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**Playing with meteorological data - what could we find out?**

**STE(A)M IT INTEGRATED LESSON PLAN**

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# Introduction

In order to inspire students, see the added value of STEM subjects and careers, contributing the same way in tacking unfavourable perceptions and the overall lack of interest in Science, there is a need to reconsider the way STEM subjects are taught. For this purpose, there is a need for an integrated way of teaching. More specifically, there is a need to combine Science classes with other disciplines, ensuring that the integrated STE(A)M education will contextualize STEM teaching is such a way that it becomes more attractive for every student.

Right now, there is no integrated STE(A)M education framework in Europe that will further enhance coherence in STEM education. It is essential to bring together partners from different countries, already working in STE(A)M education, policy, pedagogical innovation and professional development of teachers, educators and school leaders, and engage them in discussions, planning, implementing and the review of new practices. This will ensure that the topic is given new and more intense attention within each country. Therefore, the STE(A)M IT project will lead the way in the creation and testing of the 1st Integrated STE(A)M framework, aiming to strengthen the coherence in STEM education by defining collectively with MoEs and STEM teachers the integrated STE(A)M education framework. The focus group teachers that will create interdisciplinary and innovative teaching and learning scenarios, will be used to test the proposed framework of reference for integrated STE(A)M education.

The creation and implementation of the aforementioned framework is particularly important for students who do not link STEM subjects and their use with their everyday life, but most importantly with their future career paths. The teaching of each STEM subject individually often prevents students from linking those subjects, consequently missing out on a cohesive educational opportunity that might largely affect their study path choice and eventually career.

It is additionally important for teachers of Primary and Secondary schools to work together and fully exploit the benefits of the in-between them collaboration, while contributing to the creation of innovative and cross-disciplinary approaches to STE(A)M teaching in education, each adding their own insight, expertise and knowledge. This collaboration and continuous feedback aim to provide an opportunity for reflection and support a steady and much necessary change in formal education but also career consultancy. This way, schools will assume the additional role of mentorship supporting their students collectively.

A STE(A)M IT Integrated lesson plan is a teacher's detailed description of the course of instruction or "learning trajectory" for a lesson, a guide and a document that will be continuously improved and updated. Each lesson needs to combine three subjects, two of the subjects must be STEM and the third subject can be either STEM or non-STEM. is about designing educational activities that facilitate deep learning to enhance 21st century skills such as critical thinking, collaboration, communication and creativity and divergent thinking. Designing a path based on methodologies such as Problem, Project and Challenged Based learning allow to incorporate problem-solving, inquiry and design based learning into the teaching activity taking care of real challenges in an authentic context, that of our world.

With this in mind, an integrated STEM approach will develop capable citizens who personally and professionally make informed decisions in their daily lives and have the power to follow STEM careers and guide innovation at any age.

Title

**Playing with meteorological data - what could we find out?**

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Summary

Will the ferry sail? Can the plane land? Is it possible to plough the field? Will there be a lot of rainy days during the summer tourist season? A simple answer runs through all these questions, and that is the weather. People have always had a need to keep track of the weather, as evidenced by historical evidence from the Egyptians and the ancient Greeks. It is known that Aristotle is considered the founder of meteorology and wrote the work "Meteorologica" (340 BC). Through these lessons, students will get acquainted with the circulation of water in nature, and the influence of air pressure on temperature and humidity, and will learn the basic meteorological phenomena and instruments used to measure it. They will also carry out measurements using these instruments and analyze them. Students will learn about the concept of climate change and will use their IT skills to analyze the data measured by the school's weather station.

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Subject (s)

**STEM Subject 1 – Chemistry:** Study of the circulation of water in nature and the formation of precipitations.

**STEM Subject 2 – Physics:** To know geophysics as a branch of physics that studies physical processes in the atmosphere, oceans, and the interior of the Earth. Explore the parameters by which we can describe the weather: air pressure, temperature, humidity, or wind. Students will also make use of meteorological measuring instruments and understand the difference between the terms "weather" and "climate".

**STEM Subject 3 – Informatics:** Recognize mobile applications that deal with weather forecasting. Apply digital applications to represent data with graphs and spreadsheets to help identify specific data features regarding weather.

**STEM Subject 4 – Math:** Application of statistics for the analysis of the collected data.

**Non-STEM Subject – History:** Students will learn about the historical development of meteorology in the world and the Republic of Croatia.

Real- life questions

* What do meteorologists do and why are they important to us?
* Why do some people feel health problems caused by weather changes?
* How does air pressure affect air temperature?
* What kind of weather does a cyclone bring us, and what kind of an anticyclone?
* How do meteorologists predict the weather?
* How to interpret the symbolism of the tags on mobile weather applications?
* What is climate change and how does it affect humanity?
* Are summers getting warmer?
* Are we threatened by global warming?
* How do global warming affect plant and animal habitats?
* How new advances in information and communication technology and digital tools have improved some occupations and careers?

Aims of the lesson

The overall aim of the lesson is to get students acquainted with meteorology, emphasizing its importance for agricultural and economic activities and introducing them to STEM occupations associated with it.

By the end of the lessons, students should be able to:

**STEM Subject 1 – Chemistry:**

* Explain the circulation of water in nature.
* Explain the water anomaly and its importance to the living world.
* Compare ice density and water density.
* Compare the change in water volume as a function of temperature.

**STEM Subject 2 – Physics:**

* Define geophysics.
* Define meteorological parameters such as air pressure, temperature, humidity, and wind.
* List the basic meteorological measuring instruments and explain their principle of operation.
* Get acquitted with the automatic weather station that the school owns.
* Define the terms "weather" and "climate".
* Discuss and decide which meteorological parameters we should analyze to compare one of the selected years (2021.) with the climatological medium for their city.

**STEM Subject 3 – Informatics:**

* Collect and enter data to analyze a problem with the help of an appropriate program.
* Discover the relationship between the data using various tools of the program and the ability to display data.
* Apply appropriate graphical representations to highlight data relationships.
* Recognize and study interdisciplinary jobs like agriculture or else that are improved by the development of informatics and information and communication technology.

**STEM Subject 4 – Math:**

* Organize and analyze the data shown by the relative frequency diagram.

Connection to STEM careers

**Meteorology** is often called the “physics of the atmosphere.” If we want to understand meteorology, we need to know all about the parameters by which we describe the atmosphere and also their influence on the weather. For this, it is necessary to know the basic laws of physics to which these quantities are subject. In addition to physics, knowledge of mathematics, IT, but also numerical methods are required.

**Agrometeorolog**y is an activity for which the relationship between meteorological and hydrological factors and agriculture is important, as well as its impact on flora and fauna.

Age of students

13 to 14 years old.

Time

**Preparation time:**

* 6 hours to discuss with colleagues and define activities.
* 3 hours for each teacher to prepare the materials for each lesson.

**Teaching time:**

* Preparation (brainstorming and discussion): 90 min.
* STEM Subject 1 – Chemistry: 90 min.
* STEM Subject 2 – Physics: 90 min.
* STEM Subject 3 & 4 – Informatics and Mathematics: 135 min.
* Final presentation: 45 min.

Teaching resources (material & online tools)

***Materials:***

* School meteorological station with anemometer, rain gauge, barometer, thermometer and hygrometer.
* Tablets or PCs with Internet connection.
* Material for chemical experiments: jar, spoon, foil, eraser, ice bucket, laboratory cup for table salt, boiled water, table salt, and ice.

***Online tools:***

* Zoom: videoconference meeting with an external meteorologist/expert.
* MS Excel: processing of collected data.
* MS Teams: communication and cooperation.
* MS PowerPoint (or something similar): presentation of results.
* MS Word: creation of project material (for example, project report).
* Canva: creation of a poster (presentation of results).
* To check the weather (in Croatian): <https://meteo.hr/klima.php?section=klima_podaci&param=k1&Grad=dubrovnik>
* Weather and Climate Lesson (in Croatian):

<https://edutorij.e-skole.hr/share/proxy/alfresco-noauth/edutorij/api/proxy-guest/15d4d23d-ffb4-4d95-af9a-fd8dec8f9156/vrijeme-i-klima.html>

21st century skills

The most important skills needed for one to be a meteorologist are critical thinking, commitment, and personal responsibility. **Critical thinking** is important because all meteorological parameters are dependent on each other, and it is necessary to constantly apply and think about these dependencies. For example, if a sudden change in time occurs, we need to know how a change in a certain parameter will affect others. Only in this way of thinking, we will successfully compile our report. **Commitment and personal responsibility** are very important because meteorologists do a job on which a big number of people depend. The weather data that meteorologists report must be accurate and representative because it is a prerequisite, for example, for flying safely (aeronautical meteorologists).

Lesson Plan

The implementation of integrated STEM teaching and learning is facilitated by the use of specific pedagogical approaches (PBL, IBL, etc). In order to facilitate the research done by the teachers and the design of activities by teachers, a selection of such approaches is presented in Annex 1. Maintaining Annex 1 in the Learning Scenario and citing where necessary is mandatory.

| Name of activity | Procedure | Time |
| --- | --- | --- |
| 1st Lesson | | |
| Brainstorming and discussion | History of meteorology, meteorology nowadays. |  |
| Discussion and preparation for the next lesson & non-STEM Subject – History | Pupils and students discuss the impact of weather conditions on human activities such as agriculture, construction work, transport, tourism, etc. Also, the historical development of meteorology will be mentioned. Students will be introduced to the fact that Aristotle is considered the father of meteorology. Students will also meet the founder of meteorology in Croatia, Andrija Mohorovičić. At the end of the lesson, students will meet four meteorologists dealing with various areas of meteorology through Zoom: a ‘’storm chaser’’, an agrometeorologist, a forecaster on national television, and a weather watcher at the airport who will take them through a virtual walk through the department and show them the instruments they use. In this way, the students will get acquainted with the different aspects of meteorology and will be able to ask questions to each of the experts. | 90 min |
| 2nd Lesson | | |
| STEM Subject 1 | **Chemistry** | 90 min |
|  | Through the chemistry class, students will learn that the amount of water on Earth is constant and that it is constantly circulating in nature, changing the state of aggregation. The change in temperature and pressure causes the constant circulation of water in nature. Students will then work in groups (student experiments) and study the water cycle in nature and the physical changes that occur in it. Each group will study a physical change. The goal of the experiment is to understand that the action of solar energy occurs to warm the Earth's surface, so the water evaporates from the sea, rivers, lakes, and other water surfaces. Water vapor rises into the colder layers of the atmosphere where it condenses into water droplets and ice crystals (crystallization) to form clouds. Water from the clouds returns to the earth in the form of precipitation or melting. Snow from the mountain tops comes directly into surface  water or penetrates through the ground to groundwater. It is important to understand the metaphor of experimentation because  everything that happens in nature, at the macroscopic level is shown here in miniature form. Water a solution of table salt in a jar symbolizes the seas and oceans, foil water droplets represent clouds in a cold atmosphere, a glass set in the jars is the land on which precipitation falls, and the ice is represented by snow covering mountain peaks.  See Annex 2 for the worksheets of this activity. They are also available in Croatian [here](https://carnet-my.sharepoint.com/:w:/g/personal/milana_gujinovic_skole_hr/ETbibU_whPdKmxGzeL34gbUBRtJWpyUyTSICAKWT_16tdw?e=8uMRiF). |  |
| Learning products | * Students will make a poster in Canva showing the circulation of water in nature. |  |
| 3rd Lesson | | |
| STEM Subject 2 | **Physics** | 90 min |
| Video, discussion, and mind map formation | At the beginning of the lesson, the students are asked what is the link between meteorology and physics. The concept of geophysics is defined as a branch of physics that studies the physical processes of the atmosphere, oceans, and the interior of the Earth. Geophysics is also called "earth physics". It is divided into meteorology, which explains processes in the atmosphere by physical laws, oceanography which explains processes in the oceans, and seismology that explains the processes in the interior of the Earth.  Furthermore, the students discuss and list the parameters by which we describe the weather. With the help of the teacher, students define them and learn how and by what instruments we measure them and by what units of measurement we express them. (For example, they associate the principle of operation of the thermometer with the thermal spread of the substance they learned about in regular physics classes.)  Individual pictures and quizzes that were used for teaching this are available [here](https://edutorij.e-skole.hr/share/proxy/alfresco-noauth/edutorij/api/proxy-guest/15d4d23d-ffb4-4d95-af9a-fd8dec8f9156/vrijeme-i-klima.html) (in Croatian).  The teacher introduces the students to the school's automatic weather station, which is located on the roof of the school. They explain to the students the principle of operation of the station, how data is transferred, and how it is presented to users.  After being familiar with the basics of meteorology and the work of the weather station, the teacher asks the students a question about the difference between the terms "weather" and "climate." ‘’Weather’’ is defined as the current state of the atmosphere over a place, and “climate’’ as the average state of the atmosphere over a place. The teacher makes the students aware that to know the climate of a place, it is necessary to have a continuous data series of at least 30 years.  Students and teachers talk about climate change: what is it and what does it encompass? The teacher asks the students  whether they notice any phenomena in their environment that indicate climate change (e.g., increasingly warm summers, increasing droughts) and how would they check if these changes occur in reality or only in theory? The students conclude that they could compare the data measured in the past year with the data of the climatological medium that can be found on [the website](https://meteo.hr/klima.php?section=klima_podaci&param=k1&Grad=dubrovnik) of the state hydrometeorological institute. |  |
| 4th Lesson | | |
| STEM Subject 3 & 4 | **Informatics & Mathematics** | 135 min |
|  | Students use mobile devices every day as well as a range of applications that provide meteorological data and offer weather forecasts for the area in which they live. In the introductory part of the lesson, students should recognize some of the meteorological symbols and analyze the data offered by such applications on their mobile devices. Since the school has a meteorological station, the data collected through the station for the last year (2021) will be available. Students will be divided into groups. Each group will have to analyze a specific part of the available meteorological data using the MS Excel application. Students analyze a given problem and select the appropriate displays, shapes, diagrams, and functions offered by the spreadsheet editing application (like MS Excel) to solve the given problem. Every task will be presented with specific assignments and questions that will guide students through their work:   * Find the maximum daily air temperatures for each month of the year. * Find the minimum daily air temperatures for each month of the year. * Determine the total amount of precipitation for each month of the year. * Find the number of days with precipitation for each month of the year. * Graphically present collected data for the selected year and show the given climatological averages on the same graph. * Compare and discuss the results obtained.   The teacher will supervise the work of the students and help them if necessary. Students will present their results using a shared document/presentation and a digital Canva poster. The document/ presentation/poster should contain:   * Introductory remarks on the importance of meteorology. * Students' prior knowledge/assumptions. * Results of each group. * Conclusion (what happens to the climate, the importance of meteorology, student feedback).   Each group chooses which of the listed documents will produce (document/presentation /poster). It is possible to create only one type of document but since the digital content will be presented to other students as well as published on the school's website and communication and collaboration sites/teams for students, it is better if various types of presentations and digital materials are created.  A possible working product could also be a video that presents the results of the project as a “weather forecast.”  See Annex 3 for a formative rubric displaying how the digital material will be evaluated, both in terms of content and presentation. |  |
| Learning products | * MS Excel workbook containing collected data and results. * Document in MS Word, presentation in MS PowerPoint, and poster in Canva. | |
| Non-STEM Subject | **History** (the activities related to this subject will be incorporated through the teaching of the STEM subjects). | |
|  | Students will be briefly introduced to the historical development of meteorology:   * Students will know that Aristotle is considered the father of meteorology. * Students will be informed about the founder of meteorology in Croatia, Andrija Mohorovičić. * Students further independently research the presented topic. | |
| Learning products | * Document in MS Word, presentation in MS PowerPoint, and poster in Canva where relevant historical data is added. | |
| 5th Lesson | | |
| Presentation of results and discussion | Students will create a final presentation of the project in which the results of all involved subjects will be connected. All teachers, as well as outside experts who participated in the implementation of the project are included in this part. Through the discussion with students, teachers, and experts the most important results of the implemented project are highlighted. Also, students will have the opportunity to talk to specific STEM experts and ask them questions, for example, in relation to their career path. | 45 min |
| Learning products | * Final presentation. |  |

Assessment

During the realization of this project, students are expected to apply problem-solving skills and  
actively participate in research-based learning. Evaluation of implemented activities will be  
carried out in each STEM course formatively. Also, it is possible to conduct summative assessments.  
To reward the efforts of the students and evaluate the adoption of the selected learning outcomes, teachers can, for example, evaluate the learning products, such as the presentation of materials and work results.

Initial assessment

Questionnaire to students on basic meteorological concepts and phenomena (e.g. what time does a  
cyclone bring, how is pressure related to precipitation, who are meteorologists, what does a  
synoptic map show, what individual meteorological symbols mean, etc.).

Formative evaluation

When creating digital presentation content, offer students a formative section to provide  
them with quick feedback and assistance so they can improve the quality of their work and their skills. See an example of a formative rubric in Annex 3.

Final assessment

Students can be assessed through final questionnaires. You can see an example of one [here](https://edutorij.e-skole.hr/share/proxy/alfresco-noauth/edutorij/api/proxy-guest/15d4d23d-ffb4-4d95-af9a-fd8dec8f9156/procjena-odgojno-obrazovnih-ishoda-10.html) (in Croatian).

Student feedback

Teachers can use a questionnaire to investigate student satisfaction with this Learning Scenario. The survey questionnaire should offer answers to questions related to:

* The availability of teaching materials.
* The adequacy of the difficulty of problem tasks (questions).
* The timing to complete the selected activities and tasks.
* The motivation of students to participate in a problem that involves meteorology and its  
  application to everyday life.
* Students' awareness of how interdisciplinary work has been improved by the development of informatics and information and communication technologies.
* The cooperation among students when solving a given problem.

Teacher feedback

Teachers can evaluate the implementation of this Learning Scenario by focusing on:

* The difficulties identified (bad sides) during the implementation of the Learning Scenario: what can be fixed?
* The advantages (strengths) of this Learning Scenario: what is good and should be retained?
* The identification of factors that may affect the realization of this Learning Scenario.

Annexes

Annex 1: Pedagogical Trends in Education

##### PEDAGOGICAL TRENDS IN EDUCATION

Disclaimer: Information presented in this document has been previously partially published in the Scientix Newsletter “Pedagogical trends in education”, May 2019: <http://files.eun.org/scientix/scx3/newsletter/Scientix-Newsletter-May-19.pdf>

### Inquiry-based science education

[**IBSE**](https://www.youtube.com/watch?v=u84ZsS6niPc) adopts John Dewey’s principle that education begins with curiosity (Savery, 2006), and makes students go through all the steps of scientific research: ask a question, develop a hypothesis, plan how to test this hypothesis, collect data, analyse the results and share it with peers (Pedaste et al. 2015). IBSE is ideal for science education, because it makes teaching more hands-on, and is perfect to learn how scientific research works. Students learn how to formulate questions answerable through experimentation. The teacher has both a facilitator role and an instructor role, making it an in-between method compared to full facilitation in problem-based, and instruction in project-based learning. However, the approach can be gradually made student-directed; students can start an IBSE project with a question provided by the teacher, and then can come up with their own questions to transfer what they learned for deeper learning.

IBSE does not only tap into creativity, problem-solving, and critical and analytical thinking. It also sets the stage for learning about how to collect and interpret data (become science and data-literate), and how to do this ethically and reliably. All these are skills of the 21st century, where data is abundantly available in every part of life.

As mentioned in the recent European Schoolnet publication, while inquiry-based science education (IBSE) has been already around in STEM education for decades, there is still much room for improvement in teachers’ development and continued dissemination of innovative pedagogical approaches. To highlight the impact of IBSE, its challenges, and the initiatives addressing these, we published the “Teacher Training and IBSE Practice in Europe, A European Schoolnet overview”.

Research shows that IBSE results in greater interest in Science, and motivation for STEM careers. Another important observation from the publication is that the benefits of IBSE are long-term and maintained, in contrast to the short-term acquisitions of traditional pedagogies that also come with less inclusion of both genders, and less interest in STEM.

One challenge is teacher support: teachers report that they receive little support in implementing IBSE in their classroom. Another challenge to IBSE is standard assessment: PISA tests, as well as end-of-secondary-education exams, are still more focused on recall and repeated-drill exercises, deterring the use of more diverse pedagogies. In order to better integrate inquiry-based methods in school curricula, standardized tests also need to evolve along with traditional pedagogies.

### Problem, project and challenge-based learning

[**Problem-based learning (PBL)**](https://www.youtube.com/watch?v=EuzgJlqzjFw) is a student-centred multi-disciplinary method that was initially adopted in medical education as a means to put multiple topics in context(Newman, 2003) PBL aims to make students good problem-solvers in the real world: for instance, to put knowledge from multiple disciplines into use, and be able to work with others productively. After all, real-world problems are hardly ever solvable by one single discipline and one single person.

A PBL activity consists of working on an open-ended, even ill-defined question, with no solution provided by the teacher. Students need to work collaboratively and devise a solution to the problem by themselves. The key component is that it is student-centred; students are more motivated when they are responsible for the solution to the problem, and when the whole process rests with them (Savery, 2006). Decades of research has established that although students who went through PBL do not necessarily score better on standardized exams, they are definitely better problem-solvers (Strobel & van Barneveld, 2009).

**Project-based learning** also involves collaborative learning and finding a solution to a problem. However, the process and the end product are more specified from the beginning. Students work on a project for an extended period of time, a project that will produce a solution to a complex question or solve a complicated problem. The role of the teacher is more active here because multiple obstacles are typically encountered in the production of something like a rocket, or a space habitat, and these obstacles mark the moments for the teacher to instruct specific topics.

Finally, with [**challenge-based learning (CBL)**](https://www.youtube.com/watch?v=K-YU0Ea9JKg)(Johnson et al. 2009), students are again asked to develop a solution to a problem. However, they are only provided with a “big idea”, a societal problem that they need to address with a challenge of their choosing (e.g. disinterest in mathematics, low upturn in elections). While the use of technology can be considered optional in other trends, technology needs to be incorporated in every step in CBL. Similar to project-based learning, there is an end product, although this product is determined in the process, not at the beginning. The focus is on the use of ICT in the collection of data and sharing the results.

### Design thinking

If IBSE recreates scientific methodology in the classroom, **design thinking (DT)** does the same for design and prototype production. DT helps students develop the skill to identify problems and needs in the society, and entrepreneurship. DT can be implemented within problem or project-based learning; the difference is that the problem is identified by students, and the end product is a prototype to solve the problem. The product is tested and refined in multiple iterations. Students go through a cycle of steps: (1) empathize; (2) define; (3) ideate; (4) prototype; (5) test.

### Blended-learning and the flipped classroom

In a classroom where all students are facing the instructor, each moment there will be students drifting from the topic, even if for thinking deeper about a specific point in the lecture. It is challenging to have the undivided attention of the whole classroom because each student has a different way of learning and a different pace. With online content, students can learn the material at home at their own pace. In turn, the teacher can use the classroom to engage students in debates, projects and group assignments. Blended-learning and flipped classroom are instructional strategies that help students learn in their own pace, and deepen their learning with making the most of classroom hours. Although these concepts are used interchangeably, they are slightly different: while blended learning complements online learning with class instruction and support, the flipped classroom requires students to learn the material before coming to class and do assignments and projects during class hours.

### Content and Language Integrated Learning (CLIL)

Content and language integrated learning (CLIL) is a well-positioned pedagogical approach that emphasises on the integration of foreign language and thematic content within the context of all school subjects. CLIL is a pedagogical approach that allows to teachers and students use a foreign language as the medium of instruction in non-linguistic subjects, allowing this way the practice and improvement of both the second language and the immersion to subjects that may vary from science subjects to humanities. According to Cenoz et al. (2013) "*the European Commission and the Council of Europe have funded many initiatives in support of CLIL because it responded to a need in Europe for enhancing second-language (L2) education and bilingualism that was well-received*" and research further supports that CLIL is applied successfully in task-based pedagogies. In addition, when it comes specifically to the application of CLIL in the science classroom there are specific advantages including enabling learners to learn a school subject that exists in their curriculum using the respective second language they are learning, provide authentic learning settings while using the resources available at their school and support learners’ cognitive skills by equally supporting language practice and the teaching of science context.

#### References

* Bowers, C. (2002). Toward an eco-justice pedagogy. Environmental Education Research, 8 , 21–34.
* Cenoz, J., Genesee, F., Gorter,D., Critical Analysis of CLIL: Taking Stock and Looking Forward, Applied Linguistics, Volume 35, Issue 3, July 2014, Pages 243–262, <https://doi.org/10.1093/applin/amt011>
* Durando, M., Sjøberg, S., Gras-Velazquez, A., Leontaraki, I., Martin Santolaya, E. & Tasiopoulou, E. (2019). Teacher Training and IBSE Practice in Europe – A European Schoolnet overview. March 2019, European Schoolnet, Brussels.
* Gabillon, Z., Ailincai, R. (2013) CLIL: A Science Lesson with Breakthrough Level Young EFL Learners, *Education*, Vol. 3 No. 3, 2013, pp. 168-177. doi: 10.5923/j.edu.20130303.05. Hadjichambis, A. “Pedagogical Approaches on the Education for Environmental Citizenship”. 1st European Training School, Lisbon, Portugal, October 24-45, 2018.
* Johnson, L.F., Smith, R.S., Smythe, J.T. & Varon, R.K. (2009) Challenge-Based Learning: An Approach for Our Time. Austin, Texas: The New Media Consortium. Retrieved April 17, 2019 from <https://www.learntechlib.org/p/182083/>.
* Kemmis, S., McTaggart, R., Nixon, R. (2013) The action research planner: Doing critical participatory action research. Springer, London.
* Lorenzo, F., Casal, S., Moore, P., The Effects of Content and Language Integrated Learning in European Education: Key Findings from the Andalusian Bilingual Sections Evaluation Project, *Applied Linguistics*, Volume 31, Issue 3, July 2010, Pages 418–442, <https://doi.org/10.1093/applin/amp041>
* Newman, M. (2003) A pilot systematic review and meta-analysis on the effectiveness of problem-based learning. Retrieved December 12, 2005 from: <http://www.ltsn-01.ac.uk/docs/pbl_report.pdf>
* Nikula, T. (2015). Hands-on tasks in CLIL science classrooms as sites for subject-specific language use and learning. System, 54, 14-27.doi:10.1016/j.system.2015.04.003
* Pedaste, M., Mäeots, M., Siiman, L.A., de Jong, T., van Riesen, S. A. N., Kamp, E. T., Manoli, C. C., Zacharia Z. C. & Tsourlidaki, E. (2015) Phases of inquiry-based learning: Definitions and the inquiry cycle. Educational Research Review, 14, 47-61.
* Savery, J. R. (2006) Overview of problem-based learning: Definitions and distinctions. Interdisciplinary Journal of Problem-Based Learning, 1 (1).
* Schusler, T.M. & Kransy, M.E. (2015) Science and Democracy in Youth Environmental Action – Learning ―Good‖ Thinking. In M. P. Mueller and D. J. Tippins, EcoJustice, (Eds.), Citizen Science and Youth Activism Situated Tensions for Science Education (pp. 363–384). Cham, Switzerland: Springer.
* Strobel, J., & van Barneveld, A. (2009) When is PBL More Effective? A Meta-synthesis of Meta-analyses Comparing PBL to Conventional Classrooms. Interdisciplinary Journal of Problem-Based Learning, 3(1).
* Tidball, K.G. and M.E. Krasny. (2010) Urban environmental education from a social-ecological perspective: conceptual framework for civic ecology education. Cities and the Environment. 3(1): 11. <http://escholarship.bc.edu/cate/vol3/iss1/11>. 20 pp.
* Tippins D., Britton S.A. (2015) Ecojustice Pedagogy. In: Gunstone R. (eds) Encyclopedia of Science Education. Springer, Dordrecht

Annex 2: Worksheets Lesson 2

**EXPERIMENT: Circling water in nature (group 1)**

First and last name: Class: Date:

**ACCESSORIES:** jar, spoon, foil, eraser, ice bucket, laboratory cup for table salt

**CHEMICALS:** boiled water, table salt, ice

**PRECAUTIONS: Treat the jar with hot water in it carefully!**

In a glass with boiled water, add a pinch of kitchen salt and mix the contents. Cover the glass with foil and tighten the foil with a rubber band.

1. Make a note of observations.

Add 2-3 pieces of ice to the surface of the foil and wait two to three minutes.

1. Observe the walls of the jar directly above the  surface of the solution of table salt and water and note observations.

1. Support your answers with an example from nature.

**EXPERIMENT: Circling water in nature (group 2)**

First and last name: Class: Date:

**ACCESSORIES:** jar, spoon, foil, eraser, ice bucket, laboratory cup for table salt

**CHEMICALS:** boiled water, table salt, ice

**PRECAUTIONS: Treat the jar with hot water in it carefully!**

In a glass with boiled water, add a pinch of kitchen salt and mix the contents. Carefully place an empty glass in a glass with a melt of kitchen salt and water in a way that puts the bottom of the glass at the bottom of the glass. Cover the glass with foil and tighten the foil with a rubber band.

1. Make a note of the observations.
2. Add 2-3 pieces of ice to the surface of the foil and wait two to three minutes. After that, remove the foil and look at the foil from the inside. Make a note of observations.
3. Conclude what caused the resulting change in the inner cavity of the foil.
4. Then he takes the glass out of the glass and let one of the students in the group turn the glass to the palm of his hand your hands.

Make a note of the observations.

1. Support your answers with an example from nature.

**EXPERIMENT: Circling water in nature (group 3)**

First and last name: Class: Date:

**ACCESSORIES:** jar, glass, foil, eraser, ice bucket

**CHEMICALS:** boiled water, ice

**PRECAUTIONS: Treat the jar with hot water in it carefully!**

In a glass with boiled water, carefully place an empty glass in a glass in a way that puts the bottom of the glass at the bottom of the glass. Cover the glass with foil and tighten the foil with a rubber band.

1. Make a note of the observations.
2. Add 2-3 pieces of ice to the surface of the foil and wait two to three minutes. After that, remove the foil and look at the foil from the inside. Make a note of observations.
3. Conclude what caused the resulting change in the inner cavity of the foil.
4. Then he takes the glass out of the glass and let one of the students in the group turn the glass to the palm of his hand your hands.

Make a note of the observations.

1. Support your answers with an example from nature.

**EXPERIMENT: Circling water in nature (group 4)**

First and last name: Class: Date:

**ACCESSORIES:** jar, spoon, foil, eraser, ice bucket, laboratory cup for table salt

**CHEMICALS:** boiled water, table salt, ice

**PRECAUTIONS: Treat the jar with hot water in it carefully!**

In a jar with boiled water add a tablespoon of table salt and mix the contents. Then cover the jar with foil and fix the foil with an eraser. Add 2-3 pieces of ice to the surface of the foil and wait two to three minutes.

1. Observe what happens to the ice on the surface of the foil. Make a note of observations.
2. What physical change does ice form?
3. **Top up the sentences!**

In nature, water comes in three aggregation states: solid as \_\_\_\_\_, liquid as \_\_\_\_\_\_\_, and gaseous as \_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_. In what condition it will be depends on pressure and \_\_\_\_\_\_\_\_\_. At normal atmospheric pressure, water boils at \_\_\_\_\_ °C and freezes at \_\_\_\_°C. Snow, which is found in nature on the tops of mountains, made of tiny \_\_\_\_\_\_\_ crystals (solid water). By bringing heat, snow changes the state of aggregation from solid to \_\_\_\_\_\_\_\_. Such a transition of aggregation states is called \_\_\_\_\_\_\_\_\_\_\_\_.

Annex 3: Formative Assessment Rubric

This rubric will be used to provide feedback to students while working on the creation of the digital material; it will help students to improve their work, both in terms of content and presentation.

A picture containing timeline

Description automatically generated