„SCIENCE - Searching clue innovations in neighborhood countries' education"

Lesson plans and teaching science subjects ideas.

The results of the Erasmus+ project 2021-2-PL01-KA210-SCH-000050855

Realized by Miejski Osrodek Edukacji Nauczycieli in Bydgoszcz and Zakladni skola a Gymnazium Vodnany

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MIEJSKI OŚRODEK EDUKACJI NAUCZYCIELI W BYDGOSZCZY

Science ERASMUS+

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Introducion

The target group of the project are students and teachers from Poland and the Czech Republic. The project activities were aimed at achieving better results by improving teachers in the field of working with the IBSE and STEM methods. The project partners are a teacher training institution and a comprehensive public school. For two years, teachers from two neighboring countries have developed a number of interesting solutions that can be implemented in biology, chemistry, physics and mathematics lessons in primary and secondary schools.

The aim of the project was closely related to raising the level of key competences of students to help them develop as responsible and active citizens of Europe. The project enables the development of young people's competences in the field of science. Taking into account the selected priorities, we formulated a goal that we managed to achieve in the course of cooperation with the partner school: exchange of practices in the field of contextual use of the STEM method and the IBSE method.

The result of the cooperation within the project is the presented publication with methodological material in the form of ready-made scenarios to be used in lessons.

Biology, chemistry and physics are among the experiential subjects where mathematics is used. The world of living organisms and the phenomena occurring in this world and in the abiotic world should be explored by students actively, using all their senses. Teacher, guide - passionate about his subject, can infect his students with this passion.

Numerous studies prove that the independent work done by the student has a greater educational effect than just listening and watching the work done by the teacher. Such an opportunity is provided by working with Inquiary methods, e.g. IBSE (Inquiry Based Science Education) and STEM. The IBSE method is a method of intelligent and inquisitive discovery that can be used in other fields as well.

Already the EU recommendation - the Rocard report from 2007, shows that the initiation of a new pedagogy should result in an improvement in the education of natural subjects. The introduction of IBSE in schools and the development of teachers' networks should be actively promoted and supported.

The key features of IBSE are the development of problem-based learning, work in a scientific spirit (using the scientific method in posing and examining issues in the course of learning), learning from mistakes using basic knowledge,

self-establishment of connections by students between the elements of knowledge acquired from various sources.

STEM is an acronym for the English words: Science, Technology, Engineering, Mathematics and when we add to it Art we get STEAM. Its idea is to show students that the natural sciences are related to each other to help them absorb knowledge in a broader perspective. In addition, this model, through contextual teaching, is designed to develop children's independent thinking, the ability to think critically and cause-and-effect, and to draw conclusions from the observations they have made.

Research conducted by the Bureau of Labor Statistics (BLS) indicates that people with technical and engineering education will have the greatest number of car M jobs will increase by 13%.

In the IBSE and STEM methods we use during the project, we see the boundaries of scientific disciplines blurring, i.e. an interdisciplinary approach, encouraging girls and boys to participate in education in the field of all science and science disciplines to an equal extent, and promoting cooperation and cooperation of students. Autonomous learning is also emerging; recognizing the needs of both students with difficulties and talented students - diversification of teaching.

A modern teacher should only be a "manager" of the learning process that activates and mobilizes his students to act. The study is to show you the way how to find time to experience biology, chemistry, physics and mathematics lessons. When to abandon the presentation of theory and apply practical action.

The fact that we as teachers can often be the only people around young people who can show them the practical use of many issues discussed during lessons should convince us to re-introduce the principle of active demonstrativeness in lessons. The need to relate to life is huge, as evidenced by numerous books, publications, groups, associations, courses on, for example, plant care, ecological cleaning products, renewable energy, healthy eating. And we can show all this to a young person in biology, chemistry and physics, regardless of the current core curriculum. It is enough to replace the means of passive visualization with active learning about the world in selected lessons.

So let's answer the question: Are biology, chemistry, physics and mathematics to be the next subjects "sitting through" during a long school day?

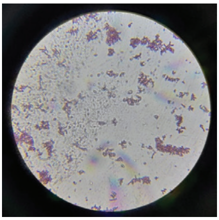
The answer is simple: Let's use IBSE, which is "learning by inquiry", or let's approach the issue using STEM.

The methodological guidelines for conducting observations and experiments contained in this publication are ready-made material on which you can rely when implementing

many issues from the core curriculum of natural sciences in primary and secondary schools. They can also be a starting point for reflection, critical analysis and discussion. The final evaluation of the work with the use of active demonstrativeness will be the results obtained. It would also be good if observations and experiments were used by teachers to create their own ideas for lessons on topics other than those given in the study.

What do we need bacteria in yoghurt and sauerkraut for? What bacteria are there in these products, GRAM-POSITIVE or GRAM-NEGATIVE?

Learning objectives	
Student: • Presents the morfology of procaryote cell, including the differences in the cell wall of Gram-positive and Gram-negative bacteria • Presents the variety of morfological forms of bacteria • Presents life activities of bacteria: (chemoautotrophism, photoautotrophism, heterotrophism); anaerobic respiration (denitrification, fermentation) and aerobic respiration; reproduction; • shows the importance of bacteria in nature and for humans.	**We consolidate:** information about the structure of bacteria - size, shapes and forms; habitat; **We ask:** Can we see bacterial cells under a microscope? Where do bacteria live? What does it mean if a bacterium is Gram-positive or Gram-negative? How big are the bacterial cells? How do the bacteria used in the study breathe? What is the Gram staining technique for bacteria? What is the importance of the bacteria used in the study? **Introducing:** staining with the Gram method and the importance of this staining.

Methods and forms of work	Teaching aids
applying scientific method (student research), talk, work in teams (or in pairs), discussion  Fot. A.Mądzielewska-Jagodzińska	• water from pickled cucumbers and sauerkraut; • thin yoghurt; • microscope; • set of reagents for Gram staining method GRAM - COLOR • slides, • burner or heater, • tap water/demineralized water, • beakers, Pasteur pipettes, clamp to hold the slide.

Duration

45 minutes

Substantive commentary

The proposed classes are of a laboratory and practical nature. They will allow students to formulate a research hypothesis and to plan and conduct an experiment - an introduction to the IBSE method. Independent planning and carrying out the proposed observation is extremely valuable in the context of developing scientific thinking, and formulating conclusions is the development of critical thinking. The choice of food products as the research material shows that what a student learns at school is applicable in everyday life. The implementation of this topic will allow students to understand some ways of food preservation, i.e. lactic fermentation used in pickling or in the production of yoghurt.

The course of the lesson

► **Introductory phase (10 min.)**

1. The teacher introduces students to the subject of the classes, repeating the structure of a bacterial cell during the talk, taking into account the differences in the structure of the cell wall of Gram-positive and Gram-negative bacteria and the variety of morphological forms of bacteria.
2. The teacher brainstorms about the life functions of bacteria and focuses students' attention on lactic acid fermentation.
3. The teacher asks questions: What is the importance of bacteria in nature and for humans? What is the importance of the bacteria used in the study? How big are the bacterial cells? Can we see bacterial cells under a microscope?
4. The teacher divides the class into study groups.

► **Executive phase (30 min.)**

1. The teacher distributes trays with prepared Gram staining kits and instructions.
2. Teacher and students together analyze what Gram staining is all about. (15 min.)

Course of experience:

a. Apply a small amount of your chosen test material (a drop of cabbage juice, diluted yoghurt) to the slide, wait until it dries.
b. After the preparation dries, fix it over a flame, it is important that it does not turn black.
c. Perform staining according to the following instructions:

    1. Crystal violet diluted with water in a ratio of 1: 3 ‣ rinse 1.5 min.
    2. Rinse with water using a Pasteur pipette for 30 sec.
    3. Lugol's solution ‣ rinse 3 min.
    4. Rinse with water using a Pasteur pipette for 30 sec.
    5. Decolorant ‣ 5-10 sec.
    6. Rinse with water using a Pasteur pipette for 30 sec.
    7. Safranin solution ‣ rinse 1 min.
    8. Rinse with water using a Pasteur pipette for 1 min.
    9. Dry ‣ 5 min.

Fot. A.Mądzielewska-Jagodzińska

3. Students observe the prepared preparations under the microscope, selecting the appropriate magnification (400x or 1000x) ▸ (5 minutes)
4. Students take pictures with their phones and then look for different forms and shapes of batteries and Gram-positive and Gram-negative bacteria, with Gram-positive bacteria staining blue-violet and Gram-negative bacteria pinkish red. They sign the found forms in the photo ▸ (10 minutes)

► **Summary phase (5 min.)**

2. Summarizing the work by answering the questions: Can we see bacterial cells under a microscope? Where do bacteria live? What does it mean if a bacterium is Gram-positive or Gram-negative? How do the bacteria used in the study breathe? What is the Gram stain for bacteria? What is the importance of the bacteria used in the study?
2. Why do you think a veterinarian uses a Gram stain for bacteria?

Author: Agnieszka Mądzielewska-Jagodzińska

What does hen's egg white not like?
- we conduct an experiment with the scientific method

Learning objectives	
Student: • knows the stages of conducting using the scientific method; • knows what a research sample and a control sample is; • is able to make a hypothesis; • is able to plan an experience using the ISBE method; • conducts the experiment correctly; • is able to note down the observations and the results from the conducted experiment; • is able to draw conclusions and verify the hypothesis; • is able to relate the results of the experiment to everyday life.	**We strenghten:** Information about conducting experiments using the scientific method; **We ask:** How to plan the experience correctly? How to make a hypothesis correctly? What is a control sample and what is a research sample? **We introduce:** An ability to carry out the experience using the IBSE method.

Teaching methods	Teaching aids
Scientific method, talk, team work, discussion	• egg white, vinegar, tealight, ocet, tealight, matches, salicylic alcohol; • 4 test tubes, stand; • watch glass, weooden paw; • worksheet (Appendix number 1);

Duration

45 minutes

Factual commentary

The classes are experimental. Students plan and conduct the IBSE experiment. The experiment is about examining the effect of vinegar, alcohol and temperature on chicken protein. In the worksheet students must write down the research question, hypothesis and all the other elements of the scientific method. After conducting the experiment, they verify the hypothesis, draw conclusions and apply the results to everyday life. The experience helps to understand that the protein, which is our main building block, is sensitive to chemical and physical factors.

Course of the lesson

► **Preliminary phase (10 minutes)**

1. The teacher asks the students what is the difference between the experience and the experiment.
2. The teacher shows the stages of the scientific method and explains what a control sample and a research sample is.
3. The teacher explains how to pose a research questions and a hypothesis correctly.
4. The teacher divides the class into research groups.

► **Execution phase (25 minutes)**

1. The teacher explains that during the classes students will work with the IBSE method (it means they will plan and carry out an experiment independently, using the kits they will receive).
2. The teacher distributes the trays with the kits prepared for the experiment and explains what is included in the kit. The set contains four test tubes, a stand, egg white, a tealight, matches, watch glass, a wooden paw, vinegar and salicylic alcohol.
3. Students receive a worksheet (Appendix number 1) and complete it in the groups.
4. The students start working
5. The teacher controls the students' work, helps in determining what will be the control test. The teacher helps to plan the experience (especially taking into account this is the students' first encounter with the IBSE method).

► **Summary phase (10 minutes)**

1. Students present the work of each group and compare the results. They discuss the reason of differences in the results and wonder what they come from.
2. The teacher asks the students how they can use the results of the experiment in everyday life.

Author: Agnieszka Kołodziejska

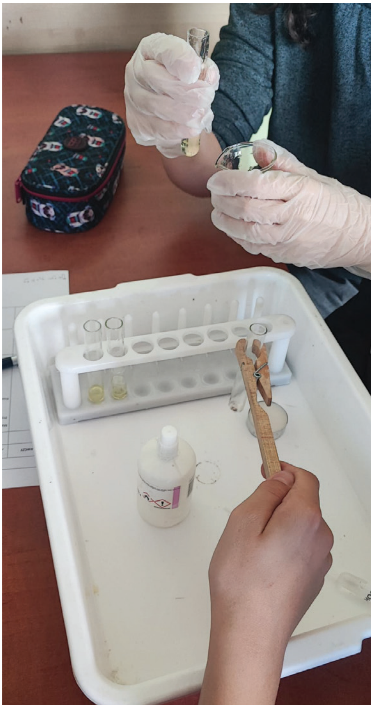
OBSERVATION / EXPERIENCE CARD	
RESEARCH PROBLEM	
HYPOTHESIS	
PROCEDURE ACCORDING TO THE INSTRUCTION	**Research material:** **Course of the experience**: • Research sample: • Control sample: **Research procedure:**
THE RESULT OF AN EXPERIENCE / OBSERVATION ATTACHMENTS: DRAWINGS AND PHOTOS	
CONCLUSIONS AND THE DISCUSSION ABOUT THE RESULTS	
REFERENCE OF THE TESTED PROCESS TO THE REAL LIFE	

Appendix number 1

Fot. Agnieszka Kołodziejska

Fot. Agnieszka Kołodziejska

Fot. Agnieszka Kołodziejska



Fot. Agnieszka Kołodziejska

Floating objects – mythbusters

Lesson objectives	
Student: • is able to predict whether a object of a given density will float in a particular liquid	**Consolidation of the concepts:** force, density **Question:** What makes some objects float and others not? **We introduce the concept:** buoyant force

Methods and forms of work	Teaching aids
Demonstraction, discussion	**beakers/glasses, cubes made of various materials:** • wpine wood, • ebony/iron wood, • aluminium, • iron, • water, • sugar, • petroleum gas, • kerosene, • turpentine, • ice cubes, • potato, • metal screw, • mercury, • heater/candle in an aluminum casing, • weight 500g/0, 1g, substance density table

Lesson duration

45 minutes

Substantive commentary

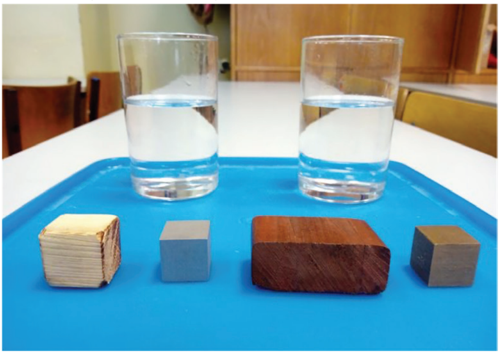
The proposed classes are of a laboratory and practical nature. They will allow students to formulate a research hypothesis and to plan and conduct an experiment - an introduction to the IBSE method. Independent planning of the experiment is extremely valuable in the context of developing scientific thinking, and formulating conclusions is the development of critical thinking. The choice of everyday products (e.g. food) as the research material shows that what a student learns at school is applicable in everyday life. The implementation of this topic will allow students to get rid of some stereotypes regarding swimming and sinking objects and to organize their knowledge in this field.

The following questions and experiences are just an example of the most common developing lesson plan based on student questions and comments. Depending on the course of an individual lesson, these questions and experiences can be supplemented or changed in their order.

The course of the lesson

► **Main question: Why do some objects float and others sink?**

- **Experiment with a cube of wood and a cube of metal.**

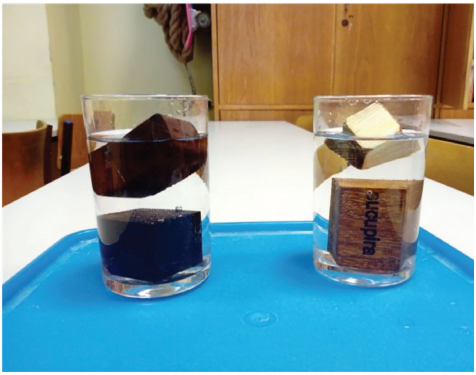


Fot. Romaric Abdoul

► **Hypotheses:**

- Something pushes the wood, not pushes the metal.
- Wood floats and metal sinks.

- **Experiment with a cube of pine and ebony/ironwood.**



Fot. Romaric Abdoul

Conclusion: refutation of the hypothesis "Wood floats and metal sinks"

► **Hypotheses:**

- Specific substances sink or not (metal, ebony wood sink, pine wood, ice float)

- ## Experiment with ice in water and extraction gasoline.

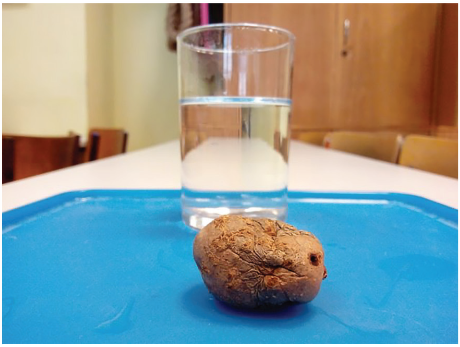
Fot. Romaric Abdoul

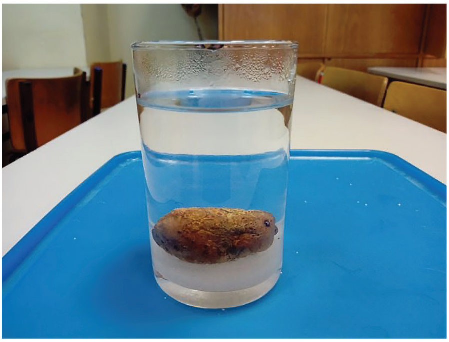
Conclusion: refutation of the hypothesis "Specific substances sink or not"

► **Hypotheses:**

- In a given substance, e.g. water, a specific substance floats or not

- **Experiment with a potato in pure water and a highly concentrated sugar solution.**





Fot. Romaric Abdoul

Conclusion: refutation of the hypothesis „In a given substance, e.g. water, a specific substance floats or not."

► **Hypotheses:**

- Light bodies float and heavy bodies sink

- **Experiment with a large cube of wood and a small metal screw.**

Conclusion: refutation of the hypothesis "Light bodies float and heavy bodies sink"

- **Experiment with a screw floating in mercury.**

Fot. Romaric Abdoul

Conclusion: even metal can float

The following questions and experiences are just an example of the most common developing lesson plan based on student questions and comments. Depending on the course of an individual lesson, these questions and experiences can be supplemented or changed in their order.

► **Hypothesis:**

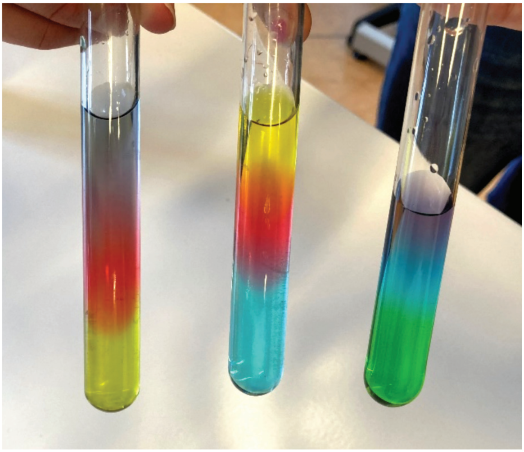
If the density of the obcect is less than the density of the liquid, then the body will float, and if the density of the object is higher than the density of the liquid, it will sink.

- **Experiment with ice in kerosene and turpentine**
- **Experiment with immiscible liquids of different densities**
- **Experiment with an aluminium/iron bowl floating on the surface of the water**

Our last hypothesis got us closer to the truth, but it doesn't seem to explain everything.
We need to check what the buoyant force depends on, but that's for the next lesson.

Author: Romaric Abdoul

Rainbow in a test tube – playing with density



Fot. Agnieszka Grzelakowska

<table>
<tr><th colspan="2">Lesson goals</th></tr>
<tr><td>

Student:

- uses correct terminology: solubility, density, saturated solution, unsaturated solution;
- eads data from solubility curve of sucrose in water and makes simple calculations based on it;
- compares the results of the experiment with other groups;
- designs and conducts an experiment to assess the density of sugar solutions of different concentrations;
- records the results of the experience in various forms, observes;
- explains the concept of saturated and unsaturated solution in the context of the solutions prepared during the experiment;
- complies with the rules of occupational health and safety.

</td><td>

We consolidate:
concepts: mixtures, solutions, types of solutions, percent concentration, density, solubility

We ask:
What do you think, what kind of mixture does sugar form with water?
Does the solubility of sugar in water depend on temperature?

We introduce:
concept: multiphase system

</td></tr>
</table>

Methods and forms of work	Teaching aids
short lecture, student experiments, teamwork (or in pairs), discussion, laboratory method	**Experimental set:** • water, • sugar (sucrose), • food dyes • long test tubes, • Pasteur pipettes, • test tube rack, • beakers, • graduated cylinder, • stirrer/glass rod, • chemical spoon • worksheets

Duration

45 minutes

Content-related commentary

1. The proposed lesson is a laboratory class with practical aspects. It will allow students to formulate a research hypothesis and to plan and conduct an experiment – an introduction to the IBSE method. Independent planning of an experiment is extremely valuable for developing scientific thinking skills, and formulating conclusions allows for developing critical thinking skills. The choice of food products as research material shows that what a student learns at school is applicable in everyday life. Introducing this topic in a laboratory way will allow students to justify and understand reasons for some of the "kitchen activities", e.g. sweetening hot drinks to increase solubility and/or dissolving rate of sugar.

2. The teacher informs the students that during the next lesson the concepts of mixtures, solutions, percent concentration, density and solubility will be used. The teacher asks that those topics be revised by the students.

Course of the lesson

► **Preliminary phase (10 min)**

1. The teacher asks the question: Does the solubility of sugar in water depend on the concentration?
2. The teacher asks the question: After analyzing the curve of the solubility of sugar in water, tell me what is the maximum amount of sugar that can be dissolved in 100 grams of water at 20 degrees Celsius?
3. The teacher divides the students into teams.

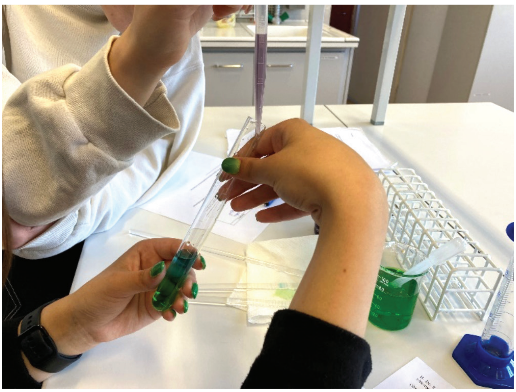
► Implementation phase

1. The teacher hands out trays with prepared sets for each team (test tubes in a rack, beakers, cylinders, Pasteur pipettes, sugar) and worksheets ▸ (5 min)
2. The teacher explains the experiment by describing all its phases:

Part 1:
Preparation of sugar solutions in water with different percentage concentrations (3-5 solutions) and coloring them in different colors with food dyes;

Fot. Agnieszka Grzelakowska

Part 2:
Preparation of a 3 (or more) phase system by carefully pouring solutions of different densities on top of each other.



Fot. Agnieszka Grzelakowska

3. Students perform parts 1 and 2 of the experiment by themselves, under the supervision of the teacher ▸ (15 min).
4. Students fill out the worksheets ▸ (5 min).
5. Students formulate conclusions and compare experimental results with the initial assumptions ▸ (5 min).

► **Summary phase (5 min)**

The teacher asks summary questions:

- What do you think, the solution of what density value was at the very top of our “rainbow”?
- Do you think it would be possible to add a layer (phase) that would be pure water?

Author: Agnieszka Grzelakowska

pH of the solution, pH scale

<table>
<tr><th colspan="2">Lesson objectives</th></tr>
<tr><td>Student:
• Uses the pH scale;
• distinguishes experimentally the pH of the solution using Acid-base indicators (phenolophtalein, methyl orange, universal indicator paper)
• plans and conducts an experiment to check the pH of the solution using chosen acid-base indicator
• records the experiment results in various forms, formulates observations, conclusions and explanations;
• safely uses simple laboratory equipment and basic chemical reagents, follows health and safety rules;</td><td>We strenghten:
An ability to conduct experiments and improve laboratory techniques.
An ability to conduct observations and draw conslusions.

We ask:
What color do the acid-base indicators take in solutions with different pH?
Is it possible to distinguish vinegar or sugar solution, from drain cleaner based on substance reaction?
Do you know everyday life substances which can be used as acid-base indicators?

We introduce:
Concepts such as: reaction, acid-base indicator, the pH scale.</td></tr>
</table>

Teaching methods	Teaching aids
talk, exercises, group work (or pair work), discussion, laboratory method	• Experimental set: pipettes with water and solutions: HCl, NaOH, pipettes with vinegar solutions, salt and drain cleaner; acid-base indicators: phenolophtalein, methyl orange, universal indicator paper, mallow flower infusionand red cabbage decoction. • Work cards put into foil document sleeves • Multimedia presentation

Duration

45 minutes

Factual commentary

Preparation of reagents anvd natural indicators:

- red cabbage decoction – pour boiling water over red cabbage leaves, drain and place in plastic Pasteur pipettes or dropper bottles, store in a fridge for a few days.
- Mallow flower infusion – pour boiling water over mallow flowers, strain and place in plastic Pasteur pipettes or dropper bottles.
- prepare diluted solution of acid and base and solution of salt, vinegar and drain cleaner, place in plastic Pasteur pipettes or dropper bottles. Before classes check if prepared solutions have concentration that changes the color of selected acid-base indicators.
- Universal indicator papers should be cut into small squares.
- Worksheets should be put into foil, transparent document sleeves, on which students will apply one drop of reagents and pieces of universal indicator papers. After the experiment, the foil should be cleaned with a paper towel.

You can find multimedia presentation at the link: **https://tiny.pl/cmtr2**

and at a QR code:

Course of the lesson:

► **Preliminary phase (10 minutes)**

1. The teacher displays multimedia presentation – gives the topic and learning objectives.
2. The teacher displays slide number 2 and asks students questions about the pH scale and the reactio n and pH of everyday life products, for example coca-cola, salt water and cleaners.
3. The teacher displays slides number 3 and 4, consolidates names of acid-base indicators (phenolophtalein, methyl orange, universal indicator paper) and gives examples of natural acid-base indicators, referring to everyday life, for example tea color after adding lemon juice.
4. The teacher divides students into teams with 3-4 people, gives worksheets in foil document sleeves, introduces students with reagents and laboratory equipment, which will be used in class.

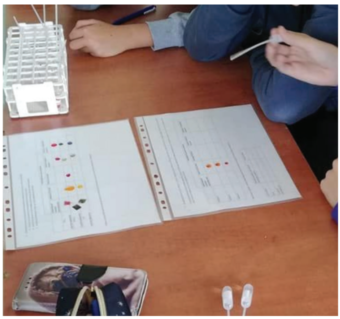
► **Execution phase (30 minutes)**

1. The teacher displays slide number 5, orders reading the instruction of executing experiment, discusses the course of the experiment.
2. Students apply one drop of solutions in the appropriate rows of the table on the worksheet put in foil document sleeves, then they put a piece of universal indicator paper in the first column and apply one drop of the indicated indicator in the next columns. The teacher controls the work of students.
3. Students write down in notebooks colors of indicators in alkaline, acidic and neutral solutions.
4. The teacher displays slide number 6 and discusses the experiment results with the students. Students compare their results with other groups, draw conclusions about colors of acidbase indicators in solutions of different pH.

5. The teacher displays sliide number 7, orders reading the instruction of executing experiment, discusses its course.
6. Students apply a drop of solutions in the appropriate rows of the table – sample 1, 2 and 3 on the worksheet put in foil document sleeves, then apply the chosen reagent or reagents in order to identify reaction of the tested solutions. The teacher controls the work of the students.
7. Students write down the results and conclusions from the experiment in the form of the table, which pattern is included in the worksheet and on slide number 8 of the presentation.
8. The teacher displays slide number 9 and discusses the results of the experiment. Students compare their results with other groups.
9. The teacher displays slide number 10 and explains the effect of H+ and OH- ion concentrations on the pH of the solution.

► **Summary phase (5 minutes)**

1. The teacher displays slide number 10, presents information about pH of urine, blood, gastric juice and intestinal contests. Students define reactions occuring in the human body.
2. The teacher displays slide number 11 and asks students why the gardener needs to know what is the reaction and the pH of the soil?
3. Students search the internet for information on importance of soil pH for growth of various plants. They search for the most beneficial soil pH for blueberries, coniferous shrubs and rhododendrons.

Fot. Kamila Koczorowska

Author: Kamila Koczorowska

1. Check what colors the acid-base indicators take in solutions with different pH:
   - apply the solutions drop by drop in the appropriate lines of the table
   - put a piece of universal indicator paper in the first column
   - add the indicator drop by drop in the following columns

	Acid-base indicator				
	UNIVERSAL INDICATOR PAPER	**METHYL ORANGE**	**PHENOLPHTHALEIN**	**MALLOW FLOWER INFUSION**	**DECOCTION OF RED CABBAGE**
HCl_{aq} **Acid pH**					
$NaOH_{aq}$ **Alkaline pH**					
H_2O **Neutral pH**					

Write down in your notebook what color each of the indicators takes in acidic, alkaline and neutral solution.

2. There are three different solutions: table salt solution, drain cleaner and vinegar in the pipettes marked with numbers 1, 2 and 3. Use the indicator chosen by you (you can use one indicator or more) to check the readings of the solutions in sample 1, 2 and 3. Determine what solutions are in each sample on that basis.

	Asid-base indicator				
	UNIVERSAL INDICATOR PAPER	**METHYL ORANGE**	**PHENOLPHTHALEIN**	**MALLOW FLOWER INFUSION**	**DECOCTION OF RED CABBAGE**
Sample 1					
Sample 1					
Sample 1					

Write down observations and conclusions from the experiment in your notebook in the form of a table according to this formula:

	The name of the indicator and its colour after adding it to the solution	**Sample number**
Table salt		
Vinegar		
Drain cleaner		

Lava lamp

Goals	
Student: • use correct terminology, recognize the terms Density, Weight, Volume • design and conduct a simple physical experiment • record the experiment's results • formulate the experiment's conclusion • observe the laboratory work safety rules • collaborate with classmates, discuss	**Reinforce:** The terms Density, Weight, Volume. **Ask:** What is the behaviour of two liquids with a different density that do not mix? How do the oil and coloured water distribute themselves in the bottle? What happens when we drop an effervescent tablet into the bottle? **Introduce:** Individual observation

Methods and forms	Teaching aids
An experiment in a class or a science circle.	Empty transparent 0,5 l bottle, oil, water, food colouring, effervescent vitamin tablets.

Duration

1 class

Notes on lesson plan:

Access to a laboratory is not necessary. This laboratory exercise can be conducted in a simple classroom as well.

Lesson plan

► **Lesson introduction**

We ask:
- What is the behaviour of two liquids with a different density that do not mix?
- How do the oil and coloured water distribute themselves in the bottle?
- What happens when we drop a piece of an effervescent tablet into the bottle?

Students receive instructions on how to make a lava lamp, without further explanation.

► **Main class activity**

Students conduct a lava lamp experiment individually or in pairs. They document the experiment by taking photographs and recording video. They try to find physics-based explanations for the experiment's results. They engage in discussions.

► **Lesson evaluation**

Together with the students, go through the answers to the questions on the worksheet. Discuss options for safe cleaning and rinsing laboratory utensils. Let the students use the fume hood for tidying up the tools used in the experiment.

Making lava lamp

► **What we need:**

- taller narrow glass bottle (e.g. those used for holding olives), or a 0,5 l PET bottle
- water
- food colouring
- oil
- effervescent tablet (e.g. vitamin tablet)

► **Working procedure:**

1. Fill 2/3 of the bottle with oil.
2. Add coloured water. As a result of the difference in density, water sinks.
3. Break the effervescent tablet in half or in quarters and throw it into the bottle.
4. Observe the lava lamp.
5. We encourage the students to properly describe what they observed.
6. We discuss the physical principles behind the observed phenomena.

► **Explanation:**

The basis of the effervescent tablet consists of the mixture of citric acid and baking soda. This mixture, when dissolved in water, releases carbon dioxide, which causes bubbles to form in the bottle. Drops of coloured water containing bubbles then slowly rise through the oil to the surface where the carbon dioxide escapes into the air and the drop of water sinks again.

► **Lesson evaluation**

At the lesson's end we show our lava lamps to each other and give physical explanations to everything we observe.

Author: Mgr. Hunešová Klára

Yeast Metabolism

Goals	
Student: • learn how to conduct a simple biological experiment • learn how to work with a wireless sensor • learn how to process measurement data • test their knowledge • use correct terminology • derive simple conclusions from the experiment's results	**Reinforce:** knowledge of yeasts **Ask:** on what depends the activity of yeasts **Introduce:** CO2 concentration, ideal conditions, fermentation process

Methods and forms	Teaching aids
Laboratory work, discussing measurement data	Wireless CO2 sensor with accessories, mobile phone, baker's yeast, sugar, water

Duration

1 class

Notes on lesson plan:

Lesson plan

► **Lesson introduction**

- Summarizing knowledge of yeasts and their metabolism
- Dividing students into groups of 2 - 3
- Handing out report forms and teaching aids
- Collective recapitulation of the working procedure and clarification of individual steps

► **Main class activity**

- Student groups carry out individual steps of the working procedure

- They ready the wireless CO2 sensor, connect the sensor to the mobile phone and then verify the influence of individual factors on the intensity of the fermentation process. They check out:
  1. Mixture of baker's yeast and water
  2. Mixture of baker's yeast and warm water
  3. Mixture of baker's yeast, warm water and sugar

- They write down the measured concentration of CO2 into the report form. They formulate the conclusion.:

► **Lesson evaluation**

Students discuss measurement data, consult about practical implications of the relationships they have discovered.

Author: Bc. Zhorný Filip

Laboratory exercise

Topic: Yeast Metabolism	Date:
Name:	
Team members:	

► **Assignment:**

Verify the influence of various factors on the intensity of metabolism of yeasts. Verify the influence by measuring CO_2 concentration by means of a wireless sensor.

► **Teaching aids:**

Wireless CO_2 sensor with accessories, mobile phone, baker's yeast, sugar, water, spoon

► **Working procedure:**

1. Connect the wireless CO_2 sensor to the mobile phone with the PASCO Sparkvue application
2. Calibrate the sensor following the teacher's instructions
3. Prepare, in turn, three different mixtures putting them into the container for measuring CO_2 and measure the changes in CO_2 concentration over time (approximately 2 – 4 minutes). Rinse the container after each set of measurements.
   a. mixture of baker's yeast (1/3 of a cube) and 100 ml of cold water
   b. mixture of baker's yeast (1/3 of a cube) and 100 ml of warm water
   c. mixture of baker's yeast (1/3 of a cube), 100 ml of warm water and two teaspoons of sugar
4. Enter the graphs of the changes in CO_2 concentration over time from the individual sets of measurements into the report form
5. Write down the conclusion of your observations

► **Measurements:**

Mixture of baker's yeast and cold water - CO_2 concentration graph

Mixture of baker's yeast and warm water - CO_2 concentration graph
Mixture of baker's yeast, warm water and sugar - CO_2 concentration graph
Conclusion:

Simple Pendulum

Goals	
Student: • use correct terminology, recognize the terms Period of Oscillation and Frequency of Oscillation • design and conduct a simple physical experiment • record the experiment's results • formulate the experiment's conclusion • observe the laboratory work safety rules • collaborate with classmates, discuss	**Reinforce:** The terms Simple Pendulum, Period, Frequency. **Ask:** Is the period of the simple pendulum influenced by the length of the cord, pendulum's weight, or amplitude? **Introduce:** Presenting measurement results using tables and graphs

Methods and forms	Teaching aids
Laboratory work followed by discussion of individual groups' work results.	Mechanical kit for creating a model of a simple pendulum, set of 50g weights, cord, ruler, stopwatch (mobile phone).

Duration

2 classes

Notes on lesson plan:

Access to a laboratory is not necessary. This laboratory exercise can be conducted in a simple classroom as well.

Lesson plan

► **Lesson introduction**

- Students have already had theoretical lessons on the subject of oscillation and are familiar with the terms Period and Frequency. We might want to go over these terms again at the beginning of the laboratory work.
- Students divide themselves into groups of three and receive the laboratory work report form from the teacher. Together with the teacher, they read the goals of the work, what measurements they are expected to conduct and what are the report and the conclusion of the work look like.

► **Main class activity**

Students' groups work independently on the goals of the laboratory work.

a. they assemble the simple pendulum
b. they perform measurements and write them down into the report form provided to them
c. they formulate the conclusion and explanation
d. they enter the measurement results into a graph (if they do not finish in time, we process the results during joint evaluation)

► **Lesson evaluation**

In the next class, we discuss with the students their measurement results. We read their individual conclusions and assess how correct they are. We then discuss other factors that might have an influence on the period of the simple pendulum.

Author: Mgr. Hunešová Klára

Topic: Simple Pendulum	Date:
Name:	
Team members:	**Class:**

► **Assignment:**

Find out how the pendulum's period of oscillation changes depending on the pendulum's amplitude, weight and its suspension cord's length.

► **Teaching aids:**

Mechanical kit, 50 g weight, cord, stopwatch.

► **Working procedure:**

Fix a thin cord to a stand, create a loop for suspending the weight at the other end of the cord.

a. Measuring the influence of amplitude: set the 1 m long pendulum (the 50 g weight) swinging only a little at first with an amplitude of 2 cm and measure the time of 10 swings. Then repeat the measurement with an amplitude of 10 cm and increase the amplitude by 10 cm for each subsequent measurement until it reaches 30 cm.

b. Measuring the influence of weight: set the 1 m long pendulum (50 g weight initially) swinging with an amplitude of 2 cm for each measurement and measure the time of 10 swings. Gradually increase the pendulum's weight by adding 50 g weights until it reaches 200 g while taking care that the pendulum's length does not increase significantly.

c. Measuring the influence of pendulum's length: set the 1 m long pendulum with a weight of 50 g swinging with an amplitude of 2 cm and measure the time of 10 swings. Decrease the pendulum's length by 25 cm for each subsequent measurement. Conduct the last measurements with the length of 25 cm.

- Write down the measured values into the table.
- Calculate the pendulum's oscillation period for each measurement.
- Create a graph of dependence of the pendulum's period of oscillation on the suspension length.
- Is there a direct proportion?
- Write down the conclusion of your observations and measurements.

► **Work results:**

a. Measuring the influence of amplitude:

amplitude **cm**	**2**	**10**	**20**	**30**
time of 10 swings **s**				
period **s**				

b. Measuring the influence of weight:

pendulum's weight **g**	**50**	**100**	**150**	**200**
time of 10 swings **s**				
period **s**				

c. Measuring the influence of pendulum's length:

pendulum's length **cm**	**25**	**50**	**75**	**100**
time of 10 swings **s**				
period **s**				

► **Graph of dependence of the pendulum's period of oscillation on the suspension length:**

X axis … pendulum's length in cm
Y axis … period in s
Choose suitable scales.

Conclusion:

Density of a body

Goals	
Student: • distinguish physical quantities, are able to measure them and to evaluate results • understand and make use of the relationship between density, weight and volume in solving practical assignments • appropriately choose measuring instruments to measure some important physical quantities of substances and bodies	**Reinforce:** unit conversion, remembering formulas **Ask:** What is the density of a coin? **Introduce:** • entering data into report form • using the formula for calculating the volume of a cylinder

Methods and forms	Measuring tools
Practical measurement of given physical quantities in specialized classroom, working in groups of three	Laboratory scales, graduated cylinder, ruler, vernier caliper, coin, calculator, paper napkins

Duration

45 minutes = 1 class

► Notes on lesson plan:

Before the lesson:

- dividing students into groups
- preparing report forms (see appendix)
- preparing tools depending on the number of groups

► Lesson goals

Measuring and recording measured values of physical quantities needed for determining the density of a coin.

► Lesson introduction

- Giving information on the lesson goals
- Recapitulation regarding laboratory work – the concepts of volume, weight, units, unit conversion
- Work instructions – how to hand in the tools, how to take care of the tools, work safety
- Handing out tools and report forms to each group

► **Main class activity**

1. Measuring 10 different coins in turn on laboratory scales, writing down the values.
2. Determining the volume of all 10 coins using graduated cylinder, writing down the values.
3. Measuring the diameter and thickness of a coin using ruler and vernier caliper, writing down the values.
4. Cleaning the workplace. If the group has time left, they begin to process the measured values.

► **Lesson evaluation**

First big measurement for the first-year grammar school students. Students have little experience with division of labour, they are clumsy with measurements and working with tools and water. Troubles reading lengths on a caliper. Inability to logically appraise values, troubles with units.

Author: PaedDr. Kalivodová Ivana

<table>
<tr><th colspan="3">Measurement report form</th></tr>
<tr><td colspan="2">Topic: Determining density of a Czech coin</td><td>Type of coin:</td></tr>
<tr><td>Name:</td><td>Class: I. NG</td><td>Date: 21. 2. 2023</td></tr>
<tr><td colspan="3">Other team members:</td></tr>
<tr><td colspan="3">Tools: 10 identical coins, laboratory scales, graduated cylinder with water, vernier caliper, calculator, sheet of paper, pen, paper napkins.</td></tr>
<tr><td colspan="3">Theory: Determining density using a formula</td></tr>
<tr><td colspan="3">Working procedure:
1. Weigh each coin separately on laboratory scales and write down its weight m_1 into the table. When finished, turn off the scales, put them back into the box and hand them in to the physics teacher.
2. Pour a suitable volume of water V_1 into the graduated cylinder and write it down into the table. Tilt the graduated cylinder in such a way that the water does not spill out and carefully insert the coins into the water one by one along the inclined side of the cylinder. After all the coins have been inserted, write down the volume V_2 into the table. Carefully pour the water out of the cylinder and wipe the coins dry.
3. Use the ruler and vernier caliper to measure the diameter d and the thickness h of the coin and write the values down into the table. Put the coins back onto the paper they came from and clean the workplace before making the calculations.</td></tr>
</table>

► **Processing the measured values:**

Determine the weight m of a single coin as the average weight of all weights m_1. Verify the calculation by measuring deviations $m_1 - m$, whose sum ∑ must be 0. Additionally calculate the values V_{10} and V for all measurements. For calculating density, choose the value V that the team members consider to be the most accurate.

Weights	weight (g) m_1	deviation (g) $m_1 - m$
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
Ar.average	**m =**	$\sum$ =

Graduated cylinder	volume (ml)
water	**V_1 =**
water + 10 coins	**V_2 =**
10 mincí	**V_{10} =**
1 coin	**V =**
Ruler	**Vernier caliper**
d = ____________	d = ____________
h =	h =
$V = \frac{\pi \cdot d^2 \cdot h}{4}$	$V = \frac{\pi \cdot d^2 \cdot h}{4}$
V =	**V =**

Calculating density: p =
Conclusion:

Revealing a fingerprint by sublimation of iodine

Goals	
Student: • identify states of matter and differences between them. • demonstrate safe handling of iodine in a laboratory setting. • gather and analyse experiment data. • use correct terminology. • collaborate with their peers in order to accomplish a task. • draw conclusions about properties of iodine and the principle of sublimation.	**Reinforce:** knowledge of halogens, states of matter, properties and composition of matter; safe working with toxic substances **Ask:** What happens when we heat up iodine to the temperature close to that of human body? What happens when we heat up iodine in a closed vessel? How does sublimation work? How can we analyse a fingerprint by means of sublimation? What form does iodine have in solid and gaseous state? **Introduce:** properties of iodine in solid and gaseous state; utilising sublimation in forensic analysis; importance of a thoroughly worked-out plan of experiment preparation

Methods and forms	Teaching aids
Laboratory exercise under the guidance of a teacher; group work; discussion; written evaluation	Erlenmeyer flask with a stopper, small piece of paper, scissors, iodine, protective gloves

Duration

45 min

Notes on lesson plan:

Iodine is a toxic substance. Contact with gaseous iodine may lead to irritation of airways, eyes and skin. Always conduct the experiment in a well-ventilated room.

Cleaning after the experiment should be done in a fume hood.

Lesson plan

► **Lesson introduction**

Divide students into groups and give them worksheets containing introductory exercises and working procedure. Leave the students some time to work on the first exercise meant to recapitulate important terms and then find out the correct answers.

► **Main class activity**

- Give the students the necessary tools (except the iodine) and let them continue working according to the instructions on the worksheet.
- Walk among the students' groups and, if necessary, help them understand the procedure and assist with the preparatory stage of the experiment.
- After the preparatory stage has finished, pour a small amount of iodine (half a spoonful) into the Erlenmeyer flask and let the students continue with the experiment.
- After the conclusion of the experiment, encourage the students to discuss the questions on the worksheet.

► **Lesson evaluation**

Together with the students, go through the answers to the questions on the worksheet. Discuss options for safe cleaning and rinsing laboratory utensils. Let the students use the fume hood for tidying up the tools used in the experiment.

Author: Mgr. Çakmak Michaela

Worksheet: Revealing a fingerprint by sublimation of iodine

1. Match the terms with their correct definitions:

1. Halogens	a. one of states of matter, in which the particles are relatively close together, but are not bound in fixed positions and can move about in the full volume.
2. Toxins	b. a phase transition, during which a solid becomes gas without the solid melting.
3. Volatile substances	c. a phase transition, during which a liquid becomes gas only from its surface.
4. Melting	d. a substance, which can interfere with functions of organisms, if it enters the organism in sufficient quantity.
5. Evaporation	e. members of the 17th group of the periodic table. They include fluorine, chlorine, bromine and iodine.
6. Boiling	f. evaporate easily. They are most commonly liquids.
7. Sublimation	g. one of states of matter, in which the particles are relatively spread apart, move about in the full volume and do not exercise attractive force on one another.
8. Desublimation	h. a particle composed of atoms or ions.
9. Atom	i. one of states of matter, in which the particles are bound in their „fixed" positions around which they oscillate.
10. Molecule	j. a phase transition, during which a gas directly becomes solid without first undergoing condensation.
11. Solid	k. a phase transition, during which a solid becomes liquid.
12. Liquid	l. the smallest particle of an ordinary matter, which further consists of electrons, protons and neutrons.
13. Gas	m. a phase transition, during which a liquid becomes gas in its full volume.

2. Conduct the following experiment:

Assignment:	use iodine vapours to reveal fingerprints on a paper strip.
Tools and chemicals:	Erlenmeyer flask with a stopper, paper, scissors, protective gloves, iodine
Working procedure:	• Leave fingerprints on a piece of paper and put the paper into the flask (see the drawing). • Make the stopper ready and call the teacher. • Plug the flask immediately after the teacher has poured a small amount of iodine into the flask. • Heat the bottom of the flask with the palm of your hand so that sublimation of iodine occurs. • Observe the piece of paper with the fingerprint inside the flask and then observe the general aspect of the gases inside the flask using a white piece of paper as a background.

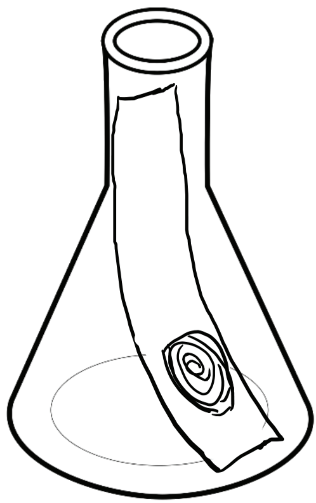


Fig.: Drawing of the proper way of inserting a piece of paper with a fingerprint into the flask.

3. Answer these questions:

a. What change on the piece of paper inside the flask did you notice?
b. How did the general aspect of the gases inside the flask change?
c. What was the aspect of the iodine before and after sublimation?
d. Estimate, why did the fingerprint become visibly coloured during the experiment.

Bird feeder station

Bird watching is a good way to connect with nature. Teachers from ZŠG Vodňany took an inspiration from this and thanks to this Erasmus + project were able to create an experimental station, that involves a bird feeding station and a live camera feed accessible to anyone with authorization.

The project involved setting up a bird feeding station outside the school building. The feeding station includes several types of feeders for different kinds of birds and also a water bowl. Additionally, a camera was installed to capture the birds' activity throughout the day. You can see the whole station in the Figure 1 below.

The live camera feed is available through a special application native to the camera brand, which can be accessed through a mobile or desktop device. Students, teachers, and anyone else with authorization can use the app to view the live feed at any time of the day. The feed has several options such as zoom, a volume slider, and night vision under low light conditions. Depending on the connection quality, users can also view the feed with high resolution and clear details. Picture from a live feed is below in the Figure 2.

The educational possibilities for this project are vast. Teachers can use the live feed as a teaching tool to help students identify different types of birds and their behaviors. It can also be used as a part of a statistical project in math, allowing students to track and analyze bird populations over time. Students can even create their own experiments, such as determining the preferred type of seed for various kinds of birds. Furthermore, the camera footage can be used for students' video assignments in their IT classes.

This project was a fantastic way for students to connect with nature and learn about the importance of bird conservation. It provides a unique opportunity to observe birds up close and personal, giving students a deeper understanding and appreciation of the natural world around them. It is also an excellent example of including technology in education and hands-on-learning.

Figure 1: Bird feeding station set up.

Figure 2: Zoomed in picture from a live feed.

Author: Mgr. Çakmak Michaela

Digital applications and sources

Teachers from both countries have exchanged a couple of digital applications and sources that they have found useful during their lessons. Here is a short introduction to each of them.

Aldogoo

Aldogoo is a desktop application that can be downloaded for free at algodoo.com. This application allows its users to create interactive 2D simulations of physical systems which can help analyze and visualize forces and momentum. There are also prepared lessons and a waste library of customized user made templates, which are free to download.

Teachers can use these tools both for demonstrational purposes and class exercises for students.
It is available in English, Polish and several other languages.

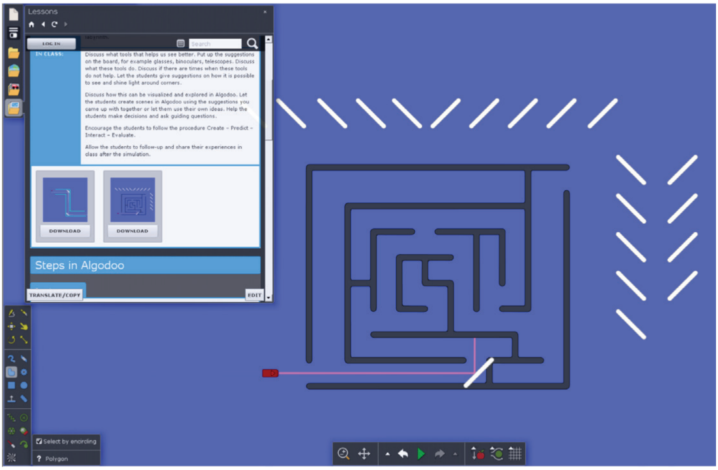


Figure 1: Example of a downloadable lesson from Aldogoo about reflection.

Phyphox

Phyphox is an application that can be downloaded for free at phyphox.org. It is available for PC users and mobile users in Play Store and App Store. Application can use available sensors on users' phone to make measurements of physical parameters. It has functions of measuring and visualizing acceleration, pressure, elevation, and various other physical parameters. It is also possible to export the data outside of the application.

This application shows its usefulness during class exercises, home projects and online teaching sessions. It is available in English, Polish, Czech and many other languages.

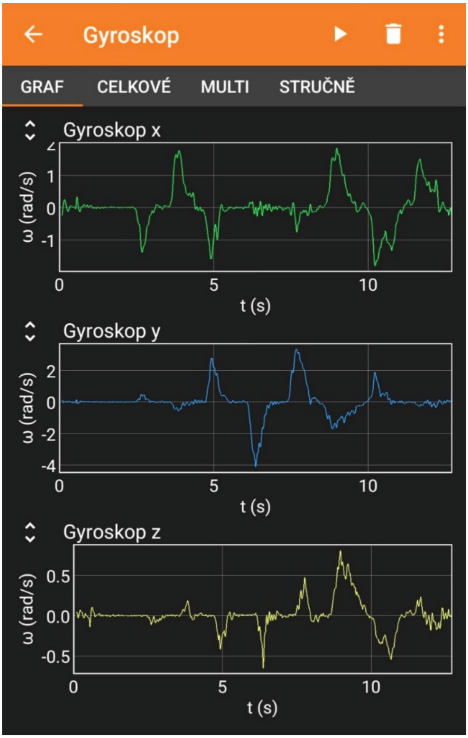


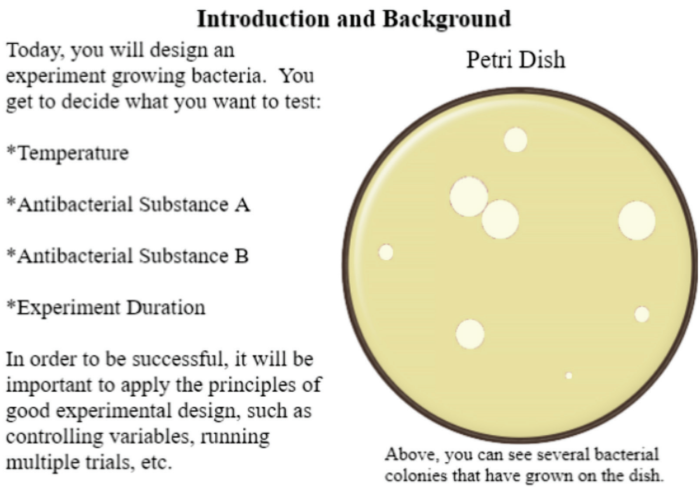
Figure 2: Data output of a gyroscope sensor in mobile phones from Phyphox.

Biomanbio

Biomanbio is a free online source available at biomanbio.com. It provides educational applications, which some are also available for mobile users. Applications are structured as lesson plans focusing on various topics from biology and chemistry. Most of the applications have an evaluation system at the end of each part.

Although it is available only in English, the creator of the website, an English teacher, is open for cooperation in translating the material to other languages.

Teachers can utilize this source both for class sessions and homework assignments.



Introduction and Background

Today, you will design an experiment growing bacteria. You get to decide what you want to test:

*Temperature

*Antibacterial Substance A

*Antibacterial Substance B

*Experiment Duration

In order to be successful, it will be important to apply the principles of good experimental design, such as controlling variables, running multiple trials, etc.

Petri Dish

Above, you can see several bacterial colonies that have grown on the dish.

Figure 3: An application about bacteria growth from biomanbio.com.

Nutriční stopa

Nutriční stopa is a Czech website, that is available at nutristopa.cz. It is an online source for keeping track of carbon footprint from the food industry. It also has a calculator for users to calculate their own carbon footprint of home prepared meals. It considers the variables from the harvesting of the ingredients until they end up in our kitchens. Resulting data can be viewed as color rich charts and graphs showing the parameters of CO2 and SO2 production, water consumption and others.

It can be used for both class sessions and homework assignments. It is only available in Czech language; however, it can be used with google translate function of browsers.v

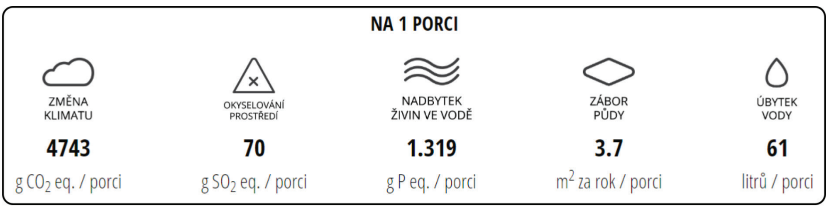


Figure 4: Environmental impact data from one portion of the svíčková home made meal from nutristopa.cz.

GarticPhone

Garticphone is a web browser-based application available at garticphone.com. It is free to use, and its functions include several modes that are based on Telephone Game. Users must pass on the information to the next person by alternating between drawing and describing the content with words. For most comfortable use, it is recommended to play on tablets or on computers.

It can be a useful platform for teachers when teaching language, naming of chemical structures, anatomy parts and many other topics. Available in English, Polish, Czech and many other languages.

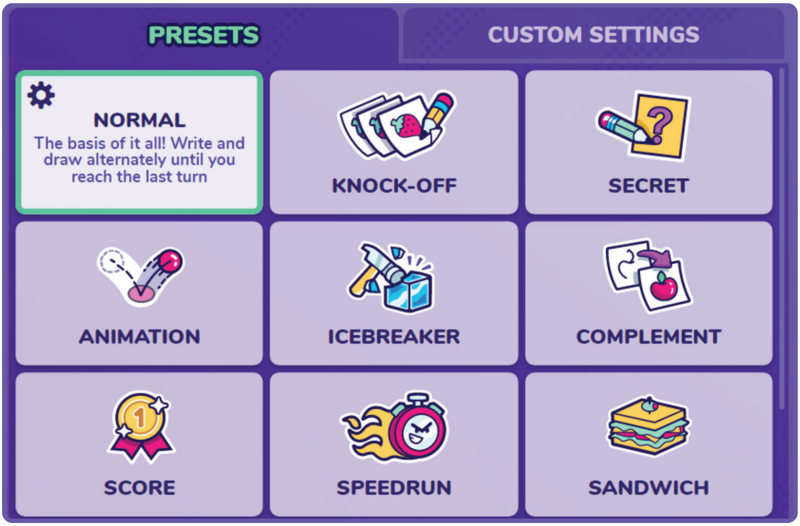


Figure 5: Game modes that are available on garticphone.com.

Blooket

Blooket is a browser-based application available at blooket.com. Teachers can create sets of questions to be answered and students will try to answer the questions through a game that is agreed on from the 15 available options. The teacher starts the game from browser and students can join on their phones, using login codes assigned. Each student will have access to see their own score after each game.

It is a growing platform with ready-to-use sets of questions available. Platform's language is English, however customized sets of questions in other languages can also be found. It can be used in class or online lessons.

Figure 6: Available games on blooket.com.

Author: Mgr. Çakmak Michaela

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Notes