Learn STEM

Innovative Model of learning STEM
in secondary schools

ERASMUS+ KA220
Cooperation Partnerships in school education

WP2: LearnSTEM Pedagogical Model

STEM Practices Implementation Handbook

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1. Learning Resources

1.1 Learning Unit – **Design A Solar Panel**

1.1.1 Background

Having a basic level of Arduino Uno control board programming knowledge before this course would be beneficial for students to create more effective designs.

A short video is shown to students to draw their attention to the importance of solar energy, a renewable energy source. After attracting the students' attention, conceptual information is given about what solar energy is and how solar panels work. Students are then asked what can be done to get more efficiency from solar panels. Students are asked to put forward different ideas on this subject. Then, students are shown examples of different solar panel designs used around the world.

By touching on the way solar panels work, it is shown how the angle of sunlight falling affects the electricity obtained from the solar panel using a flashlight, voltmeter and solar panel. It is mentioned that the angle of the sun's rays falling on the earth may change and this may affect the energy obtained from solar panels. Students are asked to think about what can be done to ensure the continuity of the sun's rays perpendicular to the solar panel. Students are asked to explain their ideas to other students. They are asked to discuss among themselves. After the students' opinions are collected, a sample study that has been done previously on this subject is shown and how they can benefit from different materials.

For this; the use of the 3D design program Tinkercad and how to get a print from a 3D printer are shown. It is then shown how the resulting parts and other electronic parts are connected. An example program is shown on how to control electronic parts with Arduino Uno. Finally, the prepared work is tested and its success is evaluated with the students.

1.1.2 Content

LearnSTEM Pedagogical Model Module 1: Design a Solar Panel	
Aim of the module/ learning unit	**The purpose of this module is to emphasize the importance of utilizing solar energy, which is a renewable energy source.**
Duration	**40’ x 8**
Learning Objectives	• Students will be able to know what solar energy is. • Students will be able to explain how solar panels work. • Students will be able to discover different solar panel designs. • Students will be able to know what can be done to get more efficiency from solar panels. • Students will be able to design a solar panel to make better use of solar energy.
Resources&Materials Required (worksheet,charts, handouts, didactic video, excerpt from books/manuals, mind maps, etc.)	• For Design: (3D design program and 3D printer) or (plywood, cardboard and silicon gun) • For Electronics: Servo motor, light sensor, jumper cable, resistor, voltmeter, Arduino uno, soldering iron
Procedure	instructional steps: 1. Capture students' attention to the topic. 2. Provide information about solar energy. 3. Show examples of solar panel designs. 4. Demonstrate the use of Tinkercad and how to obtain output from a 3D printer. 5. Show how electronic components are connected. 6. Evaluate the success of the prepared work through testing with students. 7. Feedback.

Content Delivery Methods (lecture,discussions, research, group work, etc.)	Group work Explanation Practice demonstration Discussion Brainstorming
Assessment Method	H5P Exam
References	Almadhhachi, M., Seres, I., & Farkas, I. (2022). Significance of solar trees: Configuration, operation, types and technology commercialization. *Energy Reports*, *8*, 6729-6743. Bakirci, K. (2012). General models for optimum tilt angles of solar panels: Turkey case study. *Renewable and Sustainable Energy Reviews, 16*(2012), 6149-6159. http://dx.doi.org/10.1016/j.rser.2012.07.009 Dal, A. R. (2021). Güneş enerji panellerindeki optimum eğim açısının verime etkisinin incelenmesi. *Bilecik Şeyh Edebali Üniversitesi Fen Bilimleri Dergisi, 8*(1), 241-250. https://doi.org/10.35193/bseufbd.878795 Le Roux, W. G. (2016). Optimum tilt and azimuth angles for fixed solar collectors in South Africa using measured data. *Renewable Energy*, *96*, 603-612. http://dx.doi.org/10.1016/j.renene.2016.05.003 Melhem, R., & Shaker, Y. (2023). Optimum tilt angle and solar radiation of photovoltaic modules for gulf collaboration council countries. *International Journal of Energy Research*, *2023*. https://doi.org/10.1155/2023/8381696 Tang, R. & Wu, T. (2004). Optimal tilt-angles for solar collectors used in China. *Applied energy, 79*(2004), 239-248. https://doi.org/10.1016/j.apenergy.2004.01.003 https://www.greenprophet.com/2015/11/solar-palm-trees-3d-printed-dubai/ https://www.britannica.com/science/solar-energy https://education.nationalgeographic.org/resource/solar-energy/ https://dictionary.cambridge.org/dictionary/english/solar-energy https://www.nrel.gov/news/video/solar-energy-basics-text.html https://www.energy.gov/eere/solar/how-does-solar-work https://www.energy.gov/eere/solar/solar-photovoltaic-system-design-basics https://www.energy.gov/eere/solar/concentrating-solar-thermal-power-basics https://www.energysage.com/blog/most-common-solar-energy-uses/ https://pib.gov.in/PressReleasePage.aspx?PRID=1650102

1.2 Learning Unit – **Multiplication of Yeasts as Bioorganisms**

1.2.1 Background

Yeast; oval in shape, colorless and smooth, converts carbohydrates to alcohol during fermentation, reproduces through budding, used in baking industry and in the production of ethanol, e.g. *Saccharomyces cerevisiae* (Baker's yeast). Yeast is a single-celled organism from the fungi kingdom. There are more than 500 species and thousands of variants of yeast. Yeast can be found in the soil, in sugary liquids (fruit and flowers), and on the surface of plants and animals. Yeast has several applications in biotechnology and plays a significant part in producing bread and alcoholic beverages.

In food manufacture, yeast is used to cause fermentation and leavening. The fungi feed on sugars, producing alcohol (ethanol) and carbon dioxide; in beer and wine manufacture the former is the desired product, in baking it is the latter.

In yeast, budding usually occurs during the abundant supply of nutrition. In this process of reproduction, a small bud arises as an outgrowth of the parent body. Later the nucleus of the parent yeast is separated into two parts and one of the nuclei shifts into the bud. The newly created bud.

Factors affecting yeast proliferation are:

- Temperature
- pH
- O2 Exchange
- Carbon source and concentration
- Nutrient media combination
- Mixing speed etc…

The behavior of the dough during fermentation can be presented as sigmoidal curves using different mathematical models. Bread making is fundamentally a temperature dependent two step progression, consisting of fermentation, in which CO2 production linked with yeast activity is manifested in porous dough structure with the development of dough volume during baking where yeast activity is ended and the bread structure is finalized.

1.2.1 Content

LearnSTEM Pedagogical Model Module 2: Multiplication of Yeasts as Bioorganisms	
Aim of the module/ learning unit	**The purpose of this module is to demonstrate how yeast proliferates under favorable conditions.**
Duration	**40'x 4**
Learning Objectives	Students will be able to explain that yeasts multiply under suitable conditions and show them through experiments.
Resources&Materials Required **(worksheet,charts, handouts, didactic video, excerpt from books/manuals, mind maps, etc.)**	• For Experiment 1:Yeasts, hot water, warm water, cold water, sugar, spon, graduated cylinder. • For Experiment 2:Yeasts, warm water, sugar, spon, graduated cylinder. • PowerPoint presentations
Procedure	• In order to do this activity, students must know microscopic creatures in advance and be able to give examples. These topics are repeated and the activity begins. • The materials required for Experiment 1 are prepared in advance and brought to the classroom and placed in a place where every student can see. Students are divided into random groups of 3-4 people. Using these materials, they are asked to create a mechanism in which we can compare the proliferation of yeasts in hot, cold and warm environments. The mechanisms made by the groups are compared with other groups (Figure 1). Students are asked in which environment yeast can grow best and the answers are discussed. • In the next lesson, the materials required for Experimental 2 are brought to the classroom. Students are divided into random groups of 3-4 people. Students are asked to create a mechanism in which we can compare the growth of yeasts in sugary and sugar-free environments. • Students are then asked what other conditions are required for yeasts to multiply. • Presentations and videos prepared on the subject are shown to students.

Content Delivery Methods **(lecture,discussions, research, group work, etc.)**	Teamwork Research Practical demonstration Discussions Explanation Brainstorming Problematisation Practical experiment
Assessment Method	H5P Quiz
References	Ali, A., Shehzad, A., Khan, M. R., Shabbir, M. A., & Amjid, M. R. (2012). Yeast, its types and role in fermentation during bread making process-A. *Pakistan Journal of Food Sciences*, *22*(3), 171-179. Koçak, F. 2019. Farklı Havalandırma Profillerinde Maya Çoğalmasının Betaglukan Verimine Etkisinin İncelenmesi. Ankara Üniversitesi. Fen Bilimleri Enstitüsü. Unpublish Master Thesis. Pamir, H. 1985. Fermantasyon Mikrobiyolojisi. Ankara Üniversitesi Ziraat Fakültesi Yayınları, No:936, Ankara. Walker, G. M. 1998. Yeast Physiology and Biotechnology. John Wiley & Sons Ltd., 1-7, Scotland. https://www.britannica.com/dictionary/yeast https://www.merriam-webster.com/dictionary/yeast https://dictionary.cambridge.org/dictionary/english/yeast *https://www.slideshare.net/shiningpearl18/fungiyeastmolds* https://tr.wikipedia.org/wiki/Maya_%28biyoloji%29 https://byjus.com/neet/yeast-diagram/ https://www.britannica.com/science/yeast-fungus https://www.youtube.com/watch?v=XY6akiB-IYk&t=4s https://www.seriouseats.com/all-about-dry-yeast-instant-active-dry-fast-acting-and-more https://mobil.diatek.com.tr/Makale-Yontem/Gida-Hijyeni-ve-Guvenligi/Maya-Cesitleri-Nelerdir_3580.htm https://wiki.yeastgenome.org/index.php/What_are_yeast%3F https://byjus.com/biology/budding/ https://www.youtube.com/watch?v=iyWtp_L0Kzc&t=191s https://mindthegraph.com/blog/tr/sigmoid-pattern/

1.3 Learning Unit 3 **Leaves Transport and Evaporate Water**

1.3.1. Background

The leaf is the energy factory of the plant, and clearly it is indispensable for its survival. Photosynthesis converts light energy to sugar, which in turn is transported to the photosynthetically inactive parts of the plant, such as the roots (Katifori, 2018).

Leaves are generally the major plant interface for gas exchange, and they are distally located to the main source of water, that is, the soil. As a result, they are the most dehydrated plant organ and

ultimately control transpiration rates. The network of veins in the leaf carries water from the stems to the leaves. Glucose produced is also sent to the other parts of the plant from the leaves through the veins.
The stomata (tiny holes underneath the leaf) allow air in and out of the leaf. Stomata are usually at the bottom surface of the leaf.
The stomata close in the night to retain gases and moisture in the leaf cells and opens during the day for gaseous exchange to continue.
The osmotic push of water molecules from the soil into the roots causes an upwards pressure, which is known as root pressure. Because of this pressure, the water absorbed from the soil is pushed upwards through the xylem tissue of the stem. The xylem is the vascular tissue responsible for transporting water and dissolved minerals from the roots up to the stem and leaves of the plant. The water is transported the rest of the way by transpiration, which provides most of the force needed for water transport in plants.
Like all living organism, plants also require an excretory system to discharge excess water from their body. This process of elimination of excess water from the plant body is known as transpiration. It is generally the evaporation of water from the surface of the leaves.

1.3.2. Content

LearnSTEM Pedagogical Model Module 3 : **Leaves Transport and Evaporate Water**	
Aim of the module/ learning unit	The purpose of this module is to enable students to learn how leaves transport and evaporate water.
Duration	**40x 4 dakika**
Learning Objectives	• Students will be able to explain the phenomenon of transporting water to the leaves and demonstrates it through experiments. • Students will be able to explain the evaporation of water from the surface of the plant's leaves and demonstrates it with experiments.
Resources&Materials Required (worksheet,charts, handouts, didactic video, excerpt from books/manuals, mind maps, etc.)	• Experiment 1: Water, food coloring, flowers or leaves • Experiment 2: Aluminium foil, glass jar and flower • PowerPoint presentations
Procedure	• In order to implement this activity, students must know the basic parts and functions of plants and be able to give examples. These topics are repeated and then the activity begins. • The materials required for Experiment 1 are prepared in advance and brought to the classroom and put in a place where each student can see them. Students are divided into random groups of 3-4. Using these materials, they are asked to create a mechanism where we can observe how plants transport water. The mechanisms designed by

	groups are compared with each other (Figure 1). Students are asked and discussed how plants and leaves transport water. The veins in the leaves and their functions are explained. ● Students are told that it will be observed how plants evaporate water in the next lesson. They are asked to think about what can be done about this issue. ● In the next lesson, the materials required for Experimental 2 are prepared in advance and brought to the classroom. The materials of students who bring different materials are also evaluated. ● Students are divided into random groups of 3-4 people. Students are asked to prepare a mechanism to observe how leaves evaporate water. The mechanisms prepared by the groups are compared. Students are asked how leaves evaporate water. The structure of stomata is explained and how water evaporates from the surface of the leaves is explained. ● Presentations and videos prepared on the subject are shown to students.
Content Delivery Methods **(lecture,discussions, research, group work, etc.)**	Teamwork Research Practical demonstration Discussions Explanation Brainstorming Problematisation Practical experiment
Assessment Method	H5P Quiz Continuous evaluation by observation
References	Boanares, D., Isaias, R. R. M. S., de Sousa, H. C., & Kozovits, A. R. (2018). Strategies of leaf water uptake based on anatomical traits. Plant Biology, 20(5), 848-856. https://doi.org/10.1111/plb.12832 Guzmán-Delgado, P., Mason Earles, J., & Zwieniecki, M. A. (2018). Insight into the physiological role of water absorption via the leaf surface from a rehydration kinetics perspective. Plant, cell & environment, 41(8), 1886-1894. https://doi.org/10.1111/pce.13327 Katifori, E. (2018). The transport network of a leaf, Comptes Rendus Physique, 19(4), 244-252. https://doi.org/10.1016/j.crhy.2018.10.007 https://kids.britannica.com/kids/article/leaf/433080 https://www.collinsdictionary.com/dictionary/english/leaf https://www.merriam-webster.com/dictionary/leaf https://dictionary.cambridge.org/dictionary/english/leaf https://www.passmyexams.co.uk/GCSE/biology/structure-of-leaf.html https://eschooltoday.com/learn/leaf-structure/ https://www.britannica.com/video/152187/overview-leaf-structure-functions-plant

	https://www.nagwa.com/en/presentations/638126046213/ **https://www.britannica.com/video/73123/Plants-osmosis-roots-water-transpiration-leaves-moisture** https://www.science-sparks.com/changing-colour-flowers-with-transpiration/ https://www.science-sparks.com/changing-colour-flowers-with-transpiration/ https://www.stem.org.uk/rx34bv https://eschooltoday.com/learn/transpiration/ https://byjus.com/biology/transpiration/ https://www.britannica.com/science/transpiration https://as1.ftcdn.net/v2/jpg/04/28/25/36/1000_F_428253637_KXsq3ZhVTtYAZnVtDMYALVZgWtZRDffN.jpg

1.4 Learning Unit 4- Growth of Plants and Salinity

1.4.1 Background

Factors affecting plant growth are; light, water, carbon dioxide, air, temperature, the availability of essential nutrients, the ph of the soil, and the space to grow. Water is one of the primary elements required by plants. When you think of gardening, you generally think of water, soil and sunlight. Plants can suffer when any of these are compromised. The importance of water to your plants goes beyond merely keeping them alive. Water is also a necessary element to help plants thrive. Water is what allows for the uptake of vital nutrients from the soil. It is also water that helps to carry sugar and other elements that may be required by flowers or fruit.

Soluble salts can be easily taken up by plants. Depending on the type and amount of salt compounds entering the plant, they become harmful to the plant when they exceed a certain concentration. They have a poisonous effect on the plant by disrupting nutrition and metabolism. In addition, as the salt concentration in the soil increases, it becomes difficult for the plant to absorb water from the soil, the structure of the soil deteriorates and plant development slows down or even stops. Various undesirable effects appear because of high salt concentration. Ion imbalance is one of the major consequences. A high concentration of Na and Cl ions, as an example, can lead to biochemical processes which can prove to be fatal for the plants. Sodium and chloride toxicity not only induce nutritional disorders but also cause physiological drought by lowering the osmotic potential of the soil solutions.

Salinity caused by NaCl is one of the most common abiotic stress affecting plant physiology. Salt stress causes several plants disorders (nutrient ion imbalance, decrease in stomatal conductance, low photosynthetic activity, etc.) morphological alteration (reduction in leaves number, plant size, roots length and fruit production), and secondary metabolites changes (signal molecules, hormones and oxidative compounds). Therefore, the use of saline water for plant cultivation requires the identification specie-specific thresholds at which crops show sensitivity to salinity.

1.4.2 Content

LearnSTEM Pedagogical Model Module 4: Growth of Plants and Salinity	
Aim of the module/ learning unit	**The aim of this module is to enable students to explain the salinity levels in soil affecting plant growth.**
Duration	**40'x 8**
Learning Objectives	Students will be able to explain the importance of soil salinity for the growth of plants and demonstrates it through experiments.
Required Resources&Materials (worksheet,charts, handouts, didactic video, excerpt from books/manuals, mind maps, etc.)	• For Experiment 1:Pot, soil, lentils, water • For Experiment 2:Lentils seedling, salt, water • For Experiment 3:Lentils seedling, fertilized, water • PowerPoint presentations
Procedure	• In order to do this activity, students must know the conditions necessary for the growth of plants and be able to give examples. These topics are repeated and the activity starts. • The materials required for Experiment 1 are prepared in advance and brought to the classroom. Students are divided into random groups of 3-4 people. Using the materials, students are asked to plant lentil seeds in 4 pots under the same conditions and grow them by watering them equally. After about 5 weeks the plants are observed and compared. At this stage, the plant seedlings are expected to be the same height. • In the next lesson, water with different salinity levels is prepared for Experiment 2. Groups observe their seedlings for 7 days by watering them in equal amounts. Plants of the groups are compared. Students are asked which plant grows better and whether the amount of growth of the plant changes as the salinity of the irrigation water increases, and the answers are discussed. • In the 3rd phase of the experiment, excessive fertilization is applied to the soil of one of two equally grown plants

	and observed for 7 days. The effect of excessive fertilization on plant growth is discussed. ● Tables are created and graphs are drawn to compare plant growth. ● Presentations and videos prepared on the subject are shown to students.
Content Delivery Methods **(lecture,discussions, research, group work, etc.)**	Teamwork Research Practical demonstration Discussions Explanation Brainstorming Problematisation Practical experiment
Assessment Method	5HP Quiz Assessment based on practical achievements and results Continuous assessment through observation
References	● EKMEKÇİ, E., Mehmet, A. P. A. N., & Tekin, K. A. R. A. (2005). Tuzluluğun bitki gelişimine etkisi. *Anadolu tarım bilimleri dergisi*, *20*(3), 118-125. ● Kotuby, J., Koenig, R., & Kitchen, B. (1997). Salinity and Plant Tolerance. Utah State University Extension. AG-SO-03., Utah. ● Petretto, G. L., Urgeghe, P. P., Massa, D., & Melito, S. (2019). Effect of salinity (NaCl) on plant growth, nutrient content, and glucosinolate hydrolysis products trends in rocket genotypes. *Plant Physiology and Biochemistry*, *141*, 30-39. https://doi.org/10.1016/j.plaphy.2019.05.012 ● Shahid, M. A., Sarkhosh, A., Khan, N., Balal, R. M., Ali, S., Rossi, L., ... & Garcia-Sanchez, F. (2020). Insights into the physiological and biochemical impacts of salt stress on plant growth and development. *Agronomy*, *10*(7), 938. **https://doi.org/10.3390/agronomy10070938** https://www.britannica.com/dictionary/plant https://www.collinsdictionary.com/dictionary/english/plant https://www.merriam-webster.com/dictionary/plant https://dictionary.cambridge.org/dictionary/english/plant https://www.agrowtronics.com/plant-growth-stages-an-overview/ https://aehinnovativehydrogel.com/news/what-are-the-requirements-for-plant-growth/ https://swanhose.com/blogs/general-watering/how-does-water-its-amount-its-quality-affect-plant-growth https://youtu.be/7-eFcMJYlXk https://www.sorhocam.com/konu.asp?sid=4321&bitkilerde-tuz-stresi-nedir.html https://atlas-scientific.com/blog/how-does-electrical-conductivity-affect-plant-growth/
