The BLOOM School Box

Future Classroom Scenario

Examining the thermal properties of bio-based building materials

This scenario is part of the BLOOM School Box, which consists of a set of five Future Classroom Scenarios combining bioeconomy into science, technology, engineering and mathematics (STEM) subjects. These resources were developed and tested in classrooms by 20 BLOOM expert teachers from 10 different countries.
This Future Classroom Scenario has been developed as part of the BLOOM project, using the methodology of the Future Classroom Toolkit (http://fcl.eun.org/toolkit).

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Table of contents

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Area / Subject

In which subject(s) or area of expertise can the scenario be used?

Subjects: Physics (standard and higher level), Mathematics, Chemistry, Biology
Curriculum: National Curriculum, International Baccalaureate, GCSE, GCE A-Level
The learning scenario includes three lessons for students **aged 16-19**.

Relevant Trends

Relevant trend(s) the Scenario is intended to respond to. E.g. at http://www.allourideas.org/trendiez/results

Flipped Classroom: Students become familiar with basic concepts regarding the bio-based building materials while watching movies at home. The time spent in the classroom is used to reflect, discuss in the form of the knowledge café in order to develop the assigned topic.
Collaborative Learning: A strong focus on group work.
STEM Learning: An increased focus will be given to Science, Technology, Engineering, and Mathematics that are essential subjects in the curriculum.
Lifelong Learning: The learning process should not completed by leaving school.
Mobile Learning: Due to the process of rapid digitalization of the education, students can learn anytime and everywhere.
Edutainment: Students acquire knowledge while having fun while involved in laboratory experiments.
Visual Search and Learning: Images and multimedia are more powerful than verbal stimuli as the main part of the communication process happens non-verbal.

Learning Objectives and Assessment

What are the main objectives? What skills will the learner develop and demonstrate within the scenario? (e.g. 21st Century Skills). How will the progress in achievement be assessed, ensuring the learner has access to information on their progress so they can improve?

Learning objectives

Students will:

- Acquire a basic concept of bioeconomy including an introduction of bio-based products. Special emphasis will be given to building materials.
- Obtain knowledge on communication using subject-specific vocabularies.
- Learn to collaborate with each other while working intensively on bio-based building materials in groups.
- Learn to conduct experiments in a laboratory setting employing data logging equipment.
- Learn to implement mathematical techniques to analyse the empirical data collected.

Assessment

Poster on bioeconomy and round table: The posters created during the lesson will be collected and the teacher will provide feedback. The discussion during the round table will show the progress in students' understanding of the topic.
Kahoot quiz: The teacher will offer feedback to all answers provided by the students.

Experimental laboratory: The students will send the collected empirical data to the teacher in order to receive comments on them before starting with the mathematical analysis.

Learner's Role

What sort of activities will the learner be involved in?

The learner will be involved in activities such as:

- Knowledge café as introduction to bioeconomy and insulating bio-based and non-bio-based materials
- Kahoot quiz
- Experimental work in a laboratory
- Mathematical data analysis (results of measurement).

General objectives (student outcomes):

Students should have a practical knowledge of temperature and the flow of heat from areas of high temperature to areas of low temperature. They should be able to connect the modelled and real heat flow while using bio-based building material. Students should be familiar with plotting points manually on the Cartesian plane, as well as with the significance of dependent and independent axes. They should be capable of preparing investigations, which allow to model the speed of a heat transfer and insulating efficiency of examined bio-based materials (see Annex 1: Heat Transfer).

Tools and Resources

What resources, particularly technologies, will be required?

Videos:

- Bioeconomy: https://youtu.be/2xvXkOMRTs4 [in English]
- Different types of insulation/fuel poverty: https://youtu.be/ZXPvaroR2AI [in English]
- How does insulation work? https://youtu.be/aaUz_SqOXnI [in English]

Books and Articles:

- Jones, Dennis and Christian Brischke (2017): Performance of Bio-Based Building Material, Elsevier Ltd. (https://www.elsevier.com/books/performance-of-bio-based-building-materials/jones/978-0-08-100982-6)
- ARUP (2017): The Urban Bio-Loop, Growing, Making and Regenerating (https://www.arup.com/publications/research/section/the-urban-bio-loop)
- Bioeconomy in Everyday Life (http://www.bio-step.eu)
- Lange, Lene (2016): The Fundamentals of Bioeconomy, The Bio-based Society.

Other resources:

- https://ed.ted.com
- Kahoot Quiz: https://kahoot.com/
- Data-logging equipment for each group: interface, two temperature probes, software to register and analyse data
- Different types of insulating materials (bio-based and non-bio-based)
- Spreadsheet software (e.g. Excel) or GeoGebra.

Learning Space

Where will the learning take place e.g. school classroom, local library, museum, outdoors, in an online space?

The learning process will take place as follows:

- Home
- School classroom
- Experimental laboratory

Future Classroom Scenario Narrative

The detailed description of the activity

The learning scenario includes three lessons for students aged 16-19. The first and third lessons are designed for 45 minutes. The second lesson will take place in the laboratory and it will last for 90 minutes.

Lesson 1: Knowledge Cafe (45 minutes)

Objectives of Lesson 1:

The students should be able to:

- Provide a definition on the bioeconomy: What is the bioeconomy? How does the bioeconomy influence our everyday life?
- Give sample for bio-based products and the raw materials, which are relevant for the production process.
- Learn about bio-based and non-bio-based building materials and their thermal insulation properties

Course of Activities in Lesson 1:

1. The teacher introduces the topic **of bioeconomy** and **bio-based building materials.** He/she explains the objectives of the lesson and the rules for the work in the flipped classroom (duration: 5-10 minutes).
2. The students are divided by the teacher into groups of 4-5 persons as each group will be working on a different issue. For example, the first group will watch the video on bioeconomy and read the document "The Fundamentals of Bioeconomy" (Lange, 2016) and answer questions such as:
    a. What is bioeconomy?
    b. How is bioeconomy linked to the conventional production process?
    c. What is the influence of bioeconomy on sustainable development?
    d. Is there a difference between bioeconomy and green economy?
2. Two groups will be dealing with various **bio-based products** and the raw materials needed for their fabrication. The teacher will provide each student with a bio-based product using the document "Bioeconomy in Everyday Life" (http://www.bio-step.eu). One group will answer the question "How does insulation work?" by watching the video provided by the teacher. The assigned activities should be worked out in the form of knowledge café and the results should be written down by creating a poster (duration: 25-30 minutes).
3. The lesson will be finished by **a round table discussion.** The teacher will play the moderator in the round table discussion (duration: 10-15 minutes).

The detailed description of the activity

4. **Homework for Lesson 2:** Each group should work on the same homework. Its exemplary content is written down in Annex 2.

Lesson 2: Experimental laboratory (90 minutes)

Objectives of lesson 2:

The students should be able to:

- Explain how thermal insulation works
- Undertake experiments to investigate thermal insulation of bio-based and non-bio-based building materials
- Outline testable hypotheses and verify them by collecting and analysing empirical data
- Communicate effectively the obtained experimental results in the appropriate scientific language

Course of Activities in Lesson 2:

1. The teacher starts the lesson by repeating the **learning materials**. He/she uses Kahoot as an introductory quiz about the bioeconomy and bio-based building materials. **The Kahoot quiz** is available under the link: https://play.kahoot.it/#/k/0d4b4f56-6899-4173-b9f5-ea07a734c39e (duration: 10-15 minutes).
2. The students are divided by the teacher into groups of three or four, as each group will be working on **building materials and testing its insulating properties**. Each group of students will carry out a **data logging experiment** while cooling a beaker of water insulated by either bio-based or non-bio-based building material. They will **collect empirical data** on temperature and time in order to verify the outlined hypothesis (see Annex 3). By the end of the lesson, the experiment should be completed and the collected data should be saved and shared (duration: 40-50 minutes).
3. The teacher closes the lesson by instructing the students to finish the experimental work and to clean up (duration: 5 minutes).

Lesson 3: Mathematical analysis in PC-lab (45 minutes)

Objectives of lesson 3:

The students should be able to:

- Conduct empirical analysis using suitable Mathematical techniques
- Analyse the data using Excel spreadsheet or GeoGebra
- Present the estimates and communicate them in the appropriate scientific language
- Communicate the meaning of the experimental results for future sustainable development in a global context

Course of Activities in Lesson 3:

1. The teacher starts the lesson by asking the students to continue the **experimental work** in their groups. He/she supports the groups by **analysing the collected data** (duration 5 minutes per group).
2. Students **analyse the empirical data by calculating descriptive statistics and conducting a regression analysis** (duration 20-25 minutes).

The detailed description of the activity

3. Each group presents the data analysis by creating a **PowerPoint presentation** (duration 3-5 minutes per group).

The teacher closes the lesson by a general discussion on the topic (duration: 5-10 minutes).

Learning Activities

Link to the Learning Activities created with Learning Designer (http://learningdesigner.org)

https://v.gd/TWRoSb (Full text available in Annex 4)

Annexes

Annex 1: Heat transfer

Heat Transfer

Heat transfer is a broad topic used in many branches of engineering. For example, mechanical engineers who design engines, from steam locomotives to modern internal combustion engines, rely on a detailed understanding of how heat moves through all types of matter. Industrial engineers use heat transfer concepts to design climate control systems for manufacturing facilities, such as foundries or refrigerated food production facilities, which integrate temperature-sensitive human workers with extreme temperature processes.

Newton's law of cooling is a complex topic that appears in physics and calculus. In this learning scenario, it is simplified to focus on the idea of applying the transformations learning during typical school laboratory investigations within a contextual situation. The mathematical practice in focus for this lesson could be combined with spreadsheet software such as Excel or with dynamic programmes such as GeoGebra.

Students get the possibility to observe an exponential trend demonstrated through the changing temperatures measured while heating a beaker of water insulated by three bio- and three non-bio-based materials utilising a data-logging equipment. This task is accomplished by first appealing to students' real-life cooling experiences, and second by showing an example for an exponential curve. After reviewing the basic principles of heat transfer, students make predictions about the cooling curves of a beaker of water in different environments. During a simple teacher demonstration or experiment, students gather temperature data while a beaker of water cools in an ice water bath (winter approximation), and while it cools in a hot water bath (summer approximation). They plot the data to create heating and cooling curves, which are recognized as having exponential trends, verifying Newton's result that the change in a sample's temperature is proportional to the difference between the sample's temperature and the temperature of the environment around it.

Students apply and explore how their new knowledge may be applied to real-world engineering applications. This engineering curriculum meets Next Generation Science Standards (NGSS). After completing the above-stated activities, students should be able to:

a) Record data displayed by a temperature probe

b) Plot data points to make graphs (manually and using appropriate software such as Excel or GeoGebra)

c) Identify an exponential trend in a heating or cooling curve

d) Verify the best insulating bio-based or non-bio-based material

Annex 2: Assignments

Homework: Building material timber as an insulator

Assignment 1

Observe a piece of wood and describe its structure in as much detail as possible!

_____

_____

_____

Assignment 2

Try to explain why timber is a good insulator against heat and cold!

_____

_____

_____

Assignment 3: Heating chamber

Build a heating chamber that consists of five walls. The walls should be heat insulating and fireproof. The front remains open. Position in the chamber an adjustable heat source, for instance heating plate. The open side is equipped with retaining clips to clamp different materials.

Clamp different wood panels (spruce, beech, etc.) of the same thickness (4 cm) into the heating chamber. Turn on the heating source and measure the amount of heat using an infrared camera. Repeat the experiment described above and double the thickness of the wood panels. Insert the measured values into the table pictured below.

Type of Wood	Measurement 4 cm			Measurement 8 cm		
	After 5 min	After 10 min	After 15 min	After 5 min	After 10 min	After 15 min

Repeat the experiment described above using different materials such as cork, coconut etc.

Type of Wood	Measurement 4 cm			Measurement 8 cm		
	After 5 min	After 10 min	After 15 min	After 5 min	After 10 min	After 15 min

Assignment 4: Heating chamber

Consider which insulating material is suitable for good thermal insulation. What would you recommend as insulating material if you are the specialist in this area?

_____

_____

_____

Annex 3: Data logging experiment

Thermal insulation of building materials - Data logging experiment in groups

In this experiment you will examine the process of cooling to study properties of different building insulation materials (bio and non-bio-based). One of two beakers of hot water will be insulated. You will measure temperature changes and observe the cooling curves.

Equipment and materials (for 6 groups)

- different insulation materials (3 bio and 3 no bio-based)
- equipment for each group: interface and two temperature sensors, 2 beakers, clamps to hold the probes, stands, hot water, cold water, water bath.

Figure 1: Source: Own picture

Assignments

- Think about the thermal properties of the insulating materials. What is your hypothesis? Which of the beakers will cool faster?

_____

- Connect two temperature sensors to the interface.
- Pour equal amounts of hot water into each beaker (e.g. 50 ml).
- Place the beakers in a hot water bath to get them to the same temperature.
- Set up your software to record for 15 minutes.
- Remove the beakers from the water bath, add the temperature probes and start recording.
- Wrap one beaker with insulating material (thickness 1 cm).
- Observe the temperature vs time graph

- Save your data.
- Repeat the experiment cooling the beakers in cold water.
- Share the collected data (in appropriate format) to the other groups and teacher for comments and further analysis.

Questions

a) Compare your hypothesis with the results of measurements. Does your hypothesis is correct?

b) How does insulation material affect the rate of cooling?

c) What do you think are the other possible factors that affect the rate of cooling?

(This experiment adapted from http://rogerfrost.com/exp/heat.htm).

Annex 4: Learning Design

Description	
Context	**Topic:** Bioeconomy **Total learning time:** 180 h **Number of students:** 25-30 students **Description:** The lessons are dedicated to students aged 16-19. Students learn about bioeconomy and bio-based products and materials. They take data-logging measurements with different insulating materials and analyse collected data.
Aims	Students explore experimentally the thermal properties of bio-based insulating materials, practice mathematical analysis of experimental data, cooperate with colleagues.
Outcomes	Knowledge (Knowledge): Students should know what is bioeconomy and how to check thermal properties of chosen insulating materials Application (Application): Students should know some application of bioeconomy products and materials Analysis (Analysis): Students should know how to analyse experimental data
Teaching-Learning activities	
Lesson 1: Laboratory work - data-logging experiment in groups	***Read Watch Listen 5 minutes 25-30 students Tutor is available*** Students get involve into basic concepts regarding the bio-based building materials at home. They watch videos: - Bio-Economy - https://youtu.be/2xvXkOMRTs4 - Different types of insulation/ fuel poverty - https://youtu.be/ZXPvaroR2AI - How does insulation work? - https://youtu.be/aaUz_SqOXnI The teacher introduces and motivates the students for the topic "Bio-Economy" and "Bio-based building materials". He/ She explains the objectives of the lesson and the rules for the work in the flipped classroom.
	Collaborate 25 minutes 4-5 students Tutor is not available The students are divided by the teacher into groups of 4-5 persons as each group will be working on different issue (the notes). The assigned activities should be worked out in form of knowledge café and the result should be written down by creating a poster.

	Discuss 10 minutes 25-30 students Tutor is not available The lesson will be fined by round table discussion. Each group is supposed to select a representative. The teacher will play the moderator in the round table discussion.
	Read Watch Listen 5 minutes 25-30 students Tutor is available The lesson will be summarized by teacher, the homework will be explained. For example, the first group will watch the video on bioeconomy and read the document "The Fundamentals of Bioeconomy" (Lange, 2016) and answer questions such as: What is the bio-economy? How is the bio-economy linked to the conventional production process? What is the influence of bio-economy on sustainable development? Is there a difference between bio-economy and green economy? Two groups will be dealing with various bio-based products and the raw materials needed for their fabrication. The teacher will provide each student with a bio-based product using the document Bio-Economy in Everyday Life (http://www.bio-step.eu). One group will frame the question how the insulation work by watching the video provided by the teacher.
Lesson 2. Laboratory work - data-logging experiment in groups	***Discuss 15 minutes 4 students Tutor is not available*** Reviewing the basic principles of heat transfer, bioeconomy and building materials - Kahoot quiz in groups. Discussion about the results of the home experiment.
	Read Watch Listen 10 minutes 12-16 students Tutor is available Description the task of each group, short presentation the data-logging experiment by teacher.
	Investigate 50 minutes 4 students Tutor is not available 1.Students prepare the experiment and set up the software. 2.They make predictions about the cooling curves of a beaker of water in different environments. 3.They register the cooling curve and compare their prediction with the result of their measurement. 4.They discuss the collected data. 5.They repeat the experiment using second insulation material.
	Collaborate 15 minutes 12-16 students Tutor is not available Students share the collected data. All groups present the results of their experiments.

Lesson 3. Mathematical Analysis in PC-lab	***Practice 30 minutes 4 students Tutor is not available*** The teacher starts the lesson by asking the students to continue the experimental group. He/ She supports the groups by analysing the collected data. The students analyse the empirical data by calculating descriptive statistics and conducting regression analysis
	Collaborate 10 minutes 4 students Tutor is not available Each group presents the data analysis by creating a Power Point presentation.
	Discuss 5 minutes 25-30 students Tutor is available The teacher closes the lesson by a general discussion on the topic.