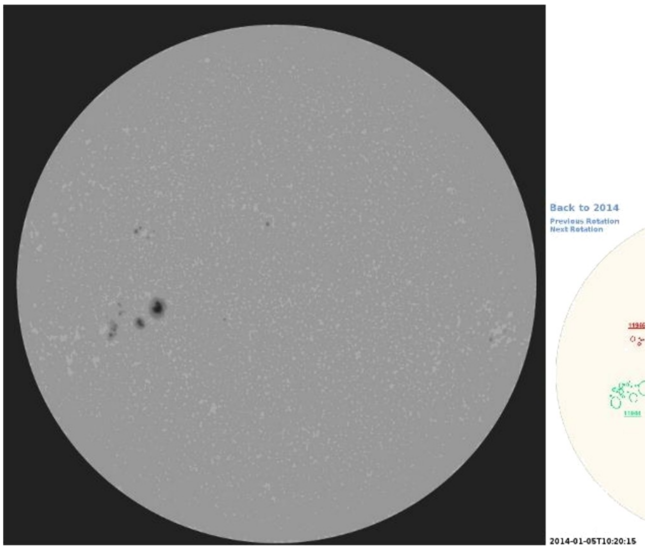
Sunspots 2014 januńr 2-13.



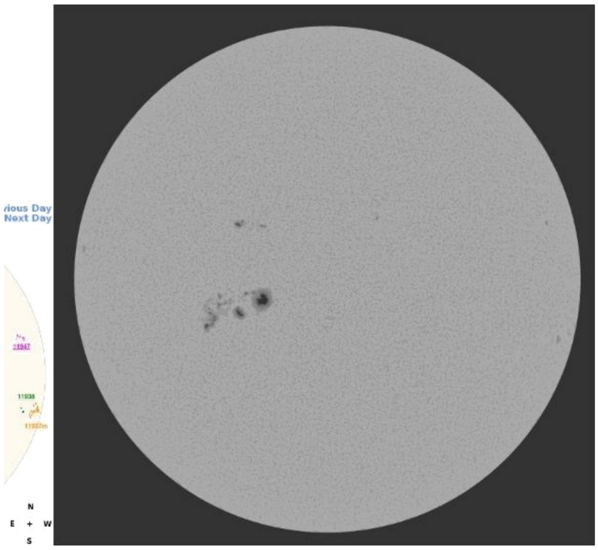


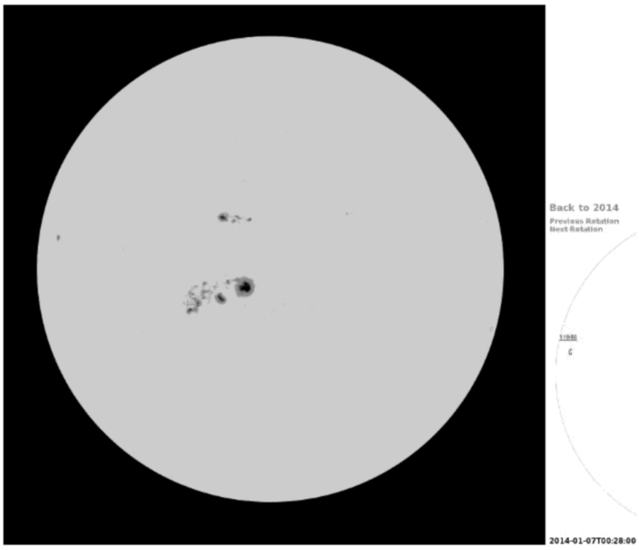
Student worksheet - Data sheet mcllćklct



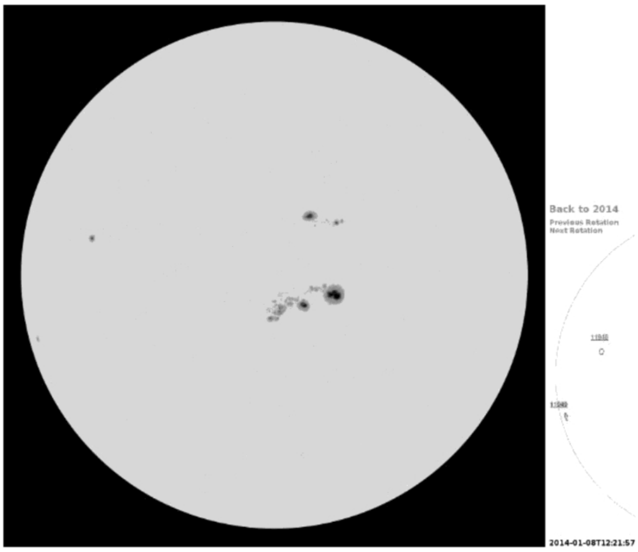


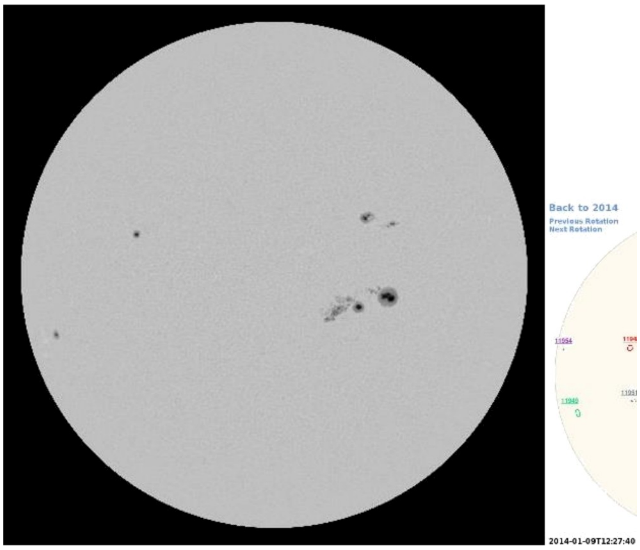
Student worksheet - Data sheet mcllćklct



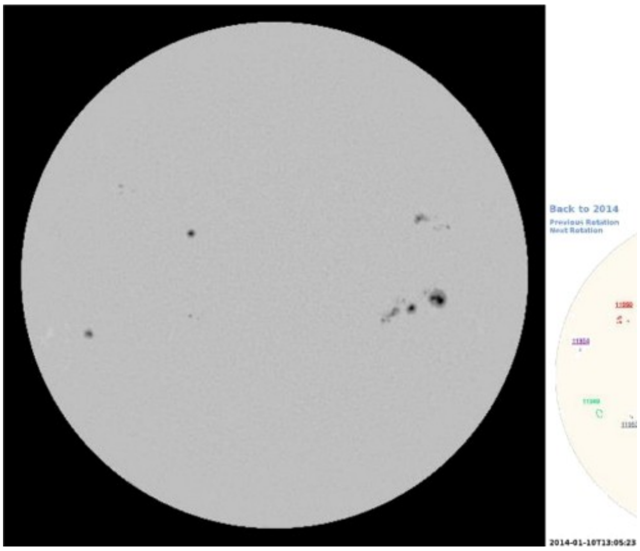


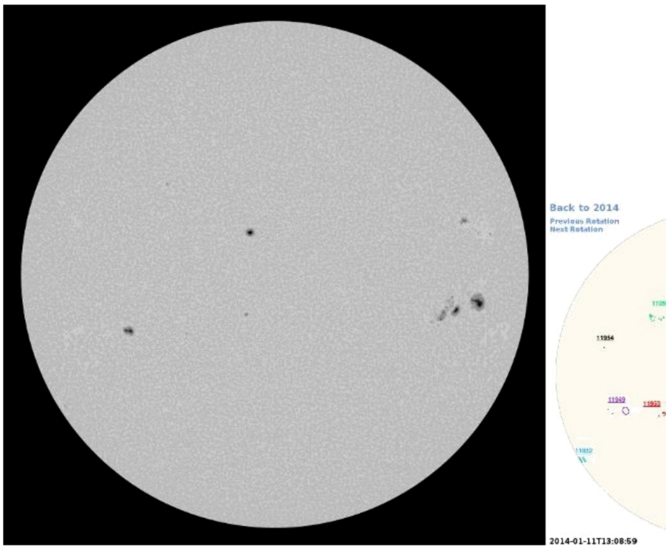
Student worksheet - Data sheet mcllćklct



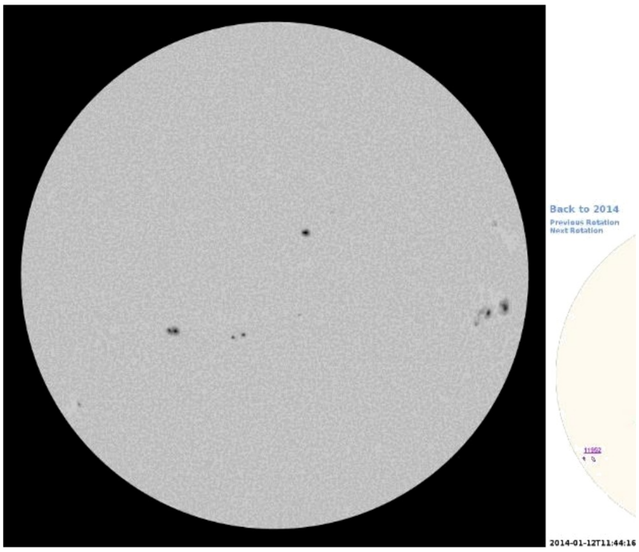


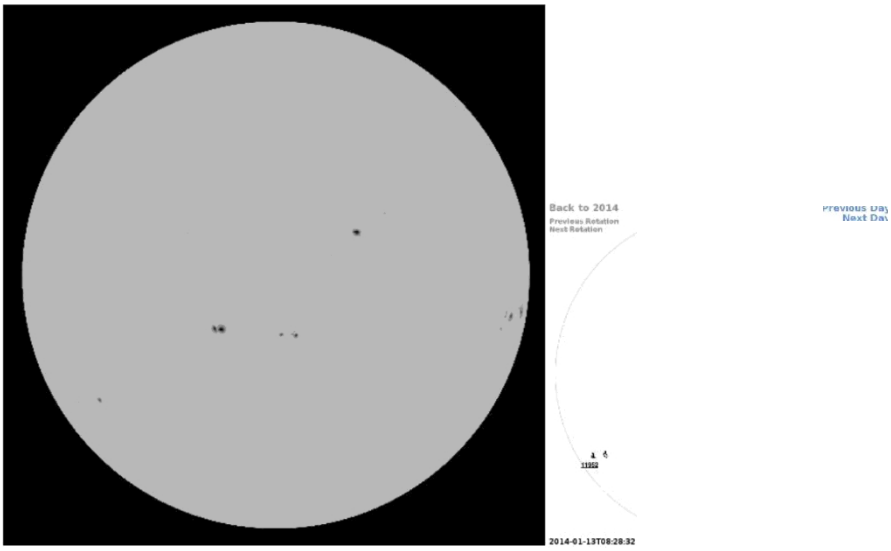
Student worksheet - Data sheet mcllćklct





Student Worksheet - Data Sheet Annex

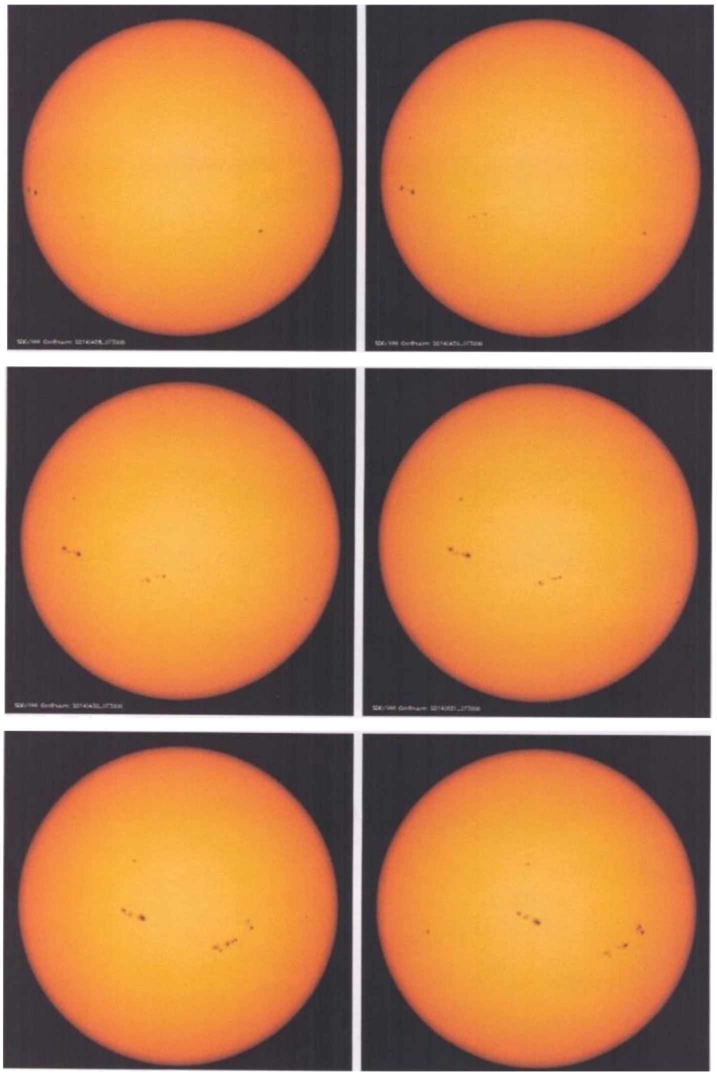




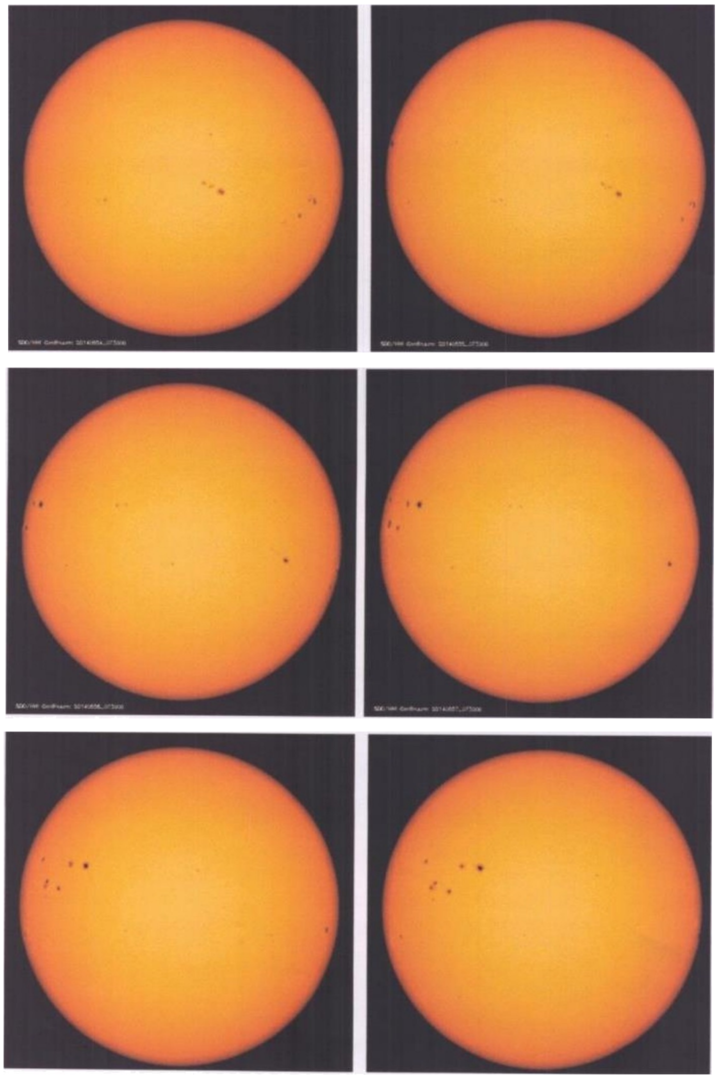
Resources: http://fenyi.solarobs.epss.hun-ren.hu/en/databases/DPD/

Student Worksheet - Data Sheet Annex

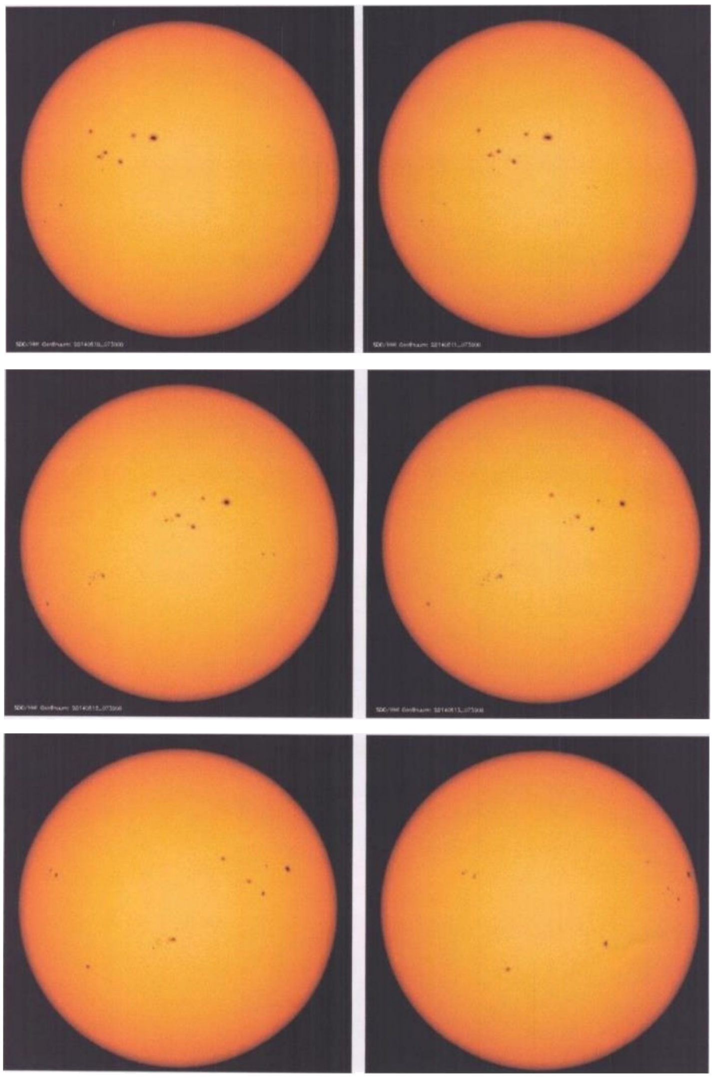
Sunspots 28.04.2014 - 15.05.2014 SDO- Continuum



Student Worksheet - Data Sheet Annex



Student Worksheet - Data Sheet Annex



Appendix: Student worksheet 2. Sunspots (simple)

Student work1day- Determine the rotation speed of the Sun using sunspots

2. Tututo worksheet

<u>Theoretical foundation:</u>

The sunspots move smoothly across the sun's surface, and are refracted in a generally circular pattern. The equations of uniform circular motion can be used to describe the motion.

$$\alpha=\alpha_o+\omega\cdot\Delta t \qquad (')$$

$$\omega=\frac{\Delta\alpha}{\Delta t} \qquad (2)$$

m- sigmoid velocity; As - change in longitude sigmoid; At - time elapsed between two consecutive observations;

$$T = \frac{2\pi}{\Delta \ldots} Dt \qquad (3)$$

T- is the rotation period;

$$v=\frac{2\pi R}{T}=\omega\cdot R \qquad (4)$$

r circumferential speed; R=6,9598 l 0-km is the radius of the Sun

Munham method:

Download at least 10-12 images (magnetograms, HMI, continuum etc.) from the NASA/ESA SDO, SOHO telescopes or the Debrecen Solar Physics Institute sunspot data.
Pld: http://fenvi.solarobs.eDss.hun-ren.hu/en/databases/DPD/ or https://soho.nascoin.iixsa.Roy sunspots/, https://sdo.esfc.nasa.eov/data/dashboard/ and https //solarmonitor oru/

Make sure you take periods when there were sunspot maxima (or a tabby spot on the disc). To do this you can check https://www.spaceweather1ive.com/en/solar- activiiY/tori-25-sunspot-regions.html or https://www..swpc.noaa.nov/r'roducts/solar-cycle- progression.

Note: *Each pupil or group should work with a different set of images from a different period, from a different database, so that the results can be compared and discussed. It is also good to pay attention to the position of the sunspots on the solar disk and their dispersion (not the same solar latitude for the spots processed by the different groups) when choosing the images.*

1. Identify the observed sunspots on the magnetograms obtained. Choose one that you can identify by **<u>looking at it.</u>**
2. Place the slotted foil on the first magnetogram and determine the position/coordinates of the selected sunspot.
3. Record the sunspot ID, the time and coordinates of the observation in a table.
4. Hover over the selected sunspots until they disappear and record the corresponding data each time. Also note how the size, shape and position of the spot changes over the time periods under study. Record these in the comment column.

5. Based on the data obtained, calculate day by day the speed at which the spot moved and the time elapsed between the two observations.
6. From the values obtained, take the period and the velocity and compare them with the rotational speed of the Sun, which you can find in the literature.

1. Table

date	idíipoint (hh:mm:ss)	width -b (degrees)	length - o(degrees)	Ao (degr ees)	Ao (rad)	At (day)	m=Ao/At (rad/day)	T=2n/"' (day)

Do the values obtained for the rotation period and the rotation speed depend on the latitude of the sunspot? How? Why?

What conclusion can you draw from this about the rotation of the sun?

Guides, resources:

httns://science nasa. gov/sun/track-the-sol-ar-cycle-with-sunspots/ httns'//www swpc noaa gov/products/solar-cvcle-progression
https://ccsar.csa.int/indcx.php'?Section=News&1d=250
httDs //svs ksfc nasa eov/gallery/sun-news/
httns //www youtube com/watch*vwgfESK u9P8
https //soho nascom nasa gov/Dickoftheweek/old/ 16dec2003/index html

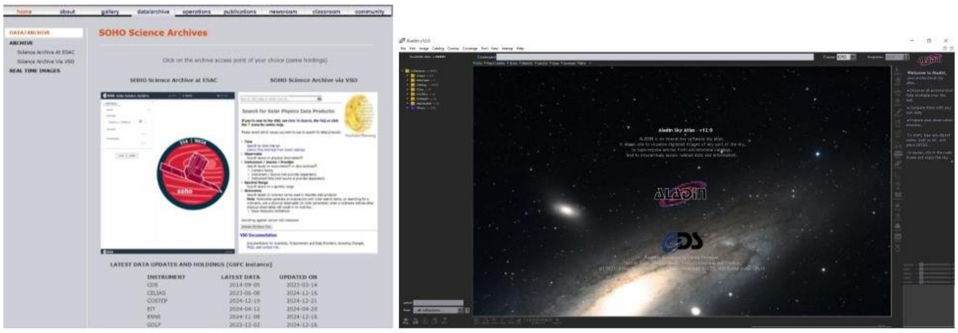
Annex: Student worksheet 3. Software analysis (advanced level)

Tanulói munkalap- NAPFIZIKA – A Nap forgási sebességének meghatározása.

3. Tanulói munkalap

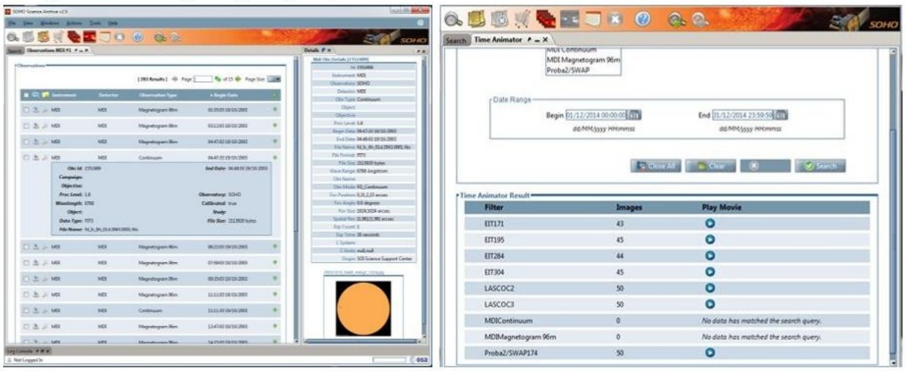
1.Adatfeldolgozás az Aladin szoftver segítségével.

A napfoltokat tartalmazó képeket a SOHO - SSA adatbázisából vesszük, amelyet az ESAC honlapon keresztül érhetünk el. Az Aladin nyílt forráskódú szoftver, amely ingyenesen tölthető le az internetről. A SOHO az Európai Űrügynökség és a NASA közös napfigyelési programjának űrszondája, amely a nap magjától a napkoronán keresztül a napszélig teljes egészében követi a naptevékenységeket.
A SOHO adatbázisban nem csak MDI képek találhatók, hanem minden napfigyelő eszköz adataihoz hozzá lehet férni, tehát a napfoltokon kívül nyomon követhetők a napkitörések, napfáklyák, flerek is.



1. ábra A SOHO-SSA adatbázis és az Aladin szoftver kezdő lapja.

Az SSA keresési paneljén be kell állítani a vizsgálni kívánt idő intervallumot, és a keresett kép, adat típusát (pld. MDI- magnetogram), majd el kell indítani a keresést.

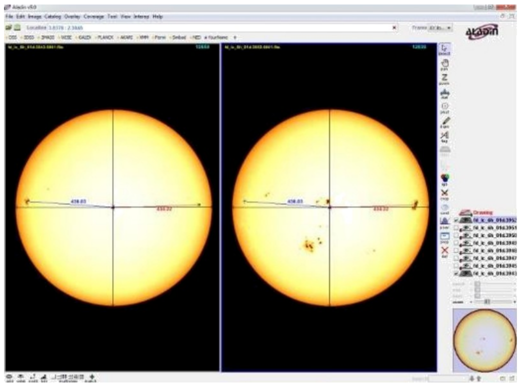


2. ábra A SOHO napfolt adatbázis keresési panelje. Animáció készítése a SOHO programmal

Ha kiválasztjuk az összes képet a napfolt megjelenésétől az eltűnéséig, akkor egy animációs képsort is létrehozhatunk a mozgás tanulmányozására, a Time Animator paranccsal (SOHO Science Archive- “Windows” menü és “Time Animator”).

1/4.

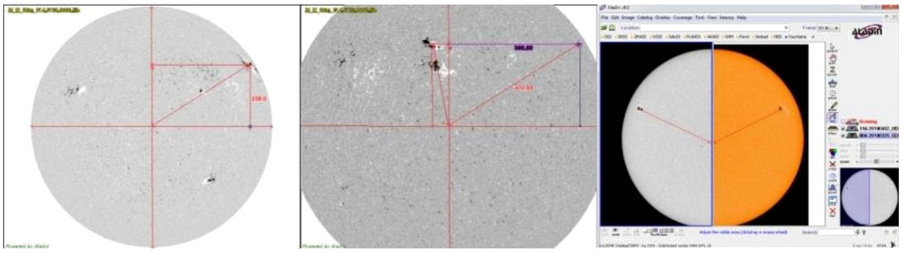
Student worksheet- NAPHYSICS - Finding the rotation speed of the Sun.



3. abra Highlighted image of the sunspot on the sun disk and positioning.

dàtum	idli(point	x	Ax	R	sinb=òx/R	Q(Rs)in	ò9	i"=òb/At	T=2a/m

In the projected images, the position of the sunspot relative to the centre of the disc can be determined by the measure command: x and y coordinates, or by determining the direct position, or by specifying the position in polar coordinates (position vector r, with horizontal color). It is possible to simultaneously project the two images in which the sunspot is appearing and the one in which it is disappearing on the edge of the solar disk. The data read from the image strip can be used to determine the rotational speed of the sun based on the movement of the spots.



4. Figure 1 Determining the position of the sunspot with Aladin Sky Atlas. The rotation period is obtained by substituting the data obtained into the isosequences below.

$$szélesség = \arcsin\left(\frac{(Y - Y_{közép})}{R_{Nap}}\right) \qquad length = \arcsin\left(\frac{(X - X_{közép})}{R_{Na}}\right)$$

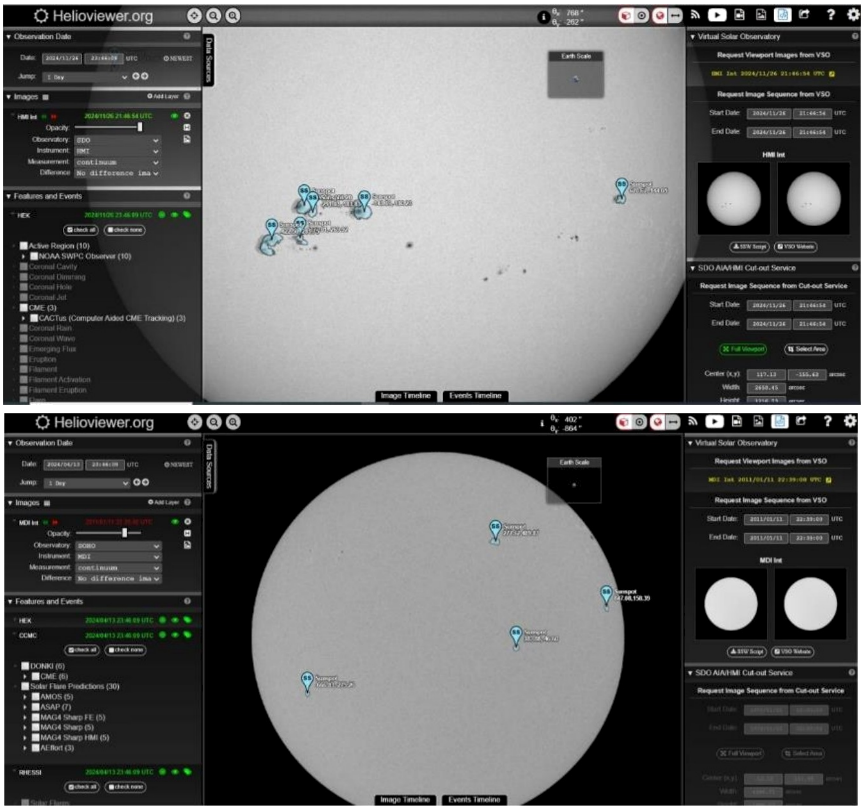
2/4.

Student worksheet- NAPHYSICS - Determining the rotation speed of the Sun.

dátum	**időpont hh:mm:ss**	x	y	R	sino=y/R	e-arcsin(y/R)	An=6]3	tu=Ao/At	**T=2π/ω (nap)**

2. View it on *helioviewer" or with the jhelioviewer software:

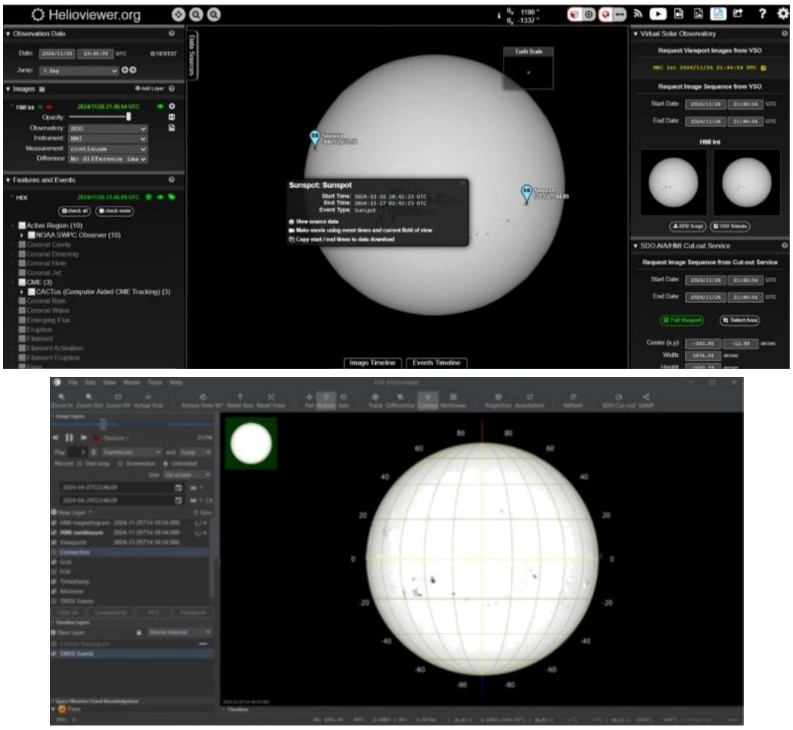
Downloadable resources: jhelioviewer: https://www.ihelioviewer.org/index.html
helioviewer online: https://heliovieu,er.org/



5. Figure 1.2 Image snapshots of the helioviewer worksheet

3/4.

Student worksheet- NAPHYSICS - Determine the rotation speed of the Sun.



6. ábra Thelioviewer - https://swhv your be/user manual/#imaEes sun

Riividities:
SOHO - Solar Heliospheric Observatory; SSA -
SOHO Science Aichive
ESAC - https://ssa.esac.esa.int/ssa/#/Lages/search
https //idoc-inedoc.ias u-psud. fr/sitools/clicnt-user/index html "oroiect=Medoc-Solar-Portal Aladin astronomical atlas/software: https'//aladin cds unistra fr/iava/noh- aladin.pl?frame-downloading#Description https://sdo.gsfc.nasa.gov/data/aiahmi/browse/quened.php
MDl - Michelson Doppler Imager; type of image taken by one of the instruments of the SOHO spacecraft;
HMI- intensitygram
Useful links, forrfisoh: https://science.nasa.gov/mission/soho https://umbra nascom.nasa gov/index.html/
https //solarmonitor org/indcx php'?datc=2024I 126 https //www lmsal com/solarsoft/last events/
htt0s'//science nasa.gov/heliophvsics/ https://science.nasa gov/sun/

4/4.

3. Exploring planets outside the solar system. Determining the parameters of exoplanets

STE(A)M-Areas	physics - computer science - geography
Interdisciplinary links	Today, research work is unthinkable without the use of information technology. That is why it is very useful to use IT as a tool to help students to develop insights that will help them to develop a realistic picture of the Universe and their place in it. They encourage independent thinking and the recognition of interconnections, which also link disciplines more closely.

Summary table	
Subjects	physics - digital culture - geography
Topics	Determining the properties of extra-solar planets.
Age of students	15-20 years
Lesson/project duration	3×45 minutes
Number of students	15-20 people in small groups
Study material	In four sessions, from the location of the Earth to the formation of exoplanets and data processing, we will explore the diverse world of planetary systems, giving us a basis for the idea of how the formation of life is a law or an accident.
Online learning tools	Szabó M. Gy. - Simon A. - Szalai T. 2011. *Physics Review*. 61/7-8: 217. Horváth Zs. 2017. Exoplanets at all levels. *Physics Review*. 67/3: 93. Ollé H. - Kovács T. 2020. What lies in the photograph, or light curve analysis in the classroom. *Physics Review*. 70/9: 324.
21st century competences	problem-solving - recognising relationships between information - applying mathematical simplifications - using information technology - cooperative skills - working in a team
Learning objectives	Students will be tested on the accuracy of a simple estimate of the transit length or depth of an eclipsing exoplanet system, avoiding the need to fit complicated mathematical models and using high-school methods to get a good idea of how astronomers determine the parameters of eclipsing planetary systems. In this way, students will develop an understanding of how to get meaningful information from a complex data set, and how it translates into everyday science and affects our daily lives.

Project plan

The name of the exercise	Exploring extra-solar planets Determining the parameters of exoplanets

The implementation process

I. Our place in the universe - theoretical underpinnings

Theoretical background

The lesson is structured around 3 main themes:

1. Solar System

In the first unit, we need to place our Earth in the Universe and explain its complex movement. This is an excellent opportunity to give students a better understanding of Kepler's Laws in the standard curriculum and to demonstrate its applicability through an example.

Let us now turn to the formation of planetary systems, the concept of the accretion disk, the visible manifestation of the law of conservation of perdition.

This lesson is a great way to link geography and physics lessons, deepening their understanding of the celestial equator, the ecliptic, and making them aware of the tilt of the Earth's axis of rotation, for example.

After clarifying the concepts of celestial and terrestrial coordinate systems, we can now turn to positioning methods.

2. Other planetary systems

It is important to highlight the similarities and differences between exoplanetary systems. Here, we will be sure to highlight why orbital orientation as seen from Earth is so important in the study of eclipsing exoplanetary systems, including in our own work.

Let's ask them what might be causing the specificities of each system, the anomalies that might occur.

What are the physical quantities that describe the planetary system (distance from the star, mass-to-mass ratio, orbital period), the concept of orbital elements.

3. Housing Authority

Make students aware of the habitability of a planet.
Does the system we are investigating meet these requirements (distance from the star, surface temperature, atmosphere, chemical composition, states of matter, spectroscopic determination of acceleration of gravity...)?

II. Peculiarities of exoplanetary systems - Exploring the database

Preparation

Before the session, the computers on which the students will work must be prepared. If you have the opportunity to teach in a computer room, take advantage of it. Make sure that all available whether you have an internet browser or spreadsheet software installed on your computer.

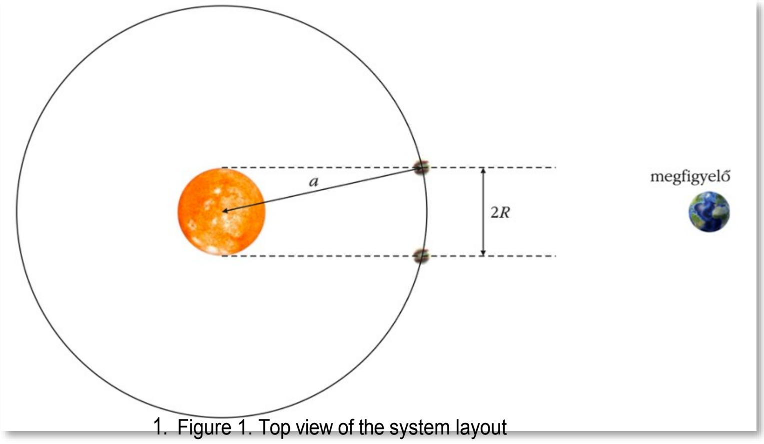
Realisation

The session is divided into 2 large units (15+30 minutes):

1. Mathematical simplifications

Choose a planetary system with a relatively small eccentricity, so that you can approximate the orbit by a circle, which simplifies your situation considerably. For example, the Kepler-1, -7, -12, -15, -41, -43, - 45 systems could be suitable (Ollé H. - Kovács T. 2020).

If the planet is far enough away from its star, the curvature of the path it travels during the occultation is also negligible and can be approximated by twice the radius of the star - 2R (Figure 1).



1. Figure 1. Top view of the system layout

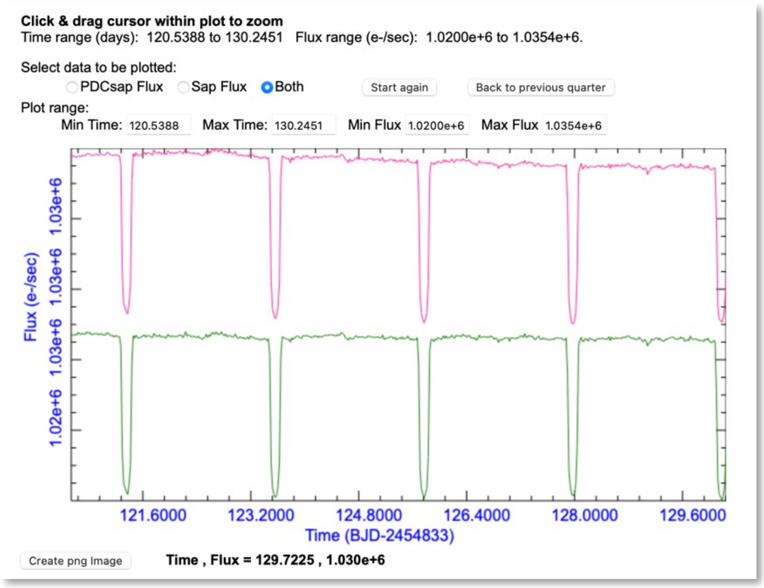
In this case, we can exploit the relationships learned during the circular motion (Ollé H. - Kovács T. 2020).

2. Definition of data

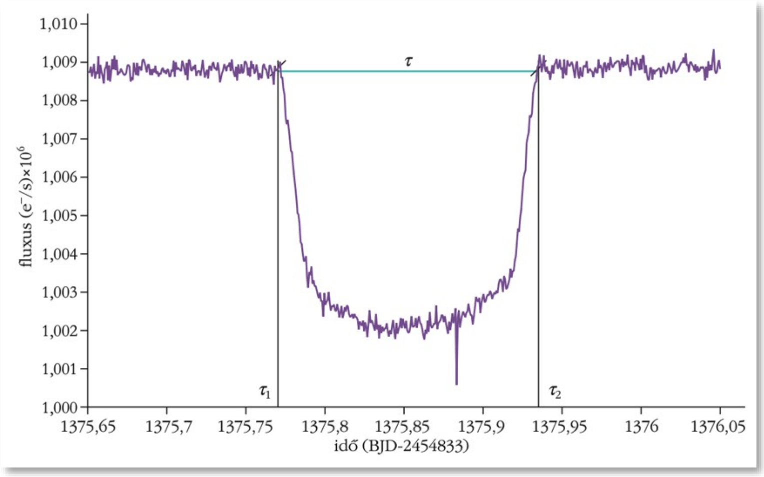
Introduce students to the database on the Mikulski Archive for Space Telescopes (MAST) website.

- in the "Target Name" field, enter the ID of the object you want to target (for example, Kepler-2),
- then click on the "Search" button to get a table,
- here you will find datasets sorted by date in the "Dataset Name" column.

Virtually any click on one of these will immediately bring up a light curve. The horizontal axis shows the time and the vertical axis the incident flux (Figure 2).

		 Figure 2. For a more accurate result, it is useful to zoom into the figure. Simply use your mouse to select the area you want to zoom in on, and the detail will automatically zoom out. By moving the cursor directly under the figure, the time and flux value for that position is displayed. This is the data we need to record. To simplify things, we have created an Excel spreadsheet (ZIP file) that is easy for students to use. If we enter the data here, it immediately calculates the parameters for the system.
	Hypothesis	If the students have mastered the use of the database and collect as much data as possible at different times - but it is important to remember that it is the same system - the more accurate the results will be in the final data processing session. This will help them understand the importance of reducing measurement error.
	Plan	The plan is to determine the parameters of a specific planetary system, e.g. the Kepler-2 (HAT-P-7b) system, with the highest possible accuracy, and compare this with currently accepted values in the literature.
	Discovery	The comparison with the literature mentioned in the previous point teaches them that, with technical and methodological progress, the results obtained can be further corrected, and they learn to search among authoritative sources, to read real scientific journals. They also make their own measurements using data from the Kepler space telescope. This is a really uplifting and motivating feeling.
		III. Data analysis
	Plan	The data from the previous session should be evaluated and converted into usable, meaningful information. This helps students to visualise the system.
	Realisation	Determination of parameters:

• **Coverage length**: looking at Figure 2, we can immediately estimate the start and end time τ_1 and τ_2 of the transit (Figure 3). Subtracting these two data from each other gives the length of the transit τ in days. Averaging these data in the spreadsheet gives the overlap
final data on the length of the



3. Figure

• **Planet to star ratio:** when a planet eclipses part of a star, the observed luminosity (flux) drops. From a geometric point of view, we obtain that the ratio of the apparent disk of the star to the apparent disk of the planet passing in front of it gives the relative decrease in luminosity, the root of which is equal to the radius ratio of the planet and the star (Ollé H. - Kovács T. 2020). In this case, we give the students the task of finding the radius of the star determined by another method in a textbook. Once this is found, the planet's mass is substituted into the ratio.

• **Orbital period:** to determine the orbital period, two consecutive occultations must be observed, since this is when the planet is in the same position during the consecutive orbits. Fortunately, this is also easily accessible on the website used. To determine the orbital period, set the view to show two consecutive occultations (Figure 4), then move the cursor between the two occultations, T_1 and T_2
minimum can be determined by a simple subtraction. This can also be easily done in the spreadsheet.

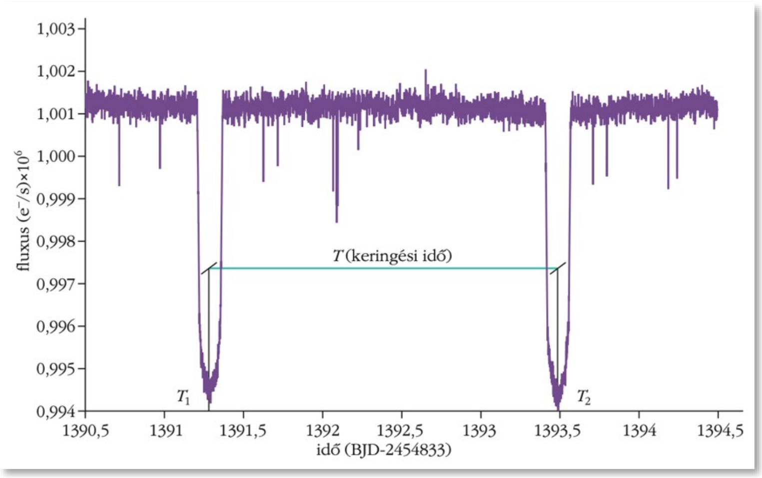


Figure 4.

• **Mass of the star:** in this case, Kepler's third law is used to determine the mass of the star, given the orbital period T and neglecting the mass of the planet, using the following equation:

$$M_{\ast}=\frac{4^{\pi(2)}a^{3}}{GT^{2}}$$

Where $M_{\ast}$ is the mass of the star in kilograms, a is the semi-major axis of the orbit in metres, G is the gravitational constant ($6.6743\cdot 10^{-11}$ m3kg⁻ 1s⁻ 2) and T is the orbital period in seconds.

Project product

At the end of the sessions, we summarise the knowledge and the results. The following table shows the parameters defined for the Kepler-2 system compared to the literature values. In this case, 53 students participated in the session (in 4 groups).

1. táblázat

A diákok, HAT-P-7b (Kepler–2) rendszer paramétereire vonatkozó becslései összevetve az irodalmi értékekkel [4].

paraméter	a diákok által becsült érték	irodalmi érték
fedés hossza (τ)	0,1667±0,009 nap	0,1669±0,003 nap
bolygó és csillag sugáraránya (r/R)	0,0807±0,0036 (ábrából) 0,0772±0,0052 (adatokból)	$0{,}077590\pm3\cdot10^{-5}$
keringési idő (T)	2,201631±0,011335 nap	$2{,}204737\pm1{,}7\cdot10^{-5}$ nap
pálya fél nagytengelye (a)	0,0366±0,0011 CSE	0,03796±0,00063 CSE
csillag tömege ($M_{\ast}$)	1,4823±0,4107 naptömeg	1,500±0,03 naptömeg

Figure 5.

Experiences

After the sessions, the students develop a clearer, clearer picture of the research work itself, and that a degree of simplification is often preferable to getting lost in the detail. However, we as teachers need to point out that this increases the uncertainty of the result, but is useful in terms of creating a clear picture.

Interdisciplinary link

Geography	The three sessions allowed students to discover for themselves how a seemingly confusing set of data can be transformed into clear, understandable information to characterise the planetary system. We used their knowledge of geography and the tools of computer science and mathematics.
Arts	The sessions can be further extended with a fourth session, where the image they have created is presented through a piece of art. This could be a poem, a drawing, a painting or even a description or description using artificial intelligence to generate a picture of the system under study. In this way, art - whether classical or AI-based - can be included in the project.
Appendix	**Sources, references** Szabó M. Gy. - Simon A. - Szalai T. 2011. *Physics Review*. 61/7-8: 217. Horváth Zs. 2017. Exoplanets at all levels. *Physics Review*. 67/3: 93. Ollé H. - Kovács T. 2020. What lies in the photograph, or light curve analysis in the classroom. *Physics Review*. 70/9: 324. Mikulski Archive for Space Telescopes (Kepler Data Search & Retrieval) Excel spreadsheet ZIP file

4. Pictorial physics

STE(A)M-Areas	mathematics - physics - technology - history - art
Intercultural relations	Who and what have discovered in physics and technology in different cultures? Where and when did these inventions appear? Is there a role for different cultures in the primacy of each discovery? What do we predict for the future in terms of discoveries? What, from whom, when and where do we expect the science of the future?

Summary table	
Subjects	physics - technology
Topics	Key laws. The history of scientific discoveries.
Age of students	12-20 years
Lesson/project duration	8×45 min
Number of students	12 persons
Online learning tools	The given paintings will be drawn by lot among the persons. They have to write an essay about it, using the pictorial clues to explain where and when they are, what laws or inventions they have discovered, what people they see in the picture. They then report back to their peers. In the second part, they choose a picture by secret ballot and then act out together what they see, feel, suspect and know in the picture. At the end, the performer and the audience evaluate and draw conclusions together.
Offline learning tools	Károly Simonyi 1986. *The cultural history of physics*. Budapest. Werner Heisenberg 1978. *The part and the whole*. Werner Heisenberg. Victor F. Weiskopf 1978. Victor Victor Weiskopf, Victor Weiskopf, Victor Weiskopf, Budapest. F. Brandel 1985. *Material culture, economy and capitalism XV-XVIII.* Budapest: Gondolat Publishing House. John and Mary Gribbin 2003. *Science for everyone*. Accord Publishing. Felix R. Paturi 1991. *The chronicle of technology*. Officina Nova.
21st century competences	innovation - creativity - problem-solving - analytical thinking - active learning - critical thinking - information and communication technologies - cooperation
Learning objectives	acquiring scientific knowledge - deepening understanding of the subject - acquiring summarising knowledge - helping to build learning communities - developing presentation, writing and organisational skills - developing abstraction skills

Project plan	
The name of the exercise	Pictorial physics
The implementation process	
Enquiry	When and where did science emerge? Who were its main proponents? Who is your favourite scientist, why did you choose him? What do you know about him? Who is your favourite inventor, why did you choose him? What do you know about him? Do physics and technology have something in common, and if so, what might it be? Does science have an impact on society, and if so, what is it? Has science changed history, when and how? Do you know the fate of a discovery or invention? Do scientists need inspiration, can you give a concrete example? What discoveries and inventions do you think will appear in the future? How will they affect our daily lives? Have you invented anything yet? If so, what and when?
Inspiration	Collecting ideas from students.
Preparation	Purchase of materials (reproductions of the pictures, paper, pens, possibly cloths for costumes and scenery, sticks, masking tape). Paper and pen to write a short essay. Clothes, hats, etc. to make costumes for the play.
View at	Writing of essays, then illustration of the painting on reproductions. 12 short presentations (10 minutes).
Plan	The essays will give you a glimpse into the social environment of the explorers of the time, their needs, wants and needs, and how they compare with today.
Discovery	The project is about using a discovery method to teach students about the laws of physics, and the hands-on mind-on method results in a deeper understanding and more lasting knowledge.
Retrieved from	Students compare their results with their preliminary guesses and formulate their experiences.
Reflection from	Why are the preliminary suspicions and the experienced ones the same or different? Is there really a strong link between science and society? How does this knowledge feed back into our daily lives? What is it like to experience the joy of discovery?
Presentation	Based on the knowledge they have acquired from the paintings, they develop the visual material of 1 specific painting into a play. They choose themselves who they want to portray (even several characters), write, direct and organise the play together. Later, they may perform their work in other venues, or write a script or make a video of their work.

Project product	Everyone has a reproduction to take home or exchange if they have a different favourite. If a textbook is produced, it will be sent to each pupil in DOCX format. Individual essays are collated and distributed to everyone, as are digital versions of the reproductions. Video of the play.
Plan	The essays will give you a glimpse into the social environment of the explorers of the time, their needs, wants and needs, and how they compare with today.
Redesign	Give students enough time to redesign their processes and modify their reports.
Stations	
Science station	Science involves thinking, observing, experimenting. It is important to formulate preliminary assumptions and share experiences. Formulating and answering questions about the history of science and society in the world. Collecting, writing up and presenting data. Tools: notebook, computer, pen, mobile phone.
Research station	Self-discovery in the relationship between science and society. For example, has the industrial revolution changed society? How? Why is a theoretical relationship in physics only accepted if it has been experimentally proven? When do you have to wait a long time for a proof? Can you give an example? Tools: iPads, books, maps, encyclopaedias, tablets, computers, fiction and non-fiction books.
Technology station	Electronic technology: computers, tablets, smartphones, interactive whiteboards, digital cameras. Traditional technology: sticks, duct tape, paper, cloths, hats, other handy utensils.
Engineer ing station	Engineering tools and materials: staples, masking tape, felt-tip pens.
Art and design station	Artistic and design accessories: clothing, hats, other handy utensils, reproductions of paintings.
Mathematics station	Mathematical tools: • draw with dice, • exploring the relationship between physicists and mathematics.
Receiving station	Record a play with your mobile phone and play it back immediately afterwards.
Experiences	After the project, you and the students will evaluate the project together, discuss your experiences and further ideas and plans.
Appendix	**Links** Location of digital images of reproductions (OneDrive) Science history curiosities, essays (OneDrive)

Videos

15 technological advances that changed the world
15 Emerging Technologies that Will Change the World (YouTube) 10 of the most influential figures in science and technology
Top 10 Influential Figures in Science and Technology (YouTube)

Vita

Discuss, confirm or refute predictions, preliminary questions. The 13th picture (the picture of the future) is a thoughtful ending, as it lacks celebrities and discoveries.

Group work

Designing a play, assigning roles and tasks, either in small groups or in groups.
Play the play in the group.

Experiments

Using the loop sticks and masking tape provided, the main experiments should be demonstrated and require a high degree of creativity. They can also involve tools from their environment.

5. pARTicle physics

STE(A)M-Areas	physics - mathematics - design - art
Intercultural relations	Differences between atomic theories (worldviews), knowledge of the arts.

Summary table	
Subjects	physics - art - mathematics
Topics	Particle physics.
Age of students	12-20 years
Lesson/project duration	12×45 minutes
Number of students	8-10 people
Online learning tools	Dr. Éva Mária Oláh: Introduction to Particle Physics Dr. Éva Mária Oláh: Playful Particle Physics Éva Mária Oláh:Let's Build Particle Physics
Offline learning tools	Éva Mária Oláh 2017. Let's build particle physics! *Nucleon*. X: 203. Éva Mária Oláh 2018. Let's play particle physics! In Polonyi Tünde - Abari Kálmán. *Psychology-Pedagogy-Technology*. Oriold és Társai Kiadó. 375-382.
21st century competences	innovation - creativity - problem-solving - analytical thinking - active learning - critical thinking - information and communication technologies - cooperation
Learning activities	to acquire scientific knowledge - to gain a deeper understanding of a given topic (Particle Phisycs) - to help develop learning communities - to develop manual skills - to develop abstraction skills - to develop artistic sensibility

Project plan	
The name of the exercise	pARTicle physics
The implementation process	
Preliminary questions	What is the Universe made of? How much did the ancient Greeks know? What were the steps in the development of atomic theory? What are elementary particles? How can we show the invisible particles? Where do we come from, what are we made of, where are we going? What do we know about additive colour mixing? What do we know about complementary colours?

Why are there 6 types of quark?
What can we use the dice (hexahedron) for? What do physics and painting have in common?
What are neutrinos?

Inspiration

Collecting ideas from students.

Preparations

Purchase of materials (coloured cardboard, scissors, glue, felt-tip pens, ruler, styrofoam, brush, paint).
Cut templates.
Drawing data on the cubes, gluing the solids together. Baking muffins, collecting candies.
Hulahopp hoops.
Coloured papers.

Introduction

1. Presentation of the REGARD research group logo: in physics there are symmetries, symmetry is beautiful.

2. What does a good physics teacher's umbrella look like?

3. The meeting of physics and painting (Stonawski-Fülöp 2020). Based on an article by Tamás Stonawski and Csilla Fülöp, to present some parallels using famous works of art.

1. Figure

4. What do we need to know about CERN? Illustrated with poem and photo.

5. Introducing Particle Zoo, an idea to raise awareness.

Figure 2.

6. The famous Large Hadron Collider.

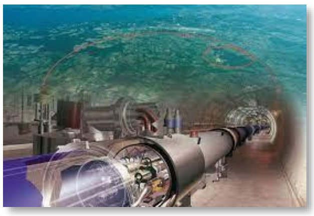
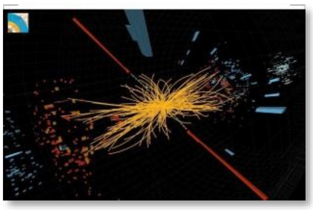


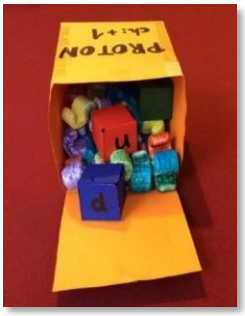
Figure 3.

7. Invisible particles with simulations (= artworks?).



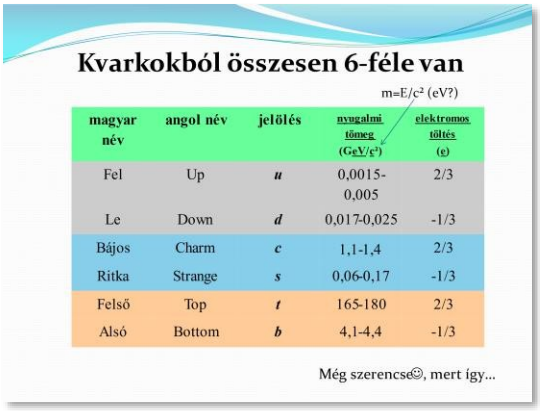
4. Figure

8. An introduction to the internal structure of the proton and neutron. Resolution of the proton cube.



5. Figure

9. The electrical burst filling of quarks. How many types of quarks are there?



Kvarkokból összesen 6-féle van

m=E/c² (eV?)

magyar név	angol név	jelölés	nyugalmi tömeg (GeV/c²)	elektromos töltés (e)
Fel	Up	*u*	0,0015-0,005	2/3
Le	Down	*d*	0,017-0,025	-1/3
Bájos	Charm	*c*	1,1-1,4	2/3
Ritka	Strange	*s*	0,06-0,17	-1/3
Felső	Top	*t*	165-180	2/3
Alsó	Bottom	*b*	4,1-4,4	-1/3

Még szerencse☺, mert így...

6. Figure

10. To make 6 types of quark cubes, write the initials of the English names of the quarks and their electric charges on the sides of the cubes with a marker pen (in the correct order).

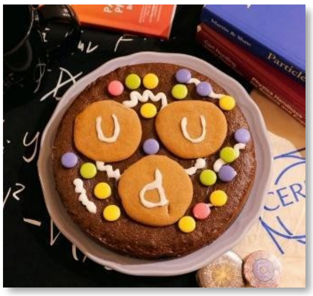
7. Figure

11. An introduction to the structure of nucleons.

8. Figure

12. On coloured cardboard, write the names of the quarks and hand them out, then have everyone find their "pair", arranged by nucleon (for example, have the students stand in a wavy-hop circle).

13. Proton muffin: put out tubes of food colouring, Smarties candies, linzer circles in small bowls with the pre-made muffins. The muffins should be decorated to show the internal structure of the nucleons, then they can be eaten.



9. Figure

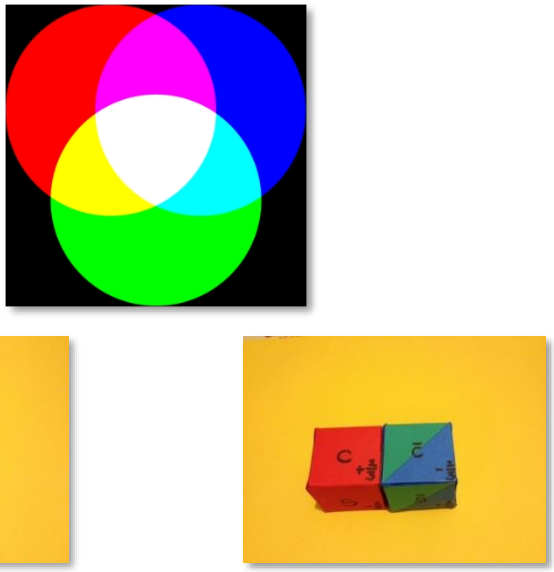
14. Quarks and antisquarks: using pre-made quark and antisquark cubes, explore the differences between particles and antiparticles.

10. Figure

15. Particles and antiparticles: building particles with the wood and paper cube set, but this involves learning about colours and anti-colours.

11. Figure

16. Compiling barions and mesons according to the rules (laws) learned. Only white hadrons exist!



12. Figure

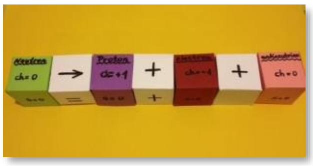
17. Gluons, mediator particles: staining white styrofoam "worms" according to the quantum colour dynamics rule that says gluons also contain colour and anticolour, like mesons, but are never white!

13. Figure

18. To learn by playing, use and eat special gummy bears (Haribo).

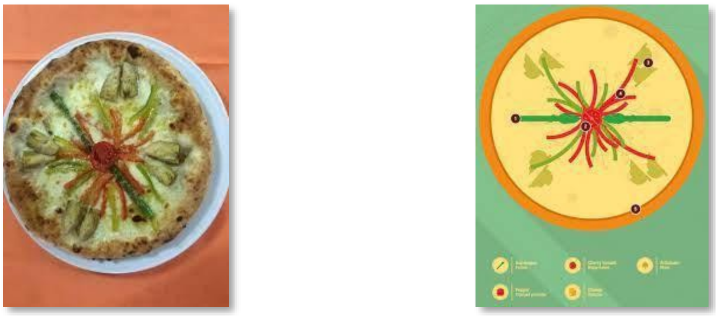
14. Figure

19. Radioactive decay modelling. Beta decay skewer.



15. Figure

20. Higgs boson pizza: learn how to make a recipe for a homemade pizza that depicts one of the decays of the Higgs boson with vegetables on top.



16. Figure

21. Particle traces: Artistic labotatories (Fermilab)

17. Figure

22. Presentation and analysis of diffusion cloud chamber, bubble chamber, gas detector, particle detector images.

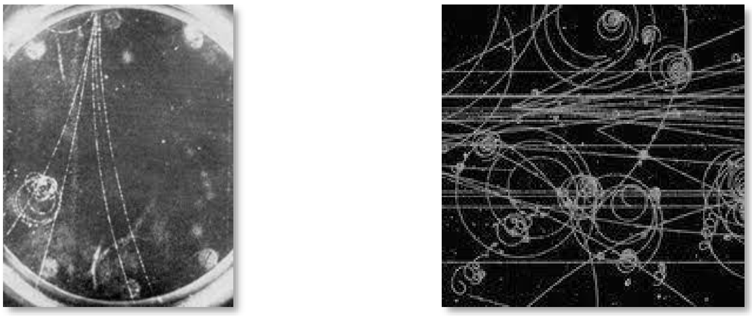


Figure 18.

23. Drawing particle patterns on the sheets of paper based on your own idea and the decomposition processes you have already learned.

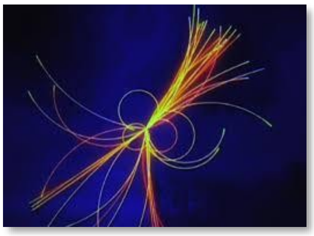


Figure 19.

Prediction	Gluons are not white. Quarks are elementary particles. White is not a colour. The particles are invisible.
Design	Understanding processes in the micro-world through the demonstration of particles through independent, active learning. To stimulate interest in the processes taking place in the micro-world through artistic and gastronomic creations.
Discovery	The project is about using a discovery method to teach students about the laws of physics, and the hands-on mind-on method results in a deeper understanding and more lasting knowledge. Combining particle physics with the arts increases motivation.
Presentation	Students compare their results with their preliminary guesses and formulate their experiences.
Reflection from	Why are the preliminary suspicions and the experienced ones the same or different? Are quarks really elementary? Are there only three types of beta decay? Are gluons really not white? What makes up nucleons? How can the decomposition processes be visualised?
Knowledge sharing	Using the cube set, students learn about the structure of non-elementary (complex) particles, physical processes and laws. They summarise their results in a presentation. The products are compared and analysed.

		They publish learning processes and results in school magazines and journals.
	Result	A set of cubes made of quarks, antiquarks, gluons, composite particles, made of cardboard. Gluonok. Nucleon muffin. Pizza. Particle trails. Drawing, painting. Presentation, document. Video.
	Redesign	Give students enough time to redesign the processes and modify their reports if they do not match the descriptions in the literature.
	Stations	
	Natural science	Science involves thinking, observing, experimenting. It is important to formulate preliminary assumptions and share experiences. Formulating and answering questions about how the world works. Collecting data, writing down decomposition equations. Tools: paper blocks, notebook, calculator, pen, coloured paper.
	Research	Independent, exploring the processes of the micro-world. For example, the proton and the neutron are non-elementary particles. Hadrons are white, but gluons are not. Mass-energy equivalence. Tools: iPad, books, maps, encyclopaedias, tablet, computer.
	Technology	Electronic devices: calculator, computer, smartphone, interactive whiteboard, digital camera. Other tools: scissors, glue, markers, cardboard, ruler, food.
	Technical area	Technical tools and materials: cardboard, blackboard, ruler.
	Art and design	Art and design ingredients: paintbrush, scissors, cardboard, food colouring (tubes), food (rice), coloured inks (pipette), markers, ruler, coffee filter, glass plates, paper cups, foil, rubber bands, paints, plastic bottles, chenille sticks, coloured jelly candies.

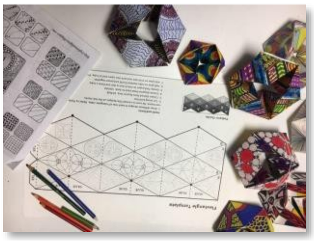
Figure 20.

The rice grains can be used to design on a black plastic sheet. They can try the arrangement of the meshes by vibration.

21. Figure 1. Color Mixing on Coffee Filters - The Kitchen Table Classroom (Pinterest).
Painting a coffee filter

22. Figure 1. Painting (Pinterest) Symmetry-asymmetry

23. Figure 1. Flextangle STE(A)M Art Project: Fusing Math and Art (Pinterest)



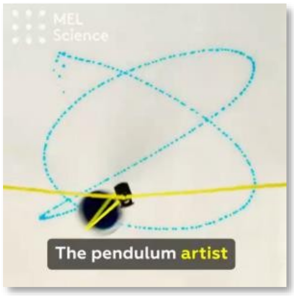
24. Figure 1. Flextangle STE(A)M Art Project: Fusing Math and Art (Pinterest)

You can design dishes on this template. The "pattern" will always be different as the template is rotated.

How to build atomic models from candy, chenille fibre?

25. Figure How to Build Atomic Models (Pinterest)

Or with paint.



26. Figure 1. The pendulum artist (Pinterest)

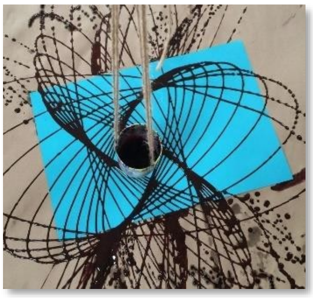
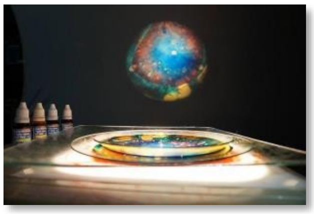


Figure 27. Full STE(A)M Ahead (Pinterest)

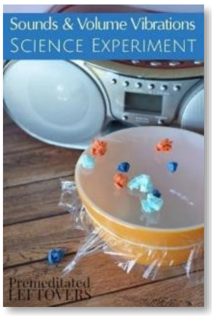
Liquid Light Show - You can observe the mixing of coloured inks, which can be combined with acoustics.

28. Figure 1. Liquid Light Shows: 4-6th Grade (Pinterest)



29. Figure 1. Liquid Light Lab (Pinterest)

Observing the strength of the sound.

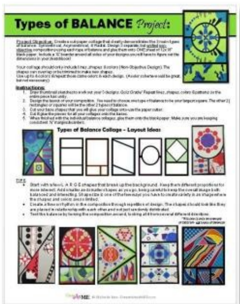


30. Figure 1. Sound and Volume Vibrations Science Experiment for Kids (Pinterest)

You can collect ideas, recipes and patterns in this small foldable book: How to make an Explosion Book/Squash Book (YouTube)

31. Figure

Symmetry or asymmetry in art.



32. Figure 1. Types of Balance Cut Paper Collage Art Project (Pinterest)

33. Figure 1. Types of Balance Cut Paper Collage Art Project

	Mathematics	Maths tools: calculator, ruler, dice.
	Presentation	Memo cards, pen, sketch paper, camera.
	Experiences	After the project, you and the students will evaluate the project together, discuss your experiences and further ideas and plans.
	Appendix	**A detailed description of the project with printable templates can be found in** Dr. Éva Oláh: Particle physics workshop **Links** Dr. Éva Mária Oláh: Let's play particle physics! Dr. Éva Mária Oláh: Playing Particle Physics Éva Mária Oláh: Let's Build Particle Physics Tamás Stonawski - Csilla Fülöp 2020 What does space mean for physics and art? *Physics Review*. 2020/4. Fermilab Quantum Chromodynamics (QCD) Quantum Chromodynamics (QCD) (YouTube) **Analysis** Discuss, confirm or refute predictions, preliminary questions. **Group work** Distribute preparation tasks in groups of 2-3 people. Dividing each task into groups. Preparing the product in small groups. Preparing the presentations in groups. **Experiments** The "pouring" of a proton cube. Preparing quark cubes. Assembling antiparticles. Painting gluons, sorting sweets. 3 types of beta decay through the laws of conservation. Hadronization. Building and decorating nucleons.

6. The gold rush

STE(A)M-Areas	maths - physics - biology - design - art
Intercultural relations	Is the gold standard an excellent ratio? What is considered beautiful and proportional in different cultures? How beautiful and proportionate are we?

Summary table	
Subjects	mathematics - biology - art
Topics	Calculating the second-degree equation, ratios, mean and standard deviation.
Age of students	12-20 years
Lesson/project duration	8×45 min
Number of students	8-10 people
Online learning tools	Stonawski, Tamás 2013. The Gold Medal in European Painting. In András Juhász - Tamás Tél (eds.). *meeting in education, research: an international conference for teachers of Hungarian*. Budapest. 89-96. Tamás Stonawski 2021. The golden ratio and other ratios: the interaction of science and art. *Physics Review*. 71/7-8: 262-266.
Offline learning tools	Fernando Corbalán 2019. *The Golden Section*. London: *Eaglemoss* Ltd. Kovács Rita 2023. Prae Publishers. Róbert Falus 2001. *The legend of the gold rush*. Budapest.
21st century competences	innovation - creativity - problem-solving - analytical thinking - active learning - critical thinking - information and communication technologies - cooperation
Learning activities	gaining scientific knowledge - deepening understanding of the subject - helping to build learning communities - developing manual skills - developing abstraction - developing artistic flair

Project plan	
The name of the exercise	The gold rush
The implementation process	
Preliminar y questions	Is the Universe fair? Who discovered this ratio, when did they discover it and what did they use it for? Who later used this ratio for other purposes? Where does the name φ come from?

	How does Fibonacci relate to the topic, is it related to your choice of name? Who gave the ratio the name golden ratio or divine ratio? Who suggested its scientific connection with aesthetics and who first measured it? What examples of gold panning have been found in nature? What is the solution formula for the second-degree equation? How do we calculate the mean and standard deviation? Is there a link between beauty and proportionality? Is there an excellent ratio associated with beauty, and if so, how can it be determined?
Inspiration	Collecting ideas from students.
Preparations	Purchase of materials (rubber tape, measuring tape, scissors, felt-tip pens, cardboard, paper clips). Cutting rectangles. Cut rubber bands to size, draw the φ ratio with a marker pen. Sliding rectangles into each other, fixing with paperclips.
Introduction	Demonstration of some of the editing techniques for gold measurement. Making the gold spiral line. See later for the construction and significance of the golden grid. Find the ideal ratio by varying the proportions of rectangles. Use the rubber band to check the position of the navel and other dominant body proportions. Paste the gold grid onto photos using PowerPoint.
Prediction	There is a link between goldsmithing and aesthetics, but not a very close one. There is a link between plant arrangements, minerals and works of art. It also appears in physics.
Design	Using the mathematical concepts and skills learned, we can explore the relationship between goldsmithing and aesthetics. We then extend it to the worldly objects around us.
Discovery	The project is about using a discovery method to teach students about the laws of physics, and the hands-on mind-on method results in a deeper understanding and more lasting knowledge. Combining maths with the arts increases motivation.
Presentation	Students compare their results with their preliminary guesses and formulate their experiences.
Reflection from	Why are the preliminary suspicions and the experienced ones the same or different? Is the gold standard really the gold standard? Is there anything mathematically different from the other ratios? Where can this knowledge be applied?
Knowledge sharing	Their measurement results are tabulated and plotted in graphs, including mean and standard deviation. They summarise their results in a presentation. They publish learning processes and results in school magazines and journals.

Result	Plasticised rectangles, rubber bands for additional measurements. The gold mesh is still available in digital form, and they can examine their own and online photographs and works of art. Presentation. Text document. Video.
Redesign	Give students enough time to redesign the processes and modify their reports if they do not match the literature descriptions.
Stations	
Natural science	Science involves thinking, observing, experimenting. It is important to formulate preliminary assumptions and share experiences. Formulating and answering questions about how the world works. Collecting data, writing down the φ ratio. Tools: paper rectangles, notebook, calculator, pen, coloured paper.
Research	An independent exploration of the relationship between gold measurement and body proportions. For example, where does the gold standard divide height? Why is a special rectangle used as a bank card? What is a sense of beauty? Tools: iPad, books, maps, encyclopaedias, tablet, computer.
Technology	Electronic tools: calculator, computer, smartphone, interactive whiteboard, digital camera. Other tools: scissors, paper clips, cardboard, tape measure, rubber band, marker pen.
Technical area	Technical tools and materials: paper clips, cardboard, tape measure, rubber band.
Art and design	Art and design ingredients: paintbrush, scissors, cardboard.
Mathematics	Mathematical tools: calculator, ruler.
Presentation	Memo cards, pen, sketch paper, camera.
Experiences	After the project, you and the students will evaluate the project together, discuss your experiences and further ideas and plans.
Appendix	**Links** Dr. Tamás Stonawsky: The Gold Metrication in European Painting Dr. Tamás Stonawsky: The Gold Metrication and Other Proportions Tamas Stonawski - Imre Beszeda: Golden Ratio and Other Relations Tamas Stonawski: The Golden Ratio and Other Relations Tamás Stonawski - Csaba Balla:The gold measurement in secondary schoolsapplication of **Video from** What is a gold rush? (YouTube) The mystery of goldsmithing Quantum Chromodynamics (QCD) (YouTube)

The Golden Ratio (why it is so irrational) - Numberphile (YouTube)

Summary
Discuss, confirm or refute predictions, preliminary questions.

Group work
Distribute preparation tasks in groups of 2-3 people. Dividing each task into groups.
Preparing the product in small groups. Preparing the presentations in groups.

Experiments
Judging a rectangle beauty contest based on predefined rectangles. Rectangle plasticity (stretching rectangles to the ideal proportion).
Measuring and evaluating neck and other body proportions.
Measurement and evaluation of proportions of faces and works of art.