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EDUCATOR GUIDE

- ENERGY AT HOME -

PART OF THE INTELLECTUAL OUTPUT 3

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Chapter 1: Introduction

This document serves as an Educator's Guide for the implementation of the Energy at Home scenario.

It contains an overview of the Energy at Home+ scenario structure and after that a detailed description of each individual unit and activity. Each activity is described in terms of a five-dimensional framework, providing information about the activity's timing, mode, approach, group synthesis and the kind of media used (for more details please see IO2).

	Icon used to indicate information about the way of conducting each activity in terms of the 5-dimensional framework

Moreover the Educator's Guide includes hints for the instructors, indicating possible pre-service teachers' difficulties and ways to help them overcome them. These hints are indicated by a green frame, as shown in Figure 1.

Hint:

The use of shared documents supports the comparison of pre-service teachers' initial ideas expressed in Activity 1 with their final conclusions formulated in Activity 3 of Unit 1.

Fig. 1 Example of a "Hint box"

Finally, suggestions of alternative ways to conduct each activity, for example if someone wants to implement the Climate Change digital scenario fully on-line, are also provided. These alternatives are indicated by an orange frame, as shown in Figure 2.

Alternative:

Activity 3 can also be conducted in an on-line synchronous mode. In that case the educator should use a teleconference application that provides separate virtual rooms for pre-service teachers to firstly discuss with their peers their views and then present them to the whole group.

Fig. 2 Example of an "Alternative box"

Chapter 2: Why the topic of “Energy at home”?

During the last decades there has been an increase in the average temperature of the Earth. Studies show that the current rise in temperature is largely due to human-made environmental changes. It has been found that the main contribution to the temperature rise is mainly due to greenhouse gases emitted as a result of human activity, of which the CO_2 content in the air has made the biggest contribution. A smaller part of CO_2 increase is due to heating, the larger part to large-scale electricity production and transportation.

The energy consumption of single electrical appliances used by people, e.g. TV sets, computers, refrigerators, etc., is constantly decreasing. Though, thanks to the expansion of industry, the expansion of applications of electrical appliances, and therefore also greater adoption, the energy consumption of mankind has been increasing.

Energy use by industry or public administration is difficult for individuals to change. However, everyone can change their habits to use less energy at home. Our experience in developing this scenario showed that people struggle to estimate which devices use the most (electrical) energy over an extended period. It is even more challenging to assess the proportion of energy used for heating in relation to the total energy consumption. Through this scenario, pre-service teachers acquire skills and habits for applying the laws of physics to create a comprehensive energy consumption model. At the same time, it provides a foundation for changing people's attitude for individual energy consumption habits.

Chapter 3: Structure of the digital scenario

The digital scenario “Energy at Home” consists of the following main units:

- Unit 1: Use of energy. Definitions and concepts.
- Unit 2: Consumption of energy at home.
- Unit 3: Thermal conductivity. Thermal energy.
- Unit 4: Energy use model for a household.

In the first unit, pre-service teachers map their existing concepts related to the topic and the connections between them. Subsequently, the definitions and concepts of important physical quantities are clarified. By discussing the created concept maps of existing connections, the discussion moves towards the topicalization of the entire subject, outlining the ultimate output and goal achievable through the scenario.

In the second unit, pre-service teachers create a table detailing electrical appliances, their power consumption, and the electrical energy they or their family use in the household. Working in small groups enables them to gather more accurate data on power consumption, providing a more realistic basis for household electrical energy consumption.

During the third unit, pre-service teachers familiarize themselves with the concept of thermal conductivity and acquire skills for finding the thermal parameters of composite materials and components of residential buildings made from them.

In the fourth unit, a household energy consumption model is compiled, taking into account the knowledge and data acquired in the second and third units. For greater flexibility, a private house is considered here (instead of, for example, a one-room apartment). Additionally, pre-school teachers need to find ways to reduce household energy consumption by 10%. Finally, the realistic aspects of the model are discussed within the entire group of pre-service teachers.

Considering the previous knowledge and skills of pre-service teachers, the scenario can be completed in various ways. The scheme we offer is shown in Figure 3.

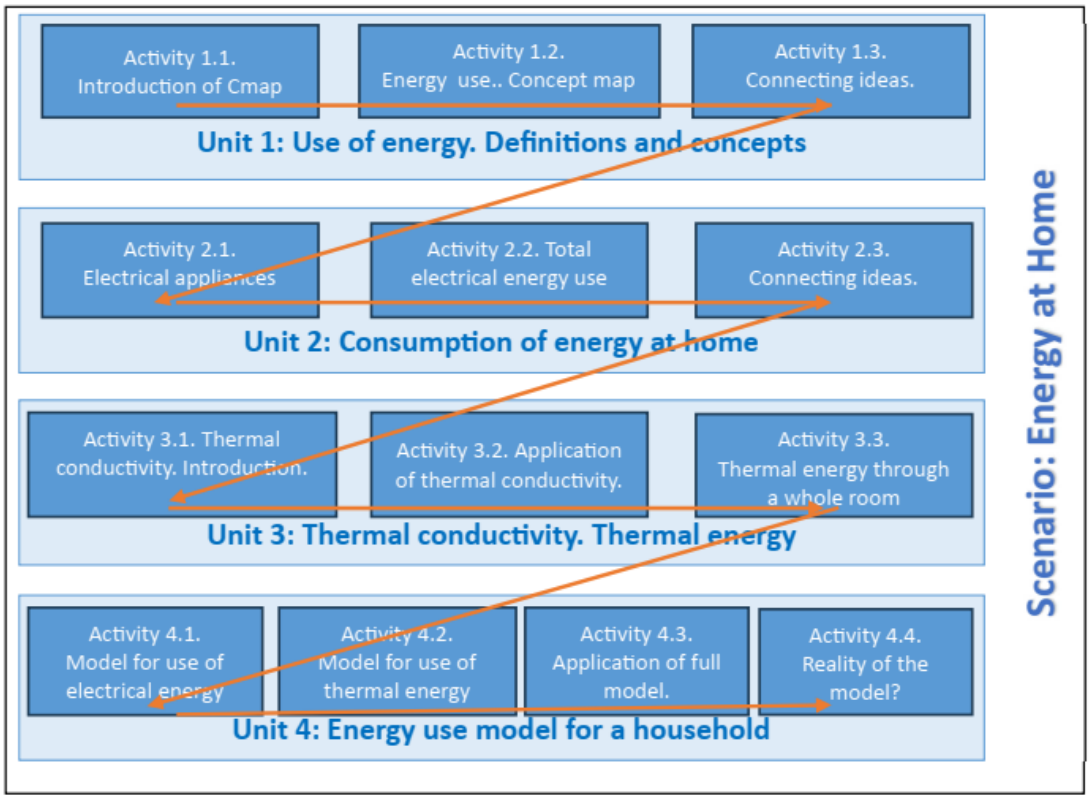

Fig. 3. Proposed sequence for Energy at Home scenario Units & Activities.

Chapter 4: Implementation

Unit 1: Use of energy. Definitions and concepts.

Activity 1.1. Introduction of Cmap

At the beginning of the activity, the teacher outlines the main ideas and goals of the scenario. After that, the teacher briefly introduces the main principles of concept maps and the creation and development of these maps using online software Cmap. During this activity, pre-service teachers should create individual concept maps focusing on the question ""How can I save energy at home?"

Activity 1.1 is started by the teacher. After introduction of the scenario and cmap-software, is suggested to be conducted in an asynchronous session, during which the pre-service teachers should create individual concept maps based on their existing knowledge of energy consumption, incorporating concepts, ideas, and electrical appliances.The digital media used in this activity is:

- Internet resources:
  Online software: https://cmapcloud.ihmc.us/

Hint:

If pre-service teachers have no prior experience with Cmap or similar software, then when conducting this activity, its is recommended that students should have initially more time to acquire skills in using the software.

Alternative:

Activity 1.1 can also be conducted in an on-line asynchronous mode. In that case the educator should use a teleconference application.

Activity 1.2. Energy use. Concept map.

During this activity, pre-service teachers should work in pairs to create a shared concept map by complementing each other's knowledge.

Activity 1.2 is carried out in an asynchronous session during which pairs align their understandings of concepts and create more complex networks between different concepts (hopefully). At the same time, they prepare for presenting their concept map to the other participants.

The digital media used in this activity is:

- Internet resources:
  Online software: https://cmapcloud.ihmc.us/

Alternative:

Activity 1.2 can also be conducted in an on-line asynchronous mode. In that case the educator should use a teleconference application to create group-work rooms. Also, it is possible to join activities 1.1 and 1.2. However, in this case, not all participant will gain experience using a concept map in the future (for example, in teaching at school).

Activity 1.3. Connecting ideas.

During this session, different understandings of concepts among pre-service teachers are aligned. Various misconceptions are also analyzed. Additionally, the discussion covers the main places where energy is consumed in households. Activity 1.3 is carried out in a synchronous face-to-face session led by educator. During the activity pairs present their concept maps. During the discussion, pre-service teachers bring out the strengths of different concept maps and also highlight misconceptions. The digital media used in this activity is:

- Internet resources:
  Online software: https://cmapcloud.ihmc.us/

Hint:
Here the educator should allow to develop the discussion between the pre-service teachers. The educator should intervene if the understandings or regularities used are incorrect. Additionally, the participants themselves should be allowed to assess, after the discussions, which connections should be added

Alternative:

Activity 1.3 can also be conducted in an on-line synchronous mode. In that case the educator should use a teleconference application.

Unit 2: Consumption of energy at home

Activity 2.1. Electrical appliances.

During this activity pre-service teachers make an initial database of eelctrical appliances they use at home with estimation of their power.

Activity 2.1 is started by the teacher introducing the Pressbook-page where the rest of instructions and links are given. The rest of the session is asyncronous individual session, where participant make a list of electrical appliances and search for their power from different internet sources.

- Internet resources:
  - Pressbook application: https://web.htk.tlu.ee/stem/stem2/chapter/consumption-of-energy-at-home/
  - www.desmos.com
- Shared worksheet: https://docs.google.com/spreadsheets/d/16lZWvSoBWf5DgdRlDrE1aQbxMA5wdEl9Eer4yREmwwU/edit#gid=0

Hint:

The educator may, in the beginning or during this activity, remind that household appliances such as washing machines and refrigerators are also used. Quite a few students initially consider only a single room, not an entire apartment or house.

Alternative:

Activity 2.1 can be conducted in an on-line asynchronous mode.

Activity 2.2. Total electrical energy use.

During this activity pre-service teachers make estimation of total energy used by different appliances for one week (e.g. in March). This allows considering the contribution of heating devices to energy consumption.

This session is carried out in asyncronous mode in pairs or small groups led by the students. The participants analyze and discuss spreadsheets created by a fellow student. The pairs present and analyze the created spreadsheets: how the consumption power is divided between heating and the rest of the electrical devices.

- Internet resources:
  - Pressbook application: https://web.htk.tlu.ee/stem/stem2/chapter/consumption-of-energy-at-home/
  - www.desmos.com
- Shared worksheet: https://docs.google.com/spreadsheets/d/16lZWvSoBWf5DgdRlDrE1aQbxMA5wdEl9Eer4yREmwwU/edit#gid=0

Hint:

Here, it should be reminded to the pre-service teachers that they should assess the average power and energy consumption of different devices (computers, refrigerators, washing machines, stoves, etc.). It becomes evident that students have very different estimates of the energy consumption of devices and also about how many of them are in the household. Discussion in pairs or small groups provides participants with the opportunity to align their estimates.

Alternative:

Activity 2.1 can be conducted in an on-line asynchronous mode. In that case the educator should use a teleconference application to create group-work rooms.

Activity 2.3. Connecting ideas.

During this activity, the participants discuss the proposed number of devices and their energy consumption put forward by each other.

This session is carried out in syncronous face-to-face session led by the educator. The participants analyze and discuss data in spreadsheets created by a other groups. The pairs present and analyze the created spreadsheets: how the consumption power is divided between heating and the rest of the electrical devices. During the discussion, the realism of the amount of energy used is assessed based on experience.

- Internet resources:
  - Pressbook application: https://web.htk.tlu.ee/stem/stem2/chapter/consumption-of-energy-at-home/
- Shared worksheet: https://docs.google.com/spreadsheets/d/16lZWvSoBWf5DgdRlDrE1aQbxMA5wdEl9Eer4yREmwwU/edit#gid=0

Hint:

The most challenging aspect of this activity is assessing the energy used by heating devices, especially when it comes to, for example, wood-burning stoves. Here, the trainer should beforehand find estimates for different types of households with various heating sources to evaluate the accuracy of the data provided by students in comparison to reality.

Unit 3: Thermal conductivity. Thermal energy.

Activity 3.1. Thermal conductivity. Introduction.

In this activity, pre-service teachers acquire understanding of parameters characterizing heat transfer.

This session is carried out in asyncronous mode where students work individually using pressbook application and instructions from pressbook. Through the simulation, an attempt is made to estimate the differences in the thermal conductivity coefficients of various materials.

- Internet resources:
  - Pressbook application: https://web.htk.tlu.ee/stem/stem2/chapter/consumption-of-energy-at-home/
- http://lab.concord.org/embeddable.html#interactives/energy2d/htb/S3A1.json

Hint:

The simulation allows for a very good assessment of which materials conduct heat better or worse. The simulation is excellent for visualizing the spread of heat. To measure the thermal conductivity coefficient according to the simulation, a separate guide should be prepared.

Alternative:

Activity 3.1 can be conducted in an on-line asynchronous mode. Alternatively, it could be suggested to conduct a laboratory experiment to determine the thermal conductivity of certain materials. Since this is a relatively simple (but not very short) experiment, pre-service teachers can carry it out in their future work at school.

Activity 3.2. Application of thermal conductivity.

In this activity pre-service teachers study the materials heat conductivity using simulations and solve the task for calculation of heat flux through one- and multilayer materials

This session is carried out in asyncronous mode in pairs or small groups led by the students.

- Internet resources:
  - Pressbook application: https://web.htk.tlu.ee/stem/stem2/chapter/consumption-of-energy-at-home/
  - www.desmos.com

Hint:

Working in pairs provides participants with the opportunity to better acquire skills in using and modifying the Desmos program according to the objectives. Although performing calculations manually or using tools like WolframAlpha is also possible, using sliders with the same formula to perform calculations with different parameters allows more time for result analysis.

Alternative:

Activity 3.2 can be conducted in an on-line asynchronous mode, where participants fill tasks given in Pressbook, individually.

Activity 3.3. Thermal energy for a whole room.

In this activity, the heat flux through composite materials and wall construction elements is calculated.

This activity is carried out as a syncronous face-to-face session led by teacher. Participants work in small groups to calculate heat fluxes through different wall elements to be used in Unit 4. Based on the calculations, the teacher leads discussions on how to reduce the heat transfer through different wall elements (wall materials, windows) more effectively.

- Internet resources:
  - Pressbook application: https://web.htk.tlu.ee/stem/stem2/chapter/consumption-of-energy-at-home/
  - www.desmos.com
- Shared worksheet: https://docs.google.com/spreadsheets/d/16lZWvSoBWf5DgdRlDrE1aQbxMA5wdEl9Eer4yREmwwU/edit#gid=0

Hint:

The skills acquired in this activity are crucial for achieving the expected results in Unit 4. Therefore, the educator should ensure that the participants understand the formulas used at the end of this activity and can apply them in calculating heat fluxes for more complex construction elements..

Unit 4: energy use model for a household.

Activity 4.1. Model for use of electrical energy

During this activity pre-service teachers compose a model for energy appliances and heating devices.

This session is carried out in asyncronous mode in the same pairs or small groups as in activity 3.3, led by the students. The participants use the database created during Unit 2.

- Internet resources:
  - Pressbook application: https://web.htk.tlu.ee/stem/stem2/chapter/consumption-of-energy-at-home/
- Shared worksheet: https://docs.google.com/spreadsheets/d/16lZWvSoBWf5DgdRlDrE1aQbxMA5wdEl9Eer4yREmwwU/edit#gid=0

Alternative:

Activity 4.1 can be conducted in an on-line asynchronous mode. In that case the educator should use a teleconference application to create group-work rooms.

Activity 4.2. Model for use of thermal energy.

During this activity pre-service teachers compose a model of heating of a household considering heat flux through walls, windows, etc.

This session is carried out in asyncronous mode in small groups led by the students. They complement the model considering the heat flux through the walls and ceiling, of the household during 1 week in March. Also, they consider the energy used by electrical appliances, in their mode.

- Internet resources:
  - Pressbook application: https://web.htk.tlu.ee/stem/stem2/chapter/consumption-of-energy-at-home/
  - www.desmos.com
- Shared worksheet: https://docs.google.com/spreadsheets/d/16lZWvSoBWf5DgdRlDrE1aQbxMA5wdEl9Eer4yREmwwU/edit#gid=0

Hint:

The realism of the entire model and the correspondence of energy costs to reality largely depend on how well the selected materials for the house match reality. At this point, various sources on the construction of modern houses can be suggested. Alternatively, an energy model for cooling houses, for example, in Southern Europe, can be proposed.

Alternative:

Activity 4.2 can be conducted in an on-line asynchronous mode. In that case the educator should use a teleconference application to create group-work rooms.

Activity 4.3. Application of full model.

During this activity gropus of pre-service teachers present their model of energy use at household, and assess shortages and weaknesses of each other´s models.

This session is carried out in syncronous mode led by the educator. During the discussion led by the instructor, the realism of the models and possibilities for reducing energy costs by 10% are debated. If possible, changes in cost and payback period can also be discussed

- Internet resources:
  - Pressbook application: https://web.htk.tlu.ee/stem/stem2/chapter/consumption-of-energy-at-home/
  - www.desmos.com
- Shared worksheet: https://docs.google.com/spreadsheets/d/16lZWvSoBWf5DgdRlDrE1aQbxMA5wdEl9Eer4yREmwwU/edit#gid=0

Alternative:

Activity 4.3 can be conducted in an on-line or blended mode.

Activity 4.4. Reality of the energy use.

Conclusion of the network of terms related to energy consumption.

This session is carried out in asyncronous mode in pairs led by the students. They change and complete the cpncept maps created in Unit 1. At the end, students explain to others what changes they made in their initial concept maps and why. There is also a discussion about the realism of the entire energy usage model, what was left unaccounted for, and how much more complex the complete model would become.

Internet resources:

- https://cmapcloud.ihmc.us/
-

Hint:

Here, it can be added that the energy consumed by electrical devices in homes also transforms into thermal energy. When proposing energy savings, one can consider, for example, that the average power of a gaming computer can be 500-1000W.