RECI BioS.



UNDERSTAND

Handbook

Design, Create, and Make Biomaterials in the Classroom



DEFINE

A Challenge-Based Guide for Teachers and Students of Lower Secondary Education.



MAKE

RELEASE



RHIZO EduQuest. Co-funded by the European Union

Challenge-based bioeconomy projects for students of lower secondary education

A Handbook for teachers of lower secondary education.

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**The RECIBIOS project has been funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or BE02 – EPOS vzw. Neither the European Union nor the granting authority can be held responsible for them. Project Code: 2023-2-BE02-KA210-SCH-000178564*

Co-funded by the European Union

Challenge-Based bioeconomy projects for students of lower secondary education

A Handbook for Teachers of Lower Secondary Education

A Message from the Authors

This handbook brings together the insights and experiences of the RECIBIOS Erasmus+ journey. RECIBIOS stands for Challenge-based experimentation on BIOdegradable RECIpeS and was born out of our shared vision: *To empower young learners to explore the principles of bioeconomy, circular thinking, and environmental responsibility in meaningful and creative ways.* The project has been implemented by a diverse team of educators and researchers committed to re-imagining science and sustainability education.

The RECIBIOS journey began with a simple question: *How can we help students understand the role of biodegradable materials and regenerative resources in protecting our planet's future?*

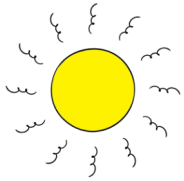
This handbook is a response to that question. A practical guide for educators who wish to bring real-world sustainability challenges into their classrooms. It draws upon a tested educational program structured in four flexible phases, each encouraging students to explore materials, experiment with new ideas, and co-create innovative solutions with a focus on biodegradable and circular alternatives.

We believe that education is one of the most powerful tools for shaping the next generation of citizens capable not only of understanding the world, but of changing it. Through the proposed interactive and hands-on activities, students can learn what is bioeconomy, why does it matter today, and how they can engage with sustainability through everyday objects, fostering curiosity, critical thinking, and creativity.

With this handbook, we invite teachers, trainers, and schools to join us in this journey.

We hope that in this pages you will find inspiration, practical tools, and a renewed belief that small actions and small experiments can spark big ideas!

Introduction to Bioeconomy for Lower Secondary Education



Bioeconomy is more than just a scientific concept, it is a new way of thinking about how we use the earth's resources, and how we can live, produce, and consume more sustainably. In simple terms, bioeconomy refers to the use of renewable biological resources like plants, crops, trees, biowaste or microorganisms, to create food, materials, and energy. In contrast to our traditional economy systems, which often rely on fossil fuels and create waste, bioeconomy promotes circularity, sustainability, and regeneration.

According to the United Nations Food and Agriculture Organisation (FAO), bioeconomy is: "*The production, use and conservation of biological resources, including related knowledge, science, technology, and innovation to provide information, products, processes and services to all economic sectors with the aim of moving towards a sustainable economy*".

The need for a bio-based future has been more urgent than ever. Today, we face serious environmental challenges: climate change, plastic pollution, biodiversity loss, and the overuse of natural resources. Or current habits of taking, making, and throwing away are no longer sustainable. Bioeconomy offers an alternative which is innovative, environmentally responsible, and grounded in science and real-world solutions.

Teaching bioeconomy in lower secondary education plays a vital role in preparing young learners to understand and respond to global challenges. Students at this age are naturally curious, eager to explore, and ready to begin connecting the dots between science, society, and their daily lives. By introducing bioeconomy early, we give them the tools to ask thoughtful questions, develop critical thinking skills, and imagine sustainable alternatives. Bioeconomy education helps students see themselves as part of the solution. Through hands-on activities and challenge-based learning, students learn to experiment with biodegradable materials, redesign everyday products, and explore how biological systems can inspire innovation. These experiences allow them to see science in action, to develop a sense of environmental responsibility, and to build critical skills for the future.

What you will find inside the Handbook

Definitions and information about bioeconomy. This part includes simple definitions, classroom-friendly explanations, good practices and examples that could stimulate interest among students, and additional sources of information for educators from other project and EU initiatives.

Our 4-step Methodology. The core of the handbook is built around four key learning steps, each helping students explore and experiment in different ways. To make your navigation easy, each step has its own color throughout the handbook.

Step 1: Understand. In this step we introduce students to the world of bioeconomy. It includes questions, quizzes, and discussions to explore what materials are made of, and how they affect the environment.

Step 2: Define. Here, we invite students to investigate and compare traditional and bio-based materials, identify key properties, and start thinking about alternatives.

Step 3: Make. The hands-on phase! In this step students create their own biodegradable materials and experiment with simple recipes inside the classroom.

Step 4: Release. Students reflect on what they have learned, they evaluate the life cycle of their products, and propose alternative ways to release or reuse what they've created.

RECIBIOS Methodology has been conceptualized and inspired by the Ellen McArthur Foundation's Circular Design Guide, and has been adapted to the bioeconomy topic through practical activities and testing inside the classroom.

In each step, we provide with thought-provoking questions to spark curiosity, quizzes to check understanding, activity ideas ready to be used inside classroom, and extra links and videos for further exploration. In addition, for each step we provide a detailed lesson plan, recommended time allocation and learning outcomes for the students.

Bioeconomy Recipes. A set of classroom-friendly experiments to allow students to create and test their own biodegradable materials using easy-to-find ingredients.

The whole educational program is designed to be implemented over a total of approximately nine teaching hours. Each phase has a specific focus and set of activities, guiding students through an engaging and challenge-based learning journey on bioeconomy and sustainability. Bellow there a general timing suggetion for each phase.

However, the total programme duration can be adapted based on classroom needs, student level, or school schedule.

- **Preparation Phase:** Approximately one (1) educational hour
- **Understand Phase:** Approximately two (2) educational hours
- **Define Phase:** Approximately two (2) educational hours
- **Make Phase:** Approximately two (2) to eight (8) educational hours
- **Release Phase**: Approximately two (2) educational hours

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Figure: *Students from Belgium experimenting with biodegradable materials inside classroom.*

0.

Preparation Phase

Introduction of students to the world of bioeconomy through quizzes, facts, definitions, and discussions to explore what materials are made of, and how they affect the environment.

Preamble to the Preparation Phase

The Preparation Phase sets the foundation for the challenge-based learning journey. It introduces students to the core concepts of bioeconomy and sustainability in an accessible, engaging, and thought-provoking way. This initial step is essential for building a shared understanding of key ideas and terms, while creating the space for students to reflect on their own knowledge and begin forming connections to their everyday experiences.

In this phase, students are invited to explore what bioeconomy means, why it matters in today's world, and how it connects to the choices we make as individuals and as a society. Teachers are encouraged to guide students through a discovery process that includes definitions, good practices, and discussion-based activities. The focus is not on giving all the answers, but on raising interest, asking the right questions, and preparing students for the hands-on experimentation and design phases that follow.

Learning Outcomes:



- Understand the basic principles of bioeconomy and its importance for fostering sustainable development.

- Learn about major EU policies about bioeconomy, future perspectives, and good practices around Europe.

- Assess current knowledge, collaborate, and brainstorm.

Tools:



- A diagnostic questionnaire to help assess student's prior knowledge and expectations.

- A quiz activity such as "Guess the bio-based material" to spark engagement and introduce key concepts playfully.

- A set of open discussion questions designed to stimulate student's thinking about topics like fossil

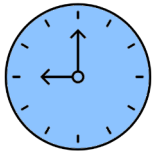
fuel dependency, waste, renewable resources, and climate change.

- Clear definitions of bioeconomy, adapted to the age and level of lower secondary students.

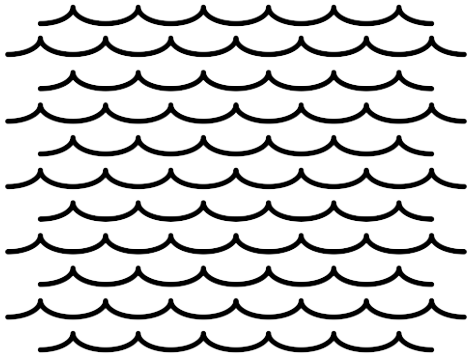
- Short case studies and good practices, including real world examples of bioeconomy products.

- Additional sources of information including videos and other sources of information to introduce the topic of bioeconomy and support diverse learning styles.

Timing and Flexibility:



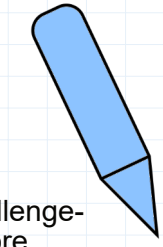
The preparatory phase is designed to be completed within one educational hour. However, teachers are encouraged to adapt the duration and activities depending on the students' background knowledge, interests, and classroom dynamics. For classrooms where bioeconomy is a completely new topic, additional time may be needed to explore foundational ideas and address questions.



Lesson Plan

- Prior knowledge on bioeconomy Intake Questionnaire — 5 min.
- Guess the biomaterial quiz — 10 min.
- Bioeconomy definition — 5 min.
- Bioeconomy applications and good practices — 5 min.
- EU bioeconomy strategy — 5 min.
- Time for reflection and discussion — 15 min.

Previous knowledge assessment quiz



The Preparation Phase sets the foundation for the challenge-based learning journey. It introduces students to the core concepts of bioeconomy and sustainability in an accessible, engaging, and thought-provoking way. This initial step is essential for building a shared understanding of key ideas and terms, while creating the space for students to reflect on their own knowledge and begin forming connections to their everyday experiences.

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QUIZ 1—Let's Explore Bioeconomy

1. Have you heard the word "bioeconomy" before?

- ☐ Yes
- ☐ No
- ☐ I'm not sure

2. What do you think the word "bioeconomy" means? Explain in your own words:

3. Which of the following materials do you think are part of the bioeconomy?

- ☐ Plastic
- ☐ Wood
- ☐ Biodegradable plastic
- ☐ Fruits and vegetables
- ☐ Waste
- ☐ Metal

4. Do you think that making products from biodegradable materials is better for the environment than using traditional materials like plastic? Why or why not:

5. What kind of activities would you most enjoy doing during this new initiative?

- ☐ Designing new products
- ☐ Learning how to turn waste into useful materials
- ☐ Making your own biodegradable materials in class
- ☐ Visiting a local business or lab working on bioeconomy
- ☐ Solving real-world problems using creative thinking

6. If you could plan one activity for this new bioeconomy initiative, what would it be? Describe the activity and explain why you would choose it:

7. Which skills would you like to improve most during this initiative?

- ☐ Creativity
- ☐ Problem-solving
- ☐ Teamwork
- ☐ Science and technology understanding
- ☐ Communication and presenting ideas

8. If you could create a product using biodegradable materials in class, what would it be? Describe your product and why you would like to make it:

9. What else would you like to learn about bioeconomy? Tell us which topics or questions interest you the most:

Guess the bio-based product

In addition, after reviewing, and discussion the responses from the preliminary pre-assessment quiz with students inside the classroom, we recommend including the "*Guess the Bio-based Product*" quiz. This quiz is designed to be fun, visual, and thought-provoking, allowing students to apply their early understanding of bioeconomy in a hands-on way. Students are shown pairs of everyday objects (such as pens, shoes, spoons, cups, and shopping bags). For each pair, they are asked to choose which one is made from bio-based or biodegradable materials.

This quiz helps students:

- Reflect on the materials used in familiar products.

- Realize how similar objects can have very different environmental impacts.

- Begin recognizing the hidden systems behind objects they use daily.

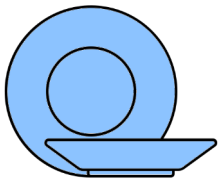
- Understand that sustainable alternatives already exist.

You can use the quiz in various ways:

- As a printed worksheet (although we do not recommend that, as we always want to minimize printed materials!)

- As an interactive slide or distribution through a link.

The aim is not to get every answer right, but to develop curiosity and awareness. Some students may be surprised to learn that bio-based alternatives look very similar to conventional products, and that making environmentally conscious choices starts with asking better questions.





QUIZ 2—Guess the bio-based product

Look at each pair of everyday objects. For each question, choose which item (A or B) is made from bio-based or biodegradable materials. Circle your answer and be ready to explain your reasoning.

1. **Pen** – Which one do you think is made from biodegradable or bio-based materials?




2. **Shoes** – Which pair is made using natural or bio-based materials?




3. **Spoon** – Which spoon can return safely to the environment?




4. **Cup** – Which cup is made from sustainable materials?





5. **Plate** – Which plate is biodegradable?





ANSWERS: 1/A, 2/B. 3/A, 4/A. 5B

TIP for educators

During our pilot RECIBIOS implementation, we also brought examples of bio-based products inside classroom in order students to explore their properties and understand similarities or differences with conventional products.



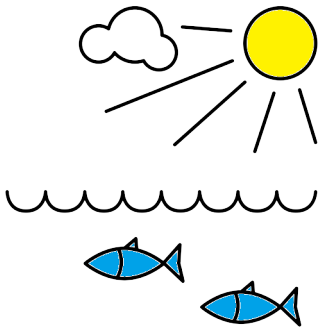
Figure. *Photos of the bio-based products that have been provided to the Greek school. They have been created in the frame of the GENB project and given by the organization QPLAN to the RECIBIOS partnership.*

Understanding the language of Bioeconomy: 10 Definitions to be shared inside classroom

Before students can fully engage with the creative process and investigative tasks that follow in this program, it is essential that they understand the key concepts and terminology related to bioeconomy. This section provides a set of clear, age-appropriate definitions that serve as the building blocks for all upcoming learning activities.

In lower secondary education, students are often encountering these terms for the first time. Words like bioeconomy, biodegradable, or regenerative materials may sound unfamiliar or abstract. By introducing and explaining these terms early on, teachers can help students form a shared vocabulary that will support group discussions, classroom activities, and challenge-based tasks. When students understand the meaning behind the terms, they can better analyze problems, propose creative solutions, and collaborate effectively with their peers. This common understanding is especially important for a project like RECIBIOS, where students are asked to experiment, design, and reflect on materials and systems that are closely tied to scientific and environmental thinking.

This section is also an opportunity to encourage questions, comparisons, and critical thinking. Students may already have ideas or assumptions about some of these terms, and discussing the definitions together can help bridge the gap between what they think they know and what they are about to explore.



Definition 1. What is bioeconomy?

The European Commission defines the bioeconomy as the production of renewable biological resources and the conversion of these resources and waste stream into value added products, such as food, feed, bio-based products and bioenergy. Stronger development of the bioeconomy will help to accelerate progress towards a circular and low-carbon economy. By strengthening the bioeconomy, we move closer to a circular and low-carbon economy.

Definition 2. What are the benefits of bioeconomy and what is waste valorization?

Transitioning to a bio-based economy brings various advantages, such as reducing greenhouse gas emissions, diminishing reliance on fossil resources, better management of natural resources, and enhanced food security. This shift also generates employment in both urban and rural settings. Additionally, the creation of new non-food markets for agriculture, coupled with alternative income sources for farmers, can significantly boost rural areas.

Waste valorization involves the processing of residues/by-products into raw materials, use of discarded products as raw materials or energy sources.

Definition 3. What common sources of renewable energies are there?

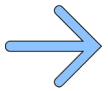
- Solar energy stands as the most abundant among all energy resources and is accessible event in overcast weather.

- Wind energy captures the kinetic energy of mobbing air by deploying large turbines placed on land (onshore) or in sea and freshwater environments (offshore).

- Hydropower captures the energy of water flowing from higher to lower elevations, generated from both reservoirs and rivers.

- Ocean energy originates from technologies that harness the kinetic and thermal energy of seawater, utilizing phenomena such as waves or currents to generate electricity or heat.

-Bioenergy utilized various organic materials like wood, crops, agricultural residues, and wastes such as straw and corn cobs. These can be directly burned for heating or power generation, or can be converted into transport biofuels

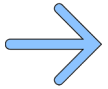


Definition 4. What is recycling, upcycling and composting?

Recycling is defined as the process through which waste is recovered and reprocessed into new useful products. Recycling is one of the most common waste valorization activities. The conversion process often involves a downgrading into raw inputs that are used in a new process.

Upcycling implies the reuse of waste so that the new product or material presents a higher quality, value, or function that the original one. Therefore, upcycling is preferred for the valorization of waste.

Composting is a form of organic recycling in a specific environment. In the composting process, organic waste is broken down by microbial digestion to create compost. To obtain stable, sanitized products for use in e.g., agriculture, organic waste must be treated under managed conditions (temperature, moisture and oxygen content). Industrial composting facilities meet the requirements of a controlled environment and high temperatures (between 50 to 60 degrees Celsius). In home composting (in a backyard, in a special composting

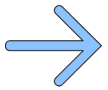


Definition 5. Which is the difference between compostable and biodegradable?

Compostable materials break down into nutrient-rich compost under certain, managed conditions (in the presence of heat, humidity and oxygen). Biodegradable materials break down naturally over time through various environmental factors. All compostable materials are biodegradable, but not vice versa.

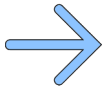
Compostable materials undergo controlled decomposition in specific conditions (with heat, humidity, and oxygen) to produce nutrient-rich compost. In contrast, biodegradable materials break down naturally over time due to environmental factors. It is important to note that while all compostable materials are

biodegradable, the reverse is not always true.



Definition 6. What is biodegradation and what are non-biodegradable materials?

Biodegradation is a natural chemical process during which microorganisms convert organic materials into simple molecules such as carbon dioxide, methane, nitrate/ammonium, and water. Like the way we convert the food that we eat. When a material is called biodegradable, it can be returned to nature without having a harmful impact on the environment. Wood, paper, and food waste are some examples of biodegradable materials. Ultimately and over time, everything will biodegrade in the environment, therefore the term “biodegradable” should always be associated with the type of medium (e.g. soil, water), the conditions (e.g. temperature, humidity, oxygen content), and the duration of the biodegradation. Even when disposed properly, many synthetic man-made materials such as plastic, batteries and glass can take hundreds or event thousands of years to decompose in the environment. Non-biodegradable materials and waster contribute to environmental pollution because they do not break down easily in the environment. These materials, such as plastics and synthetic fibers, persist for long periods, accumulating in landfills, oceans and other ecosystems. Their presence not only disrupts natural processes, but also poses threats to wildlife and human health due to toxic chemicals and physical hazards.



Definition 7. What does renewable mean and what does non-renewable energy mean?

A renewable resource is a material, energy, or water source that is never used up or that can be replaced by new growth after human extraction within a finite amount of time. Non-renewable sources of energy, such as fossil fuels (coal, oil, natural gas) and nuclear energy, are finite resources that cannot be replenished within human timescales. These energy sources took millions of years to form and are being consumed much faster than they can be naturally replaced. As a result, their extraction and use contribute to environmental degradation, air pollution and greenhouse gas emissions, making the transition to renewable energy sources crucial for sustainable energy futures.

Definition 8. What is biowaste?

Biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises, and comparable waste from food processing plants.

The term “biodegradable waste” has a much broader scope, and includes forestry and agricultural residues, animal waste, manure, sewage sludge, or other biodegradable waste such as natural textiles, paper, or processed wood as well.

Definition 9. What is biofuel?

Biofuels, such as biodiesel and bioethanol, are produced from renewable organic materials like plans and agricultural waste. They are a more sustainable alternative to traditional fossil fuels because they emit fewer greenhouse gases. The production and use of biofuels can help reduce dependence on fossil fuels and mitigate climate change.

Definition 10. Bio-based plastics: recycling and benefits.

Bio-based plastics, derived from renewable biomass sources like plants and agricultural waste, offer several environmental advantages. They help reduce dependence on finite fossil fuel resources and lower greenhouse gas emissions compared to traditional plastics. Additionally, bio-based plastics can be replaced similarly to conventional plastics, contributing to a more sustainable waste management system.

Recycling bio-based plastics supports the transition to a circular economy where materials are reused and waste is minimized. This approach not only conserves natural resources but also reduces environmental impacts such as plastic pollution in oceans and landfills.

**The definitions presented in this section have been taken from the “GENB-Young Biovoices for a Sustainable Future” Horizon project, and its educational toolkit which provides a wide range of learning resources aimed at introducing bioeconomy concepts to young learners. For those interested in exploring additional definitions or accessing the full set of educational materials, you can visit the GENB project website.*

EU and bioeconomy

The European Bioeconomy Strategy provides a long-term vision for building a more sustainable, circular, and resource-efficient society. Adopted and updated by the European Commission, this strategy highlights the essential role of bioeconomy in achieving the EU's environmental and economic goals, particularly in the context of the European Green Deal and climate neutrality targets. Bioeconomy is expected to grow significantly in the coming years, transforming sectors such as agriculture, forestry, food production, biotechnology, construction, packaging, and energy. According to the EU’s projections:

- Bioeconomy already generates €2.4 trillion annually across the EU.

- It supports approximately 18 million jobs, with strong potential for job creation in both urban and rural areas.

- Future bioeconomy innovations will help reduce dependence on fossil fuels, lower greenhouse gas emissions, and stimulate local economies.

As technological advances continue, we can expect the emergence of new sustainable materials, bio-based products, and low-impact production systems, all contributing to a more circular economy. From compostable packaging and alternative proteins to green chemistry and regenerative agriculture, the bioeconomy will be at the heart of Europe’s shift toward sustainability.This strategic transformation also places great importance on research, education, and public awareness. Empowering young people through education is a key element in building a bioeconomy-literate society that can actively participate in shaping a more sustainable future. `**For more information, you are invited to explore the full EU Bioeconomy Strategy.*

The 10 R's of Circular Economy: Rethinking our use of resources

The circular economy is a model of production and consumption that aims to keep materials in use for as long as possible, reducing waste and the need for new raw materials. If offers a powerful alternative to the traditional linear economy, which follows a "take-make-dispose" model".

In a circular system, we design products and systems that prioritize reuse, repair, and generation, creating a cycle where resources are valued, materials flow efficiently, and environmental impact is minimized. To help both educators and students understand the key strategies behind this concept, the 10 R's of circular economy have been introduced. Each "R" represents an action that can extend the life of a product or reduce its environmental footprint.



***Figure**. Photo taken by phone during a RECIBIOS student's workshop in the environmental organization InCommon in Thessaloniki on 7/11/2024*

Breakdown of the 10 R's, adapted for teaching use:

1. Respect. Respecting nature, resources, people, and future generations. It invites students to reflect on the relationship with the environment and the social and ethical impact of their choices.

2. Rethink. Encourages rethinking how products are made and used. Can we design smarter? Can we do things differently to reduce waste and pollution?

3. Refuse. Saying "NO" to unsustainable products like single-use plastics or products with excessive packaging. It empowers students to make conscious decisions as consumers.

4. Reduce. Using fewer resources by simplifying needs, consuming less, and choosing efficient and long-lasting products. It's about reducing both material and energy use.

5. Reuse. Extending a product's life by using it again, for the same or even a new purpose, without changing its form.

6. Refurbish. Giving a product a functionable update, often involving cleaning, adjusting, or restoring components to extend its usefulness.

7. Repair. Fixing something that is broken instead of replacing it. This promotes durability, skill-building, and waste reduction.

8. Repurpose. Finding a new use for a product or its parts, beyond its original function, like turning an old t-shirt into a shopping bag.

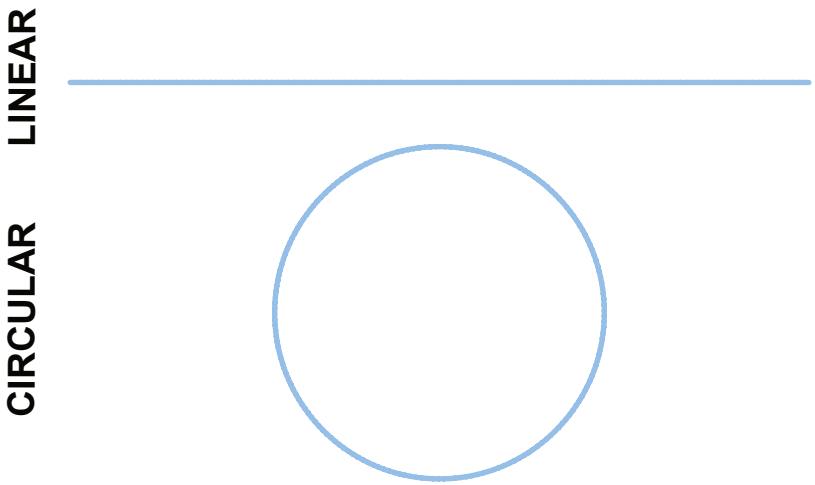
9. Rot. Allowing organic waste to decompose naturally (e.g. through composting). This closes the biological loop, returning nutrients to the soil and reducing methane emissions from landfill.

10. Recycle. Processing waste materials to make new raw materials, which can be used again in production. Recycling is valuable but should be a last option, after the previous R's have been considered.

The 10 R's offer a perfect entry point to help students evaluate the life cycle of products and make more sustainable decisions. The key message is: *not all solutions to waste are equal. The most impactful change happens before waste is created, through respect, rethinking, refusing, and reducing!*

Why materials matter in circular economy and bioeconomy

In both circular economy and bioeconomy, the materials we use and how we use them, play a crucial role in determining the environmental impact of the products we create, consume, and discard. Choosing the right materials means more than finding alternatives to plastic or reducing waste. It means rethinking the entire system behind a product: from sourcing raw materials to design, production, use, and end-of-life treatment.



In a linear economy, most materials are used once and then thrown away. But in a circular and bio-based model, we aim to design materials and products that are renewable, reusable, recyclable, repairable, and biodegradable. Materials should come from sustainable sources, have a long or regenerative life cycle, and be able to safely return to the environment or production chain.

Optional Activity: Discovering Best Bioeconomy Practices in your neighborhood

This optional activity intents to help students connect classroom learning with real-world applications of circular economy by observing and identifying examples of circular practices in their own urban or rural environments.

You are encouraged to take a guided walk around their town or city with the goal of identifying visible signs of bioeconomy or circular economy in practice. These could include second-hand shops, repair cafés, local refill stations, compost bins, urban gardens, upcycled product designs, or businesses that promote reusability, bioeconomy, or waste reduction.

After the walk, students will return to the classroom and reflect on their observations, discuss their findings, and evaluate how circular thinking is applied in real life.



***Figure**. Photo taken by phone during a RECIBIOS student's workshop in the environmental organization InCommon in Thessaloniki on13/05/2025. Students accormpanied by teachers are exploring the neighborhood of the upper town of Thessaloniki for the identification of circular economy practices.*

Step 1: Prepare the Students

Before the walk, introduce students to the idea of observing through a "circular economy lens." Revisit the 10 R's of Circular Economy and ask students: '*What kinds of places or practices do you think follow one of these R's?*', or *'What might be signs of reuse, repair, or recycling in everyday life?*'.

Provide them with a simple observation sheet/map (or let them use their notebooks or mobile phones) to take notes or photos.

Step 2: Go for the Walk

Organize the class into small groups (3–4 students). Walk through the neighborhood, city center, or a local marketplace. Encourage students to look for and document:

-Repair services (bike shops, cobblers, electronic repair stores)

-Second-hand stores or swap initiatives

-Compost bins or community gardens

-Public recycling infrastructure

-Businesses using eco bio-packaging or promoting reusable items

-Cafés with returnable cup systems or waste-reducing practices

Step 3: Reflect and Discuss Back in Class

Upon return, ask students to share:

-What examples of circular practices did you find?

-Which of the 10 R's did they relate to?

-Were you surprised by any discoveries?

-Do you think your town or city is circular? Why or why not?

You can also create a shared classroom map or poster highlighting all the observed practices and places.

Real-World examples of Bioeconomy

To help students understand the importance of materials, this section presents real-world examples of how circular and bio-based thinking is already being applied not in theory, but in everyday business, packaging, and design.

Good Practice No.1: DAMN PLASTIC Shop – Ljubljana, Slovenia



Figure. *Photos taken by phone during a study visit in Slovenia in 2024*

DAMN PLASTIC is a shop that completely rethinks what a plastic-free retail environment can look like. Here, no plastic is used: not in the products, not in the packaging, not even in the store's interior design.

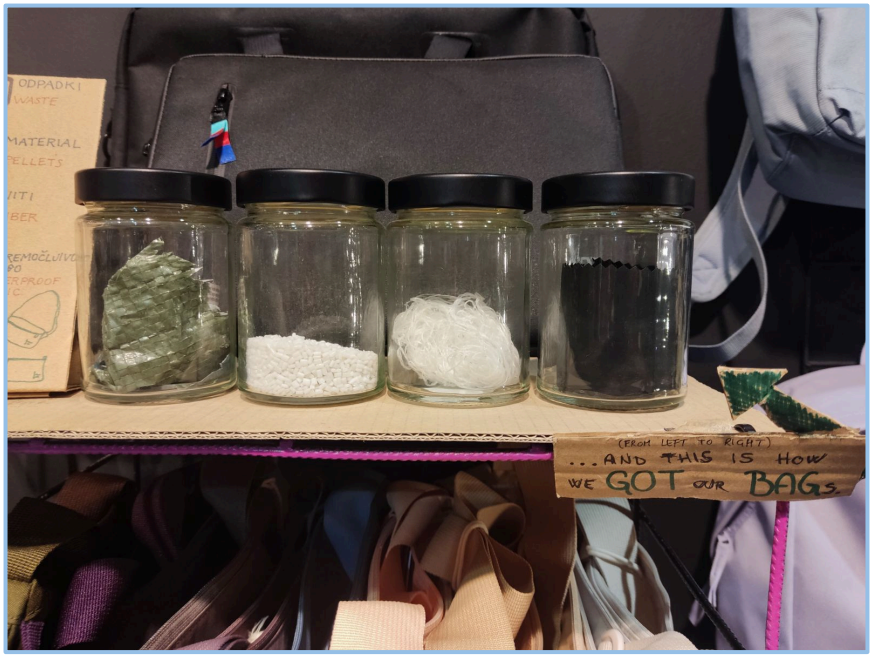


Figure. *Photo taken by phone during a study visit in Slovenia in 2024, showcasing the materilas of a bag.*

- The shelves are made of compressed paper, proving that sustainable materials can be functional and visually appealing.

- Product packaging is biodegradable or reusable, demonstrating alternatives to petroleum-based plastics.

- What makes this store even more educational is that it shows the raw materials of each product. For example, the materials used in a bag are displayed in glass jars. Students can see what the product is made of, raising awareness about transparency and material origins.

This practice offers teachers an opportunity to encourage students to think not only about end-products but about the invisible systems behind them and the decisions that make products truly sustainable.

Good Practice No.2: Staramaki – Kilkis, Greece



Figure*. Photo of the social enterprise Staramaki. Source: www.in.gr*

Another inspiring bioeconomy initiative is Staramaki, based in Kilkis, Northern Greece. This social enterprise produces biodegradable drinking straws made from wheat stems, an agricultural byproduct that would otherwise go to waste.

Staramaki shows how local materials can become sustainable alternatives to plastic, while also supporting rural employment and inclusive entrepreneurship. The straws are compostable, locally sourced, and part of a circular, zero-waste philosophy, combining economic, social, and environmental impact.

Teachers can use this example to highlight how bioeconomy can emerge from local solutions and natural cycles, and how innovation is possible even with simple, low-tech materials.

Good Practice No.3: HEINZ Tomato Ketchup – Biodegradable Packaging

Finally, a large-scale example comes from an international brand: HEINZ tomato ketchup. The company introduced 100% biodegradable packaging, moving away from plastic containers and adopting materials that can safely decompose without harming the environment.



Figure. *HEINZ tomato ketchup 100% biodegradable packaging. Source: https://news.kraftheinzcompany.com/*

This case shows students that big businesses, too, are adapting to bio-based thinking and changing their practices to meet consumer expectations and environmental regulations.

**For teachers who want to go further, the European Union has published several inspiring resources highlighting good practices, local innovations, and funding initiatives across the continent. These stories can serve as case studies or simply show students the diversity and creativity of bioeconomy projects in real life.*

***Now is a chance to spark classroom discussion: Can all brands follow this path? What kind of materials should food packaging be made from in the future?*

Using multimedia resources to spark inspiration and engagement

To make bioeconomy concepts more tangible and relatable, you are encouraged to use videos and real-world stories during classroom sessions. Videos help students visualize complex ideas, stimulate discussion, and connect what they're learning with actual practices, products, and innovations happening across Europe.



Figure. *Students from the 1st Junior High School of Naousa LAPPEION watching educational videos about circular economy during the study visit in the environmental organization InCommon on 7/11/2024*

Here are some recommended short videos that can be shown at the beginning of a lesson or during discussions to introduce students to the bioeconomy and its impact:

What is Bioeconomy? *A simple and engaging explanation of the concept.*



***A Bioeconomy Day (Real-life examples)**. A celebration of bioeconomy innovations around Europe.*



***Animated Bioeconomy Introduction.** A short animation explaining how bioeconomy supports sustainability.*



***The BLOOM Bioeconomy Suitcase.** A visual exploration of how bioeconomy can be taught in schools.*

** Incorporating videos and real-world examples not only enhances understanding but also helps students see themselves as future changemakers in sustainability, science, and innovation. You may choose to use these videos to introduce a topic or phase (e.g. before starting the "Understand" step, create a starting point for class discussions or project brainstorming, or compare examples with your local context.*



Wrapping Up the Preparation Phase: Ideas for Group Discussion

Now it's the time to reflect on what we have learned so far! To close the Preparation Phase, you are encouraged to facilitate open group discussions in the classroom. These conversations will help students reflect on what they've learned so far, explore new ideas, and connect the concepts of bioeconomy and sustainability to their everyday lives.

At this point, students should have a basic understanding of what bioeconomy is and why it matters. Group discussion provides an opportunity to deepen that understanding, build confidence, and prepare for more hands-on tasks in the next phases of the project.

Method: You can choose to organize this as:

- A short 15-minute group activity (2–4 students per group).

- A roundtable classroom discussion.

- A "Think-Pair-Share" activity where students discuss in pairs before sharing with the whole class.

Group Discussion Ideas:

1. What are fossil fuels, and what kinds of products do we make from them today? Encourage students to think about plastic, fuel, clothing, and packaging, and how deeply fossil-based materials are integrated into our lives.

2. Why can't we continue to rely on fossil fuels in the future? Prompt ideas about climate change, pollution, resource limits, and economic challenges.

3. What alternative energy sources or materials can replace fossil fuels? Introduce renewable energy (solar, wind, bioenergy) and bio-based materials (plant-based plastics, compostables, etc.).

4. What does “bioeconomy” mean in your own words? Have students try to rephrase the definition they learned. This helps assess understanding and encourages ownership of the term.

5. Think about ways bioeconomy can improve our lives or protect the planet? Invite personal reflections or examples from the videos, products, or good practices shown earlier in the lesson.

Encouraging students to voice their ideas and questions at this stage helps them feel engaged and ready to dive into the challenge-based tasks that follow.

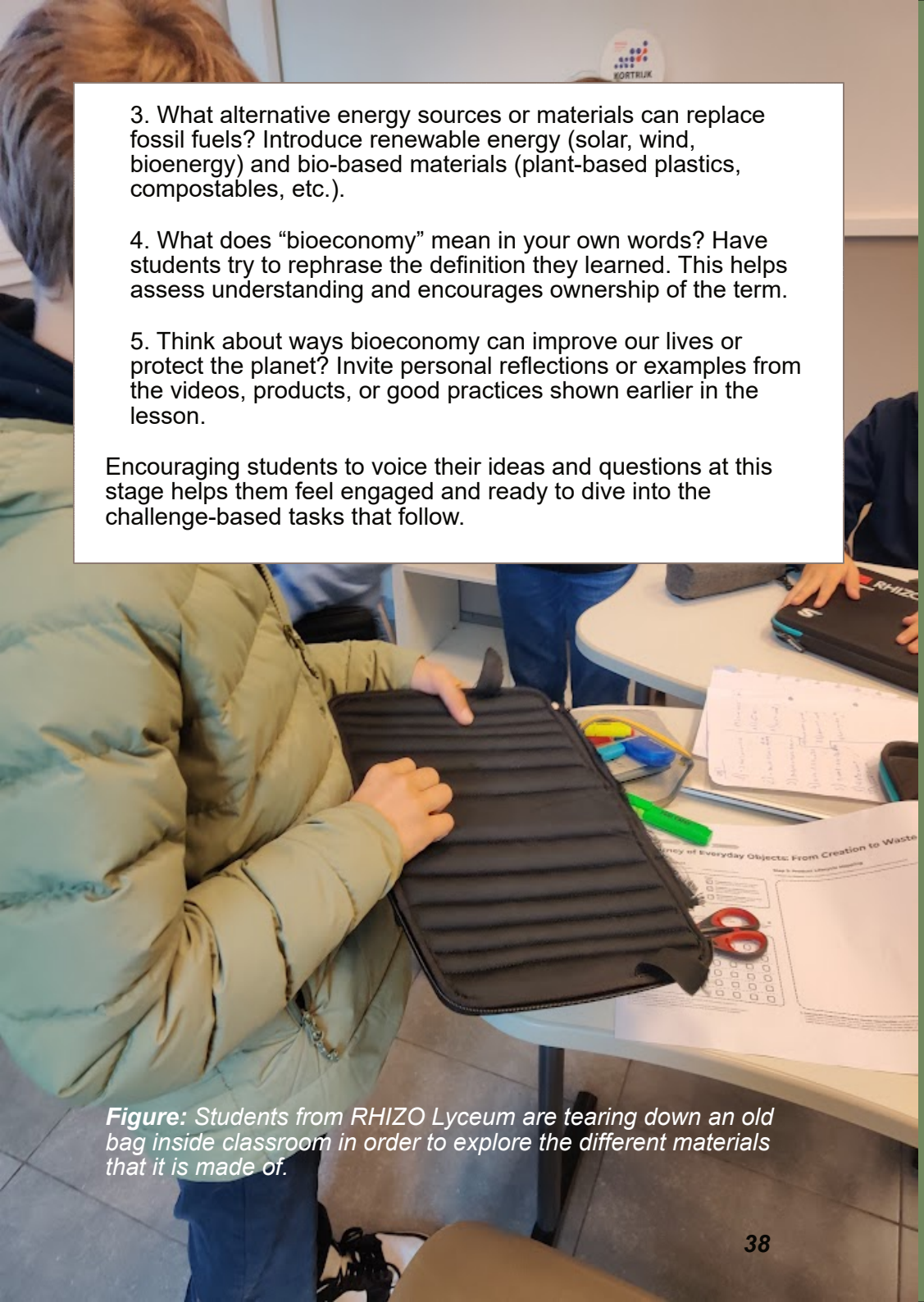


Figure: *Students from RHIZO Lyceum are tearing down an old bag inside classroom in order to explore the different materials that it is made of.*

1.

Understand Phase

Understanding the properties of materials, exploring what everyday objects are made of, obtaining information about plastics, be able to understand differences between biodegrable and non-biodegradable materials.

Preamble to the Understand Phase

The Understand Phase builds upon the curiosity sparked during previous classroom activities, and takes students one step deeper into the world of bioeconomy. In this phase, students begin to examine the life cycle of products, the environmental impact of materials, and the role of human decisions in shaping sustainable futures. It is a moment of critical observation and exploration, where students learn to recognize what materials are made of, how they are produced, used, and eventually disposed of, and what this means for our planet.

At this stage, the focus is on making the invisible visible: helping students notice the hidden systems, resources, and consequences behind everyday objects. Through guided activities, group work, and hands-on analysis, students begin to understand that materials matter, and that what we choose to produce and consume can either support or harm the environment. This phase encourages students to question not only what things are made of, but why those materials were chosen, and how alternative, bio-based materials might perform better for people and the planet. Students explore examples of traditional vs. bio-based products, identify unsustainable practices, and begin to build a framework for evaluating materials critically.

The Understand Phase is designed to foster systems thinking by helping students trace product life cycles and map the flow of materials from extraction to disposal. It lays the groundwork for creative experimentation in the next phases and strengthens students' ability to connect personal choices with broader environmental consequences.

Learning Outcomes:



- Develop observation, analysis, and systems thinking skills.

- Begin imagining better material choices and design solutions for a circular future.

- Identify differences between traditional, fossil-based materials, and sustainable, bio-based alternatives.

- Understand the full life cycle of everyday products, from resource extraction to disposal.

- Recognize the environmental impact of different materials and products.

- Understand property materials.

Tools:



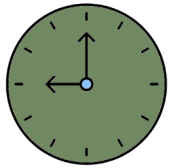
- The Understand Phase Worksheet.

- Guidelines and links for additional sources of information and tools to be used inside classroom.

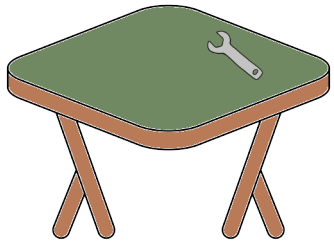
- A set of open discussion questions designed to stimulate student's thinking and awareness about bioeconomy.

**Other tools that may be used are also old and unused everyday objects for classroom experimentation!*

Timing and Flexibility:



The Understand phase is designed to be completed within two educational hours. However, teachers are encouraged to adapt the duration and activities depending on the students' background knowledge, interests, and classroom dynamics. For classrooms where bioeconomy is a completely new topic, additional time may be needed to explore foundational ideas and address questions.



Lesson Plan

- Questions to spark reflection
- Introduction to the RECIBIOS Methodology
- Choose and tear down a product
- Properties of plastics
- Chemical dangers
- Biodegradable and regenerative materials
- Life Cycle Mapping
- Reflection and Assessment

1st Educational hour

2nd Educational Hour

Starting the Classroom Activities: Preparing the Group



Figure. *Students of the 1st Junior High School of Naousa LAPPEION attending a group discussion about circular economy during the study visit in the environmental organization InCommon on 7/11/2024*

To begin the Understand Phase, start with a short classroom discussion that helps students reflect critically on their everyday experiences with materials and products. These questions are designed to activate prior knowledge, build on the Preparation Phase, and guide students toward observing and thinking in new ways.

You can ask these questions as part of a class-wide discussion or pose them to students in pairs before sharing responses as a group. The aim is not to assess correctness, but to spark curiosity, observation, and critical thinking.

Suggested discussion questions:

- Have you ever thought about what your school bag, shoes, or pens are made of?

- Do you know where these materials come from and what happens to them when they are no longer useful?

- What do you think that happens to a t-shirt after we throw it away?

- Have you ever seen before a product that looks “*eco-friendly*”? What made you think that?

These questions help shift student’s attention from the objects themselves, to the materials, origins, and life cycles behind them, fostering the necessary mindset for the next steps of the UNDERSTAND phase.

After the opening discussion, organize students into small working groups of 2 to 4 students. This structure supports collaboration, peer learning, and shared discovery, and it mirrors real-world design and sustainability teams. During the working groups activity, students will explore, investigate, and analyze real products, learn to recognize different materials, and begin thinking about how everyday items are made and what environmental impact they might have.

The Journey of Everyday Objects: From Creation to Waste

Now its time to introduce to students the 1st Worksheet: The Journey of Everyday Objects: From Creation to Waste! The challenge-based design process starts at this step. This phase invites students to explore a product they use every day and investigate the materials it is made of, its life cycle, and how it might be improved through circular and bio-based thinking.

The Journey of Everyday Objects: From Creation to Waste

Step 1: Choose a product

Pick an everyday object you use either at school or home (e.g., a pen, water bottle, backpack).

Consider the following criteria:

Name of Product	Check	
	☐	Frequent Use: Pick something you use regularly, at least once a day.
	☐	Problems or Frustrations: Is there anything annoying or inconvenient about the product?
	☐	Bioeconomy Potential: Does it ends up as waste after use? Can the materials be improved?

Step 2: Product Tear Down

1. Disassemble the Product: If possible, carefully take the product apart to see what materials and components it's made of. This helps you understand how it's built and what it's made from.

2. Materials List: As you break it down, make a list of all the materials you find (e.g., plastic, metal, rubber).

Name of Material	Biode-gradable	Regen-erative	Chemical Dangers	Can be Recycled
	☐	☐	☐	☐
	☐	☐	☐	☐

3. Analyse the Materials: For each material, ask yourself the following questions: Is it biodegradable (breaks down naturally)? Is the material regenerative (sourced from renewable or regenerative resources)? Does it pose any chemical dangers (harmful to the environment or people)? Can it be recycled or reused?

Step 3: Product Lifecycle Mapping

Sketch the Lifecycle: Draw a diagram showing the life stages of your product from beginning to end.

Evaluate the Product's Lifecycle for Circular Opportunities: Look at the current lifecycle of the product you've chosen. Now think: how can we make it more "circular"? Explore ways to reuse, repair, or recycle parts of the product instead of throwing it away. Can it be designed differently to last longer or use fewer materials? Place a green dot at every step in the product's lifecycle where you see a chance to reuse, recycle, or extend the product’s life.

This worksheet is designed to build core skills in observation, analysis, teamwork, and reflection, while helping students relate global sustainability ideas to objects in their everyday lives. Teachers can guide the process step by step, allowing time for discussion and comparison between groups.

Step 1: Choose a product

Ask students in teams to select one everyday object that they do not regularly use at school or at home. This could be something like a pen, a backpack, a water bottle, or any small item that you're familiar with. Ideally, choose a product that is no longer working, damaged, or ready to be thrown away, so you can safely explore its materials and structure in the next step.



Figure. *An example of object that was choosen by students during the RECIBIOS implementation*

In teams, they may use the space in the worksheet to write the name of the chosen product and carefully consider the following criteria:

Frequent Use: Is it something that students use often — at least once a day?

Problems or Frustrations: Does the product have something annoying, uncomfortable, or inconvenient about it? Could it be improved?

Bioeconomy Potential: Does the product turn into waste after just one use or too quickly? Can its materials be changed or replaced with something more sustainable or biodegradable?

These questions help students think like a designer and begin to view everyday products through the lens of bioeconomy and circular thinking. The answers will guide investigation and prepare the groups for the teardown and analysis activities that follow.

**Remember: there are no wrong answers. The goal is to start observing, questioning, and discovering.*

Step 2: Product Tear Down

This is one of the most fun and hands-on parts of the project. The students really enjoyed this phase! In this step, students become material explorers. After choosing an everyday product, each team now takes a closer look by disassembling the item to discover what it's made of and how it's constructed. This activity allows students to discover a new world behind everyday objects.

Instruction video of product tear down: *QR code of video instruction for how to tear down objects by Ellen MacArthur Foundation*

Students carefully take the object apart (only if it's safe and appropriate to do so) to uncover the materials and components used inside. Encourage them to look beyond the surface. Sometimes objects contain layers or hidden parts made from different materials.

**This can be done with basic items like scissors or screwdrivers, and can be as simple as unzipping a bag, peeling apart packaging, or examining glued or stitched parts.*

As they break the product down, students use the worksheet to list each material they find. They might identify things like:

- Plastic
- Cardboard or paper
- Fabric or leather
- Rubber
- Metal
- Foam or glue





Figures. *Object tear down during RECIBIOS implementation inside classroom*





Figures. *Exploration of the different materials of a bag during RECIBIOS implementation in Belgium*

For every material they identify, students fill in the table by answering the following guiding questions:

Is it biodegradable (does it break down naturally)?

Is it regenerative (sourced from renewable or regenerative resources)?

Does it pose any chemical dangers (e.g., is it harmful to the environment or human health)?

Can it be recycled or reused?

**You may also provide again the definitions that are provided in the Preparation Phase!*

This process helps students connect science with real-world choices, while learning about material properties and their environmental impact. It also encourages them to reflect on how different materials are treated after a product's life ends.

Encourage students to take their time, discuss in their groups, and question everything: Why was this material chosen? Could something better be used? What would happen if this product ended up in nature?

Some tips that could be shared inside classroom is that:

Bio-based materials are often designed to mimic the function of traditional materials but degrade naturally (e.g., straws made of wheat stems).

Some materials may seem "*natural*" but are treated with **chemicals** or combined with plastics, making them less sustainable than they appear.

Transparency in design matters. In many products, consumers don't know what materials are used. Projects like this build awareness and demand for better practices.

You may also ask students:

Which materials in your product are the most problematic?

Could these materials be replaced with something better, e.g. bio-based, reusable, or recyclable?

What kind of waste will this product create in the end?

This step creates a bridge between observation and design thinking, preparing students to evaluate and improve products in the phases that follow. This deepened understanding of materials helps students move from simply identifying objects to critiquing and improving them, a key step toward circular thinking and sustainable design.

Optional Activity: Plastic Investigation Lab

The Plastic Investigation Lab is an optional activity that helps students investigate and compare different types of plastic. Plastics are one of the most commonly used materials in everyday life, but not all plastics are the same. Some can be melted and reused, while others are rigid or rubber-like and behave very differently. In many EU countries, learning to distinguish between thermoplastics, thermosets, and elastomers is a standard part of science education. This activity brings that concept into your classroom in a hands-on and exploratory way without needing lab equipment.



What to Do

Collect a variety of plastic samples (clean and safe for handling), such as:

- A plastic water bottle

- A plastic spoon or food tray

- Flexible rubbery plastic (like a bottle cap or part of a shoe sole)

- Bioplastic items (if available)

Students observe and describe each item's physical properties:

Does it feel rigid or flexible?

Does it snap or bend?

Is it lightweight or heavy?

What happens when you try to stretch or twist it?

Does it return to its shape?

Based on their observations, students try to categorize the plastic as one of the three main types listed below.

Types of Plastics (based on structure and behavior)

1. Thermoplastics
Soften when heated and can be reshaped multiple times
Recyclable
Found in: plastic bottles, food containers, packaging
Structure: Linear or branched polymer chains

2. Thermosets (Thermosetting Plastics)
Harden permanently after being heated once
Not recyclable by melting
Found in: plugs, switches, hard casings
Structure: Dense, tightly cross-linked polymer network

3. Elastomers
Flexible and elastic — stretch and return to original shape
Found in: shoe soles, rubber bands, seals
Structure: Loosely cross-linked polymers (rubber-like)

Flame Test (Teacher Explanation Only — Not Performed in Class)

In advanced or lab settings, a flame test can be used to identify plastic types:

- Thermoplastics burn and drip

- Thermosets char but do not melt

- Elastomers burn with a smell and become brittle

For now, students should stick to observing physical properties only.

Plastic Investigation Lab Template

Sample Name	Rigid or Flexible	Stretchy?	Returns to Shape?	Melts or Warps?	Your Guess
	☐	☐	☐	☐	
	☐	☐	☐	☐	
	☐	☐	☐	☐	
	☐	☐	☐	☐	

This activity helps students:

- Understand that plastics are diverse in structure and behavior

- Reflect on why certain plastics are chosen for specific products

- Begin thinking critically about recyclability, material impact, and substitution

- Connect their findings to the previous product teardown and life cycle analysis

** To explore more on plastic types and identification, see: Boedeker Plastic Identification Resource*

Step 3: Product Lifecycle Mapping

In this final step of the Understand Phase, students are invited to map out the life cycle of the product they examined. The goal is to help them visualize the entire journey of an object, from the extraction of raw materials to its end-of-life, and to reflect on the environmental impact at each stage.

This activity strengthens students' systems thinking skills, encouraging them to view products not as isolated items, but as part of a complex set of processes, decisions, and consequences.

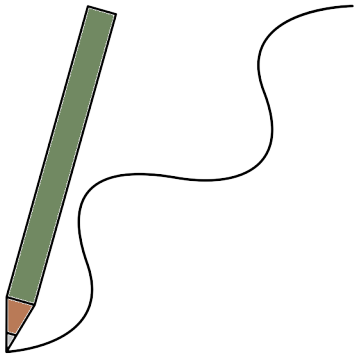
Activity Instructions

- Work in pairs or small groups and use the worksheet space provided to draw the life cycle of your product.
Ask: *Where does the product start? What stages does it go through? Where does it end up?*

- Spend 5–10 minutes sketching all the steps the product might go through during its existence. Students can use arrows, icons, labels, or drawings. There are no wrong answers at this stage.

- As a class, the teacher can draw five columns on the board, and once groups begin sharing, help them place each idea into one of the five life cycle stages.

Think about where the product begins, how it is made, used, and what happens to it when it is no longer needed. Use the table below to organize your ideas for each stage. You can add sketches, keywords, or short descriptions.



Product Lifecycle Mapping Template

Design	
Production	
Distribution	
Use	
End-of-Life	

Students will eventually group their findings into these five categories:

1. **Design** – Where the idea for the product is developed; what materials are chosen; how it is meant to function.

2. **Production** – Where and how the materials are sourced, processed, and assembled into a final product.

3. **Distribution** – How the product is transported, packaged, and delivered to users or stores.

4. **Use** – How long the product is used, how it performs, and whether it is disposable, durable, or reusable.

5. **End-of-Life** – What happens after the product is no longer useful, is it thrown away, recycled, reused, or composted?

Students can then guess the names of the phases as a class and compare them to their own sketches.

Evaluate for Circular Opportunities

At the end of the activity, students reflect on how the product could be improved. Use this prompt:

How can this product's life cycle become more circular? Where could we reuse, recycle, repair, or redesign something to make it better for people and the planet?

Students can place green dots or notes on their diagrams where they see opportunities for circular design. This will prepare them for the Define and Make phases ahead.

Optional Video Resources

Lifecycle of a T-Shirt: *QR code for the life cycle of a t-shirt video*

Illustrative video *for Life Cycle Assessment.*



Wrapping Up the Understand Phase: Ideas for Group Discussion

The Understand Phase invites students to take a closer look at the everyday objects around them. What they discover is often surprising! Through observation, disassembly, discussion, and reflection, students begin to realize that materials matter, and that each product we use has its own hidden story: a story of resources, design decisions, energy, and environmental impact.

This phase helps students develop a new way of seeing, one that connects their personal choices with larger systems and sustainability challenges. They learn that the things we throw away were once valuable, and that designing better products starts with understanding what's wrong with the current ones.

By the end of this phase, students have begun thinking like young sustainability experts: asking critical questions, identifying problems, and recognizing potential for improvement. They are now equipped with the vocabulary, mindset, and analytical tools to move from exploration to solution-finding.

To conclude the Understand Phase, we recommend holding a short classroom discussion (10–15 minutes) to help students share what they've learned and connect their findings. Here are some guiding prompts:

- What surprised you most about the product you examined?

- Did you notice any materials that could be replaced with better alternatives?

- Which phase of the product's life cycle do you think has the biggest environmental impact?

- What does "circular thinking" mean to you after this activity?

- How might you use what you've learned when buying or designing something in the future?

These closing discussions allow students to make meaning from their experience, while giving teachers the chance to assess

understanding and prepare the class for the next phase of the project: Define.

The next step will take them into the Define Phase, where they will dive deeper into material properties and real-world alternatives, and begin shaping their own ideas for more sustainable and circular design. Let’s keep the momentum going.

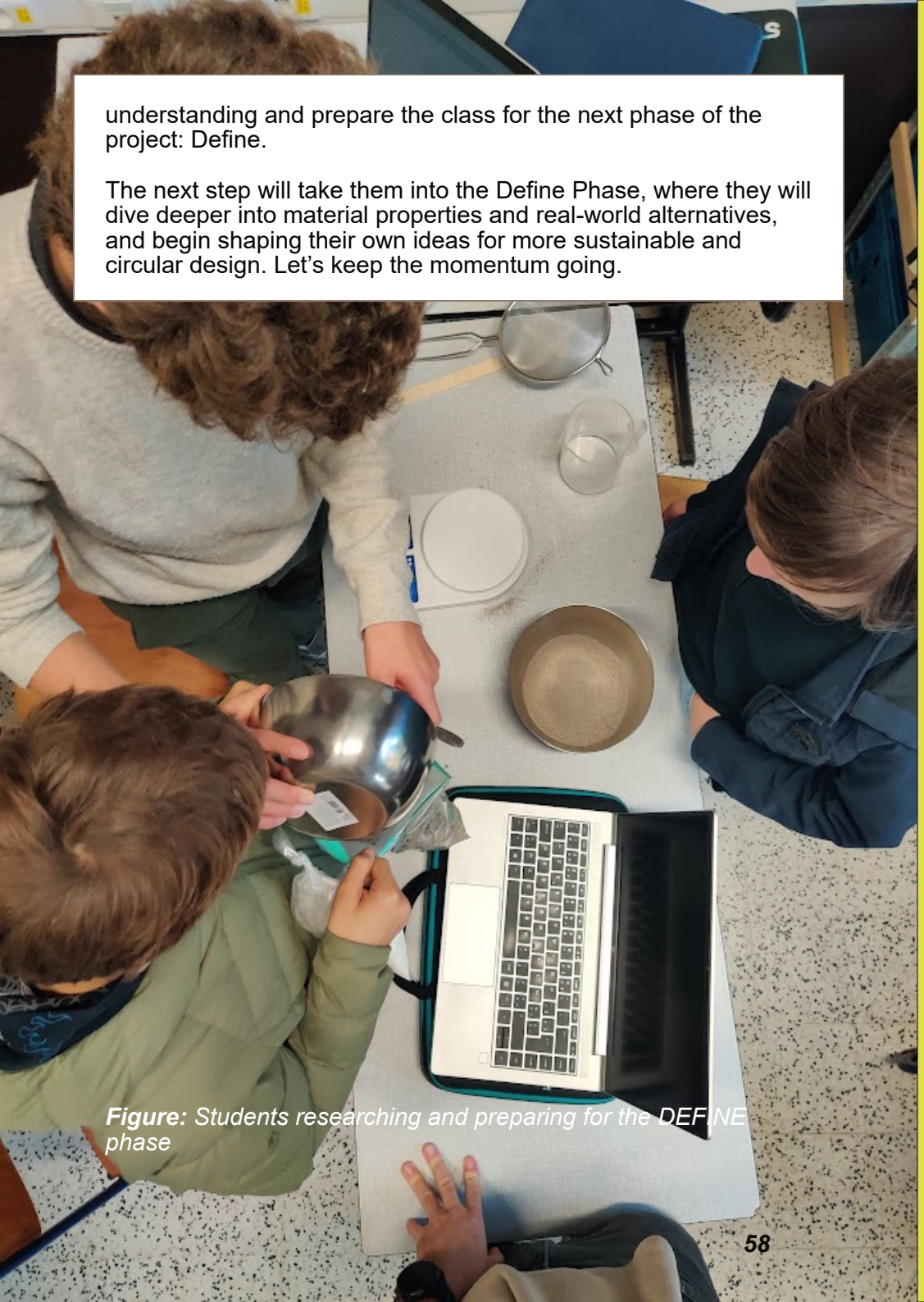


Figure: *Students researching and preparing for the DEFINE phase*

2.

Define Phase

Understanding the properties of materials, exploring what everyday objects are made of, obtaining information about plastics, be able to understand differences between biodegrable and non-biodegradable materials.

Preamble to the Define Phase

The Define Phase is where critical thinking meets creativity. After exploring the materials and life cycle of everyday objects, students are now ready to go deeper: to investigate why certain materials behave the way they do, to compare traditional and bio-based alternatives, and to begin shaping ideas for more sustainable designs.

In this phase, students build their understanding of material properties, such as flexibility, resistance, water absorption, or transparency. They are also asked to consider how those properties influence the performance and environmental impact of a product. They are introduced to simple tools and experimental techniques to test materials, reflect on how materials meet different needs, and begin forming opinions about which choices are most responsible.

This phase is also about developing a more analytical and experimental mindset: students are no longer just discovering what exists, but starting to imagine what could be improved. They are encouraged to compare products (e.g., a plastic spoon and a bioplastic spoon) and materials (e.g., wood vs. recycled plastic), and consider what makes each one more or less sustainable.

By engaging in guided comparisons and classroom experiments, students begin to define the criteria they believe are important when designing sustainable solutions. They might prioritize biodegradability, ease of use, local sourcing, safety, or circularity. Each decision brings them closer to thinking like a designer with a purpose.

The Define Phase sets the groundwork for the Make Phase, where students will bring their ideas to life using real materials and recipes. But before we get there, this stage gives them the tools and insight to make informed, thoughtful, and sustainability-driven design decisions.

Learning Outcomes:



- Identify and describe key material properties such as flexibility, transparency, resistance, and biodegradability.

- Compare traditional and bio-based materials and evaluate their strengths and weaknesses.

- Define sustainability criteria for selecting materials in the design of circular products.

- Begin to make informed decisions about which materials are better suited for sustainable solutions.

- Reflect on how material choices impact the usability, durability, and environmental footprint of a product.

Tools:



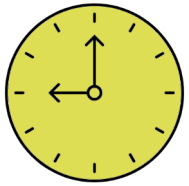
- The Define Phase Worksheet for material testing and comparison.

- Simple classroom activities that introduce students to the properties of materials.

- A materials comparison chart to support observation and analysis.

- Open questions and prompts that encourage students to reflect on material performance and design decisions.

Timing and Flexibility:



The Define Phase is designed to be completed within approximately **two educational hours**. However, teachers may adapt the schedule based on classroom conditions, availability of materials, or the depth of discussion and experimentation. Some activities can be extended or repeated depending on student interest, or used as preparation for the Make Phase.

Lesson Plan

Questions to spark reflection

Selection of a material

Research for material properties

Define main material properties and characteristics

Research for bioeconomy alternatives

Reflection and assessment

1st Educational hour

2nd Educational hour

During the Define Phase, students move from exploration to evaluation. They begin to understand what makes a material “fit for purpose” and what makes it more or less sustainable. The phase is centered on selecting product parts, analyzing material properties, and identifying better, bio-based alternatives.

This phase includes four main steps, all of which are supported by the worksheet: **Redesign with Biomaterials.**

Before diving into the steps of the Define Phase, it’s important to create the right mindset and prepare students for a more analytical and creative process. This phase is about observation, comparison, and decision-making, and it works best when students are encouraged to think critically, ask questions, and collaborate.

Start the session with a brief class conversation to reactivate the knowledge from the Understand Phase and transition into deeper material exploration. Invite students to work again in small groups (2–4 students) (ideally the same ones used previously) to ensure continuity and shared ownership of their ideas.

Open the Define Phase with reflective questions like:

- What made some materials in your product useful or problematic?

- Which part of your product do you think could be improved and why?

- What qualities do you think make a material sustainable?

- Have you ever used or seen a product made with unusual or natural materials? What stood out about it?

- What kind of materials do you think we'll use more often in the future?

These questions help students begin thinking like designers. They shift from simply noticing materials to defining what makes a “*better*” material in terms of functionality, sustainability, and circularity.

Redesign with Biomaterials

Step 1: Material Selection

Pick a product part and material from the product and materials list created in the understand phase.

Describe the Product Part & Current Material

Check

- ☐ **Frequent Use:** Pick something you use regularly, at least once a day.
- ☐ **Problems or Frustrations:** Is there anything annoying or inconvenient about
- ☐ **Bioeconomy Potential:** Does it ends up as waste after use? Can the materials be improved?

Step 2: Evaluate Current Material Properties

It's important to understand the characteristics of the material you're replacing. Explore key properties of the current material (e.g. is it rigid or flexible, does it need to be water-resistant, heat-resistant, etc.). Think about why this material was chosen in the first place. What purpose does it serve in the product?

	Name	Description
Material Property 1		
Material Property 2		
Material Property 3		
Material Property 4		

Notes / Remarks

Step 3: Identify a Biomaterial Alternative

Using your previous research (e.g., from Materiom.org), select a biomaterial that matches the characteristics of the material you want to replace. Make sure this biomaterial is feasible—you should be able to source the necessary ingredients and tools.

	Name	Description
Material Property 1		
Material Property 2		
Material Property 3		
Material Property 4		

Biomaterial Name

Option A **Option B** **Option C**

Notes / Remarks

Step 4: Feasibility

Before moving forward, ensure all ingredients can be sourced.

Step 1: Material Selection

This first step in the Define Phase is all about choosing a meaningful material to improve. Students return to the object they examined in the Understand Phase and decide which part or material they would like to redesign using a bio-based alternative. This decision will guide their entire investigation and experimentation during the upcoming activities. The goal it to help students narrow their focus, connect with a real-world design challenge, and begin thinking about materials in terms of function, sustainability, and improvement.

In their teams, students discuss and choose:

1. One everyday object they already explored.

2. One specific part or material from that object that could be redesigned.

<u>For example:</u>

- The plastic casing of a pen
- The sole of a sneaker
- The plastic bag used for packaging
- The lid of a disposable coffee cup
- The plastic handle of a toothbrush

Encourage students to choose a part that has a clear function in the product, is not sustainable or causes waste, and could be realistically replaced with a different, better material

To support their decision-making, students should reflect on:

Frequent Use – Is this object used daily or often? Does that increase its environmental impact?

Problems or Frustrations – Is there something annoying, fragile, wasteful, or uncomfortable about this material?

Bioeconomy Potential – Could this material be improved by using natural, regenerative, or biodegradable alternatives?

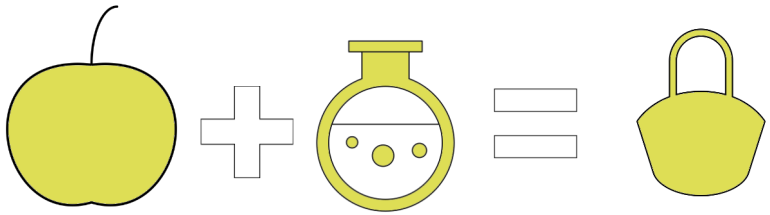
You may want to list these questions on the board or worksheet, or lead a short group brainstorm.

This step is more than just picking a material. It invites students to make a case:

- Why does this material matter?
- What's wrong with it today?
- How would improving it help the environment, the product, or the user?

This is a chance to encourage values-based thinking alongside creativity.

The form of choosing materials could be used and distributed to students.



Material Choosing Form

Team Name:
✎ Write your team name.

Which object and material do you want to redesign?
✎ Be specific! For example: the outer plastic casing of a pen.

Which material properties are most important for your application?
✎ Example: flexibility, water resistance, strength, biodegradability.

Which material from Materiom.org do you think is the best match, and why?
✎ Name the bio-based material you found and explain why it fits your design challenge

To support their investigation, students are encouraged to use Materiom.org, an open-source library of bio-based materials and recipes from around the world. The platform allows users to search for materials based on properties (e.g., water resistance, elasticity) and available ingredients (e.g., starch, agar, eggshells

Link for Materiom.org

**Information from Materiom should be used in all the steps of the DEFINE phase.*

Step 2: Evaluate Current Material Properties

What makes a material '*fit for purpose*'? In this step, students shift from selecting a material to analyzing its performance. They explore the physical and functional properties that determine how a material behaves and whether it's suitable for a specific product. This activity deepens their understanding of why materials are chosen, and helps students define what an ideal alternative might look like.

Material properties describe how a material reacts or behaves in certain conditions, for example, how flexible, tough, or water-resistant it is.

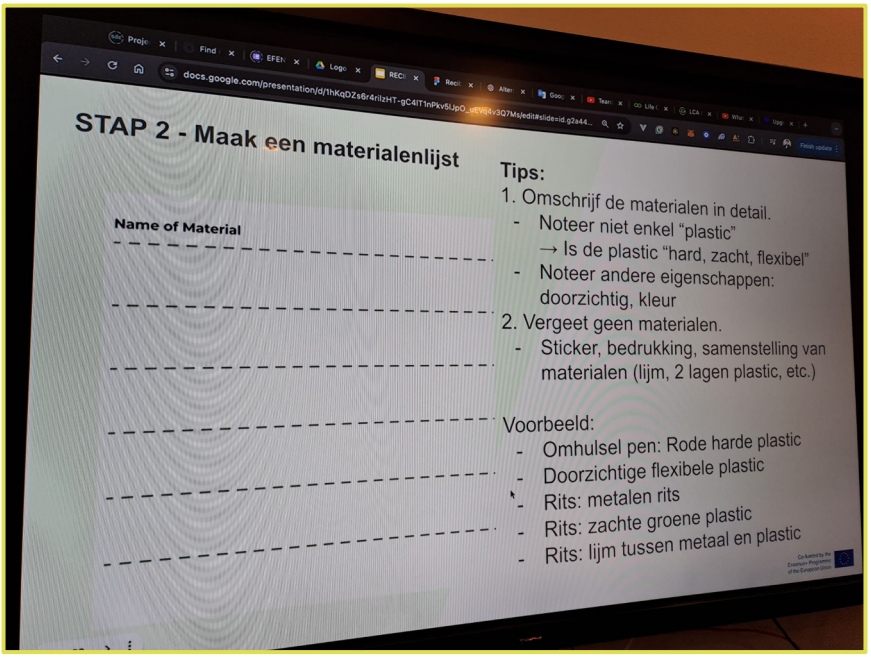


Figure. *Presentation of Step 2 to the students from Belgium*

Material properties describe how a material reacts or behaves in certain conditions, for example, how flexible, tough, or water-resistant it is.

These properties matter in product design. For example:

If students are redesigning the cover of an umbrella, they need to understand that the material should be:

- Water resistant
- Tear-resistant
- Flexible

The better students understand these properties, the more informed and creative their design choices will be.

It is advised that teachers share the following material properties list to students, in order for them to have more information about the next steps

Density – How heavy the material is for its size

Hardness – Resistance to scratching or indentation

Corrosion Resistance – Ability to resist rust or chemical damage

Plasticity / Ductility – How easily it can be shaped or stretched

Elasticity – How easily it returns to its original shape

Flexibility – How easily it bends without breaking

Transparency – How much light passes through

Water Absorption / Resistance – How much water it absorbs or repels

Roughness (Texture) – Smooth or textured surface

Toughness / Tear Resistance – Strength under impact or stretching

Brittleness – How easily it breaks or shatters

Melting Point – The temperature at which it melts

Thermal Expansion – How much it expands with heat

Electrical Conductivity – Ability to conduct electricity

Thermal Conductivity – Ability to conduct heat

Tensile / Compressive Strength – Resistance to pulling/ pushing

Fatigue Strength – Ability to withstand repeated use

Abrasion Resistance – Resistance to wearing down

Porosity – How many small holes it has (affects strength/water flow)

UV Resistance – Resistance to sunlight or UV degradation

** Tip for Teachers: Keep it simple. Students don't need to learn the science in depth. They only need to understand what the property means and why it matters in their chosen design.*

Optional Activity: Material Properties Quiz

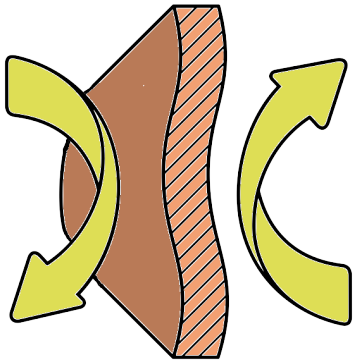
The following short multiple-choice quiz is designed to assess student understanding of key material properties after completing Step 2 of the Define Phase. It can be used:

- As a self-check activity after the class discussion or presentations

- To support consolidation and reinforce new terminology

- As a fun way to encourage students to apply what they've learned

The quiz uses real-life product examples to test students' ability to connect properties with functionality, helping them build confidence in analyzing and selecting materials. You can review the quiz together as a group, ask students to complete it individually, or even set it as a game or team challenge.



Material Properties Quiz

1. Which property measures the amount of matter in a material per unit volume?
A) Hardness
B) Density
C) Elasticity
D) Flexibility

2. Which property describes how a material returns to its original shape after stretching or compression?
A) Plasticity
B) Elasticity
C) Roughness
D) Brittleness

3. Imagine you are designing a glass window. Which property is most important?
A) Transparency
B) Water absorption
C) Thermal expansion
D) UV resistance

4. What happens to a material with low fatigue strength when exposed to repeated pressure?
A) It melts
B) It breaks or weakens over time
C) It conducts electricity
D) It stays the same

5. Which material is most likely to be brittle?
A) Glass
B) Rubber
C) Wood
D) Fabric

6. You are choosing a material that should not break easily when hit or dropped. Which property is most useful?
A) Transparency
B) Elasticity
C) Brittleness
D) Toughness

7. Which material has the lowest melting point?
A) Paper
B) Aluminum
C) Ceramic
D) Plastic

8. Which material is most likely to expand a lot when heated?
A) Wood
B) Aluminum
C) Plastic
D) Metal

9. Which material would you use for a product exposed to sunlight for a long time?
A) Paper
B) Plastic
C) Glass
D) Metal

10. What is the best definition of brittleness?
A) The ability to bend without breaking
B) The tendency of a material to break easily
C) The resistance to scratching
D) The material's weight

11. Which material behaves both elastically and plastically depending on the pressure applied?
A) Thermoplastics
B) Elastomers
C) Thermosets
D) Metals

12. What happens to the density of a material when it is heated above its melting point?
A) It stays the same
B) It decreases
C) It increases
D) It depends on the material

Answers

1.B, 2.B, 3.A, 4.B, 5.A, 6.D, 7.D, 8.B, 9.C, 10.B, 11.B, 12.B

Step 3: Identify a Biomaterial Alternative

"Which sustainable material fits our product — and can we actually make it?"

This step invites students to combine imagination with evidence-based decision-making. After identifying which material properties are important for their redesigned object, students are now asked to explore real-world alternatives: biomaterials made from natural, regenerative sources, like starch, glycerin, seaweed, coffee grounds, or fruit peels.

By exploring the Materiom.org open-source library, students will see that a better material already exists or could be made with ingredients they may already find at home. The activity brings circularity to life in a tangible, creative way.

Activity Objectives

This step supports students to:

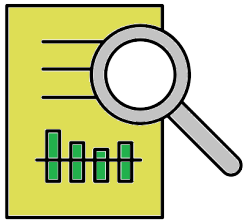
- Research and compare biomaterial recipes based on their design criteria

- Understand how ingredients and material properties are linked

- Evaluate how realistic it is to make the material within a school project

- Build teamwork, planning, and scientific reasoning skills

By the end of this step, students will not only have chosen a preferred material but will also know what it's made of, where to find the ingredients, and what they can try to make with it.



Biomaterial alternative activity instructions

1. Go to materiom.org and search for materials that seem promising based on your needs.
Use filters or keywords like biodegradable, flexible, strong, waterproof, or transparent.

2. Review at least 2–3 materials and compare how well they match your material property checklist.

3. Choose one material that you think is the best option. Your group will prepare a plan to present this choice.

4. Fill in the provided Biomaterial Planning Form to explain why you chose this material and how you plan to collect the ingredients.

Biomaterial Planning Form

Use one form per material (students may submit up to 3).

1. Team Name:
✎ Write your team's name.

2. Name of Selected Biomaterial:
✎ Enter the name used on Materiom.

3. URL of the Recipe on Materiom:
✎ Copy the direct link for easy reference.

4. Ingredient 1 – What is it, and how will you collect it?
✎ Example: Cornstarch – ask students to bring from home.

5. Ingredient 2 – What is it, and how will you collect it?
✎ Example: Vinegar – bring a small bottle from home or borrow from school kitchen.

6. Ingredient 3 – What is it, and how will you collect it?
✎ Example: Glycerin – ask science teacher if it's available in the lab.

7. What 3 sample objects would you like to try creating with this material?

Evaluation Criteria

Help students decide by guiding them through three key criteria. Encourage open reflection and let them justify their choices.

1. Properties (Functionality):
Can this material do the job we need it to do?
→ Is it strong, flexible, waterproof, etc.?

2. Availability (Can we find the ingredients?):
Can we access the raw materials? Are they safe, common, and cost-effective?
→ Can students bring some from home? Can the school help source the rest?

3. Feasibility (Can we make it in class?):
Is the recipe simple enough for a classroom?
→ What tools, equipment, or space do we need? Will it dry or cure in time?

These criteria make it easier for teachers to assess proposals and help students prioritize sustainable, realistic choices.

<u>This activity supports the development of:</u>

Systems thinking: understanding how ingredients, materials, design, and function interact

Teamwork and planning: each group prepares a mini-proposal for their material

Ownership and creativity: students choose what they will create, using their own research and reasoning

<u>You can use this step to:</u>

- Collect student choices via printed forms (although it is not suggested as we want to minimize printed material during classroom activities) or a shared Google Form

- Plan material sourcing for the Make Phase

- Group students by preferred materials to reduce duplication or allow for comparison

** You may encourage students to explore more than one option and select a Top 3 shortlist. This will give them a chance to compare, and you'll have backup options in case some ingredients aren't available.*

By the end of this step, each group should have a well-justified, feasible material ready for testing, and a sense of excitement about what they'll make next!



Figure: *Eggshells collected by students of LAPPEION for their preparation for the Make Phase*

Step 4: Assess Feasibility

"Can we really make this in the classroom?"

The final step of the DEFINE Phase is about making a realistic and informed decision. After identifying and evaluating different biomaterial options, students now assess which one is actually feasible to produce and use in their classroom context.

This is not about choosing the "*perfect*" material, but the one that best balances creativity, functionality, and practicality. It's a chance for students to reflect, organize, and prepare in order to enter enter the Make Phase confident and well-equipped.

What Feasibility Means for Students

Students are invited to review their chosen material(s) using three guiding questions:

1. Is it technically possible?
Can we realistically produce it with the tools, time, and space available in our classroom?

2. Are the ingredients accessible?
Can we collect or bring all the raw materials in time for the next phase?

3. Is the material suitable for what we want to make?
Will it work well for our chosen object (e.g. shapeable, strong enough, not too fragile)?

Teacher Tips: Supporting Student Decisions

Encourage teams to:

- Revisit their worksheet from Step 3

- Discuss any limitations or risks (e.g., drying time, equipment needed, safety concerns)

- Choose one final material they are confident about

- Share their decision with a short justification in writing or orally

"We chose this material because it's strong and easy to shape. The ingredients are simple and we think we can test it with basic classroom tools."

As a teacher, you may also:

- Group students who selected the same or similar materials

- Help them coordinate ingredient collection (especially bulk ingredients)

- Suggest slight modifications to recipes or object ideas, if needed

Optional Final Feasibility Checklist: Ask students to confirm:

- We have chosen one material to test

- We understand the steps to prepare it

- We know where to find all the ingredients

- We have selected 1–3 small objects we will try to make

- We feel confident this is possible in class!

By the end of Step 4, every group should have:

- ✓ Selected one bio-based material recipe
- ✓ Planned how to collect the ingredients
- ✓ Prepared a short list of items they want to create
- ✓ Confirmed that the making process is safe and realistic

This will set the stage for the Make Phase, where ideas are finally brought to life!

WRAPPING UP THE DEFINE PHASE



From ideas to action: Getting ready to make!

As the DEFINE Phase comes to a close, students have taken significant steps toward becoming sustainable designers. They have explored the material world through the lens of bioeconomy and circular thinking, and have built the skills to make thoughtful, informed choices about the materials we use every day.

This phase was not just about learning facts — it was about evaluating, prioritizing, and connecting values to decisions. Students reflected on the environmental impact of conventional materials, learned how material properties influence performance, and discovered the wide possibilities offered by bio-based alternatives.

By making their final selection, each group has now built a bridge between their initial investigation and real-world action. They are ready to take their ideas forward into the Make Phase, where creativity meets experimentation.

What Students Have Achieved. During the DEFINE Phase, students:

- Identified and analyzed the properties of everyday materials

- Explored alternative materials using Materiom.org

- Evaluated the sustainability, functionality, and feasibility of biomaterials

- Collaborated on planning, decision-making, and documentation

- Selected one final material and object for prototyping

These skills mirror real-world innovation processes and help students understand how science, design, and sustainability intersect.

Ideas for Classroom Reflection and Group Discussion

To wrap up this phase meaningfully, you may invite students to reflect and share through open conversation or written journaling:

- What surprised you most about the materials you explored?

- What made it difficult to choose just one material?

- How did your thinking change during this phase?

- What are you most excited or unsure about as we move into the Make Phase?

This helps solidify learning and creates a sense of anticipation for what comes next.

Preparing for the Next Phase

Before moving on, make sure each group has:

- ✓ Submitted or reviewed their final biomaterial selection
- ✓ Shared their ingredient sourcing plan
- ✓ Listed the object(s) they plan to create
- ✓ Identified any support or tools they might need

This will allow you to prepare materials and organize the classroom environment for a hands-on and joyful Make Phase.



Figure: *New biomaterials are being dried inside school during the RECIBIOS implementation*

3.

Make Phase

Hands-on experimentation with materials inside classroom, application of what students learned during previous steps, clear understanding of how bioeconomy can solve real-world challenges

Preamble to the Make Phase

The Make Phase is where ideas come to life. After investigating everyday products, analyzing materials, and selecting the most promising bio-based alternatives, students now take the next step: transforming research into real prototypes.

This phase is hands-on, creative, and full of exploration. Students are invited to experiment with natural materials, apply the knowledge gained in the previous phases, and explore how design choices influence the shape, texture, strength, and sustainability of a product. Whether it's cooking up a batch of bioplastic, molding a container from starch and vinegar, or crafting a natural coating from leftover peels, the Make Phase is all about learning by doing.

At its core, this phase encourages students to:

- Test and evaluate the bio-based material they selected

- Create simple, functional prototypes

- Observe how materials behave, and reflect on what works and what needs improvement

- Collaborate, troubleshoot, and adapt as they go

This is also a phase where failure becomes part of learning, or as we like to call it *Safe Place to Fail*. Some materials might break, not dry fast enough, or turn out differently than expected. And that's okay! Students learn to embrace iteration, take notes, and reimagine their process, just like real-world designers and innovators.

It's a space where science meets creativity, where the classroom becomes a mini-lab or makerspace, and where sustainability is not just an idea, it's something you can shape with your hands.

Learning Outcomes:

- Prepare and produce a bio-based material using natural ingredients and basic tools

- Apply safety, hygiene, and collaboration practices during experimentation



- Observe and record the behavior of materials (e.g., texture, drying time, durability)

- Build a simple prototype or product using a chosen biomaterial

- Reflect on material performance, usability, and limitations

- Begin thinking about improvements, adjustments, or new applications

Tools:

- A structured MAKE Phase worksheet or recipe sheet

- Guidelines for handling and preparing bio-based materials safely

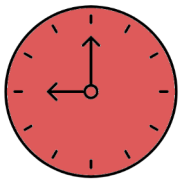


- Suggested tools and materials for basic classroom experiments

- Examples of classroom-friendly bioeconomy recipes (e.g., bioplastics, edible films, biodegradable composites)

- Optional media (videos, tutorials, or student examples) to inspire confidence and curiosity

Timing and Flexibility:



The timeline of the MAKE phase should remain flexible to support experimentation, problem-solving, and creativity. It can vary depending on the materials selected and classroom conditions, or time needed for shaping, drying and experimenting with materials inside classroom. We suggest spending around two to eight educational hours for this phase, as it is the most interesting one for the students where they experiment through hand-on activities!

Lesson Plan

Questions to spart reflection

Hands-on experimentation inside classroom

Reflection and assessment

Flexible timing according to the needs of the classrooom

Preparation of the classroom for hands-on experimentation

Before students begin mixing, molding, and making with their selected biomaterials, it's important that teachers prepare the classroom environment to support a safe, creative, and well-organized learning experience.

This phase involves real materials, ingredients, and experimentation, which means a bit of planning ahead can make a big difference in ensuring everything runs smoothly and safely.

Start by reviewing the materials chosen by students during the Define Phase:

Confirm the top 1–3 biomaterial alternatives selected by each group

Use the submitted biomaterial planning forms to identify:

- The required ingredients (e.g., starch, glycerin, vinegar, etc.)
- Any special needs (drying time, molds, stirring tools)
- The objects students plan to create

This review helps consolidate materials and avoid duplication — especially if many students selected similar recipes. In addition to student-selected materials from Materiom.org, the MAKE Phase may offer a set of recommended bioeconomy recipes for classroom use. Teachers are encouraged to review the equipment needed for each recipe, in order to have everything ready for classroom experimentation.

Once you know which materials and recipes will be tested, create a materials checklist and prepare the needed tools. These may include:

- Mixing bowls, spatulas, or spoons
- Measuring cups or digital scales

- Baking sheets, trays, or molds

- Gloves, aprons, baking paper, or reusable tablecloths

- Jars, containers, or cups for sorting or shaping

- Markers or masking tape for labeling student work

You may ask students to bring simple ingredients (like flour or starch) from home, while ensuring the rest are bought and stocked in advance.



Figure. *Preparation of the classroom during the pilot implementation of RECIBIOS*

Set Up the Classroom or School Lab

Whenever possible, consider using the school's science lab, home economics room, or an open, well-ventilated space that allows:

- Easy cleanup

- Safe use of heating tools (if needed)

- Group work with space for materials to dry or settle

<u>If the classroom is used:</u>

- Protect desks with plastic sheets or baking paper

- Create workstations per group, each with their ingredients and tools

- Assign drying areas (shelves or windowsills) for finished items



Figure. *Equipment used during the pilot implementation of RECIBIOS*

The Making Process of a Bio-based Material and Product

Step 1: Making the Biomaterial Mixture

Step 2: Manufacture the Biomaterial Product

Planning of the Making Process

“Think before you mix!”

Before diving into the hands-on creation process, it is essential that students take time to plan their experiment using the provided Biomaterial Making Planning Template. It is recommended to spend around 5 to 10 minutes for planning.

In the planning form, students are asked to:

- Name the material and object they will make
- List the ingredients and required quantities
- Identify tools and equipment they will need
- Describe the steps of their recipe or process
- Predict the time needed for mixing, shaping, and drying
- Highlight any safety notes or challenges they anticipate

This also helps you as a teacher check that measurements are reasonable, materials are safe and available, and the the group is aligned on what they are making and how.

** Before students start preparing their mixture, invite them to take a closer look at the recipe instructions, both from Materiom.org and the set of bioeconomy recipes provided in the ANNEX of this playbook. Advise them to read through their selected recipe(s) from Materiom carefully, compare their chosen recipe with the recommended classroom-tested versions, and think about why certain ingredients or steps are important (e.g., heating time, cooling process, proportions).*



The Making process of a bio-based material and product



Figure: *Students experimenting during the Making Phase*

From recipe to reality!

After planning and preparation, it's time to dive into the hands-on experimentation phase. In this step, students work in teams to prepare their selected bio-based material, test it, and begin shaping it into a usable product. This is where sustainability, creativity, and science come together in the most tangible way. This part of the Make Phase is often students' favorite. A chance to experiment, play, and learn through doing. Teams follow the recipes they explored on Materiom.org, or use the recommended bioeconomy recipes provided in this handbook, and adapt them based on availability, temperature, and tools.

Step-by-Step Guide for the Classroom



Figure*: Bioeconomy recipe implementation inside classroom*

Students should follow this simple 4-step making process:

1. Read the Recipe Carefully. Students start by reading through the selected recipe from Materiom or the handbook. They should check the measurements, understand the preparation steps, and clarify any doubts before proceeding.

2. Gather the Necessary Materials and Tools. Teams collect the ingredients and utensils they'll need. These may include mixing bowls, stirring sticks, measuring cups, hot plates, molds, baking trays, baking paper, etc.

3. Work in Teams to Create the Raw Material. In small groups (2–4 students), teams prepare the biomaterial by mixing, heating, or blending their selected ingredients, following the steps of the recipe.

4. Create Test Samples of Your Material. Before shaping the

final object, students are asked to create test samples — small portions (e.g., discs, squares, or thin sheets) of their mixture.

These will help them observe:

- Texture and consistency

- Drying or curing time

- Strength and flexibility after setting

- Potential improvements before making the final product

Let it Dry: Waiting, Watching, and Exploring the Outcome



Figure: *New materials inside classroom*

After pouring their mixtures into molds, students enter the final stage of patience and observation. Depending on the ingredients and thickness, some biomaterials may dry within a few hours while others may need several days or even more than a week to fully set and harden. It's important to label all molds clearly with group names and dates, and store them in a safe, ventilated space to dry undisturbed.

This period is an opportunity to build anticipation and curiosity: What will the final texture be like? Will it be flexible, strong, or fragile? Once the materials are fully dry, students can unmold, test, and explore their creations, noticing what worked, what surprised them, and what could be improved next time. Remind them: *even imperfect results are valuable discoveries in the world of bio-based design!*

Plan How to Use Your Biomaterial

"What part of your object could be made from your new material?"

Once students have created and tested their bio-based material samples, it's time to think like designers. In this step, they are asked to reflect on the properties of their material and reimagine how it could be used in the object they selected earlier in the process.

There are no right or wrong answers here. Only possibilities! Students will:

- Observe the texture, flexibility, strength, and surface of their dried samples

- Revisit the object they originally wanted to redesign (e.g. a bag, a pencil case, a phone stand)

- Think about which parts of the object could be made from their biomaterial

They should then mark or sketch these parts and describe why they chose them. For example: *"We think our material could replace the plastic bottom of a school pencil case, because it's rigid and has dried with a smooth surface."*

This phase encourages creative thinking, material awareness, and linking form to function, all while keeping sustainability at the center. Remind students:

- Every material has limitations but also new opportunities

- Focus on what the material can do, and adapt the product idea accordingly

- They don't need to redesign the whole object. Just one part is enough!

This step is a perfect setup for the final part of the MAKE Phase, where students begin shaping their finished prototypes.

Safety & Hygiene Guidelines

Creating responsibly in a clean, safe, and respectful classroom.

As students begin experimenting with bio-based materials and creating their prototypes, safety remains a top priority. While most of the ingredients and tools used in the MAKE Phase are non-toxic and classroom-safe, it is essential to establish and follow clear safety rules throughout the process.

This chapter serves as a practical guide to help students stay safe, protect the environment, and show care for their shared workspace and materials.

General Safety Guidelines

- Always wash hands before and after working with any ingredients or tools.

- Do not ingest or taste any material or ingredient. Even natural ingredients are for making, not eating!

- Use gloves or aprons when necessary to avoid skin contact or spills on clothing.

- Handle tools carefully, especially scissors, stirring utensils, hot surfaces, or mixing equipment.

- Ask before using anything you're unsure about, and never work alone without supervision.

- Label all materials and trays clearly with group names and date of creation.

- Clean your workspace after each session — wipe tables, wash utensils, and properly store materials.

Working with Heat or Hot Surfaces

If your recipe includes heating, cooking, or drying with devices such as hot plates, toasters, or ovens:

- Only use these tools under the supervision of a teacher or lab technician.

- Make sure there is adequate ventilation in the room.

- Use heat-resistant gloves or cloths if needed.

- Keep water, cords, and appliances away from the edges of the table to avoid spills or accidents.

Promoting a Culture of Care

Safety is not just about rules. It's also about respect:

- Respect the tools, the space, and the time we have together.

- Support your teammates and help each other stay safe.

- If you see something unsafe, speak up or tell your teacher.

**A safe learning space is one where everyone feels confident, supported, and free to explore. When students care for their materials and their environment, they also build habits of responsibility, sustainability, and empathy!*



Wrapping Up the Make Phase



From making to meaning: What did we learn through creation?

As the MAKE Phase comes to an end, students have moved beyond ideas and into action. They've taken part in a process that mirrors real-world experimentation: preparing raw materials, testing, observing, adapting, and ultimately creating a product from something they made themselves.

This phase wasn't only about crafting a final object. It was about exploration, trial and error, teamwork, and creative thinking. Students encountered the challenges of working with natural materials, saw how recipes respond to heat, moisture, or time, and made hands-on decisions about what works and what needs improvement.

They've experienced how sustainability isn't just a theory, but a practice, one that can be shaped, stirred, molded, and dried.

What Students Have Achieved

- Prepared a biomaterial recipe using natural ingredients

- Applied planning and teamwork to organize and conduct an experiment

- Created test samples and observed material behavior

- Produced a prototype or product using their chosen bio-based material

- Reflected on what worked, what didn't, and what could be improved

Through this experience, students gained not only scientific and technical insights, but also resilience, creativity, and confidence, essential skills in any sustainable innovation journey.

Ideas for Classroom Reflection and Group Discussion

Invite students to reflect individually or in groups using these

guiding questions:

- What was your favorite part of the making process?

- What was harder than you expected?

- Did your material behave as you predicted? Why or why not?

- If you could make this again, what would you change?

- What did you learn about sustainability through making?

You may also ask students to document their process with photos, journals, or short presentations, capturing not only the final product but also the path that led there.

Preparing for What Comes Next

Before wrapping up:

- Allow time for materials to fully dry and be tested

- Encourage teams to photograph or present their final objects

- Ask groups to evaluate their material (flexibility, strength, texture)

- Invite students to begin thinking about how to share or showcase their work with others

This creates a smooth transition into the RELEASE Phase, where students will communicate, exhibit, and reflect on their work as part of a growing community of young changemakers.

**You may search for addirional information, facts, and video tutorials for bioeconomy recipes in the RECIBIOS project resources. The recipes are inspired and licenced from materiom. org. However, your use of any information or materials listed on the recipes is entirely at your own risk, for which the partnership of RECIBIOS shall not be liable. It shall be your own responsibility to ensure that any the information of the recipes meet your specific requirements.*



Figure: *Students preparing for the Release Phase and the design of the new bio-products.*

4.

Release Phase

Reflection on the whole process, brainstorming on how to solve real-world sustainability challenges, thinking outside of the box and designing new bio-products.

Preamble to the Release Phase

The Release Phase is the final and most reflective step of the journey. After researching, experimenting, and creating their own bio-based materials and products, students are now invited to take a step back and imagine how their idea could exist in the real world.

This phase is about bringing everything together: creativity, sustainability, critical thinking, and design. It encourages students to think not only about what they created, but how it could be used, reused, shared, or transformed into something bigger. Here, students explore the idea of a circular business model, a sustainable system where products, materials, and ideas flow in loops instead of ending as waste.

In this phase, students shift from makers to circular thinkers and storytellers. They will reflect on their process, learn the basics of circular economy in a simple and engaging way, and begin designing how their product could live beyond the classroom, as part of a creative, regenerative system.

At its core, this phase encourages students to:

- Learn the fundamentals of circular economy and product life loops

- Explore how their product could be reused, collected, or transformed after use

- Imagine creative business or product service ideas that support sustainability

- Share their work through a final visual map or presentation

- Celebrate their learning journey and reflect on the impact of their ideas

The Release Phase gives students the opportunity to say:
“I didn’t just make something. I imagined how it could be part of a better future.”

Learning Outcomes:



- Understand basic principles of circular economy and product life cycles

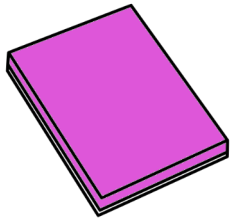
- Reflect on their material’s usability, reuse, and environmental potential

- Imagine and describe a circular business model for their product

- Present their ideas visually through a product map or simple business sketch

- Communicate their work with creativity and clarity Develop entrepreneurial and systems-thinking skills

Tools:



- Short introductory presentation on circular economy (adapted from Circionopoly or similar resources)

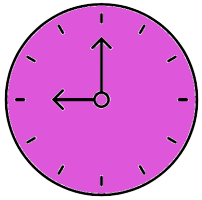
- A printable or sketched circular business model mapping template

- Optional examples of circular products and models for inspiration

- Space for students to present their ideas (posters, slides, short talks)

- Time for feedback, reflection, and celebration

Timing and Flexibility:



The Release Phase is designed to be completed within 1 to 2 educational hours, but can be expanded depending on student interest and time available. Some teachers may wish to combine this phase with a class exhibition, an open day, or digital storytelling activity. The main objective is to help students reflect, share, and feel proud of what they’ve created.

Lesson Plan

1st Educational hour

Questions to spart reflection

Learn what circular economy means

Learn how to design a circular business

Map the circular lifecycle of a product

2nd Educational hour

Reflection and assessment

Understanding the Circular Business Model

Designing systems where nothing goes to waste

In the final phase of your journey, students are invited to think beyond materials and products, and start imagining systems. The circular business model is a way of doing business that creates value without creating waste. Instead of the traditional linear model (make → use → throw away), a circular business thinks in loops: *how can a product or material be reused, repaired, shared, collected, or transformed again and again?*

In this chapter, students will explore some of the key building blocks of circular economy thinking, using playful examples adapted from real business strategies.

Core Elements of a Circular Business Model

1. Product Redesign. Reimagine the object to make it simpler, modular, or easier to repair or disassemble.

2. Sustainable Materials. Use bio-based, renewable, recycled, or low-impact materials instead of finite or polluting ones.

3. Extend Product Life. Offer repair services, replacement parts, or instructions so users can fix or maintain their items.

4. Take-back Systems. Set up return points or delivery systems so used items can come back and be reused or recycled.

5. Product-as-a-Service. Instead of selling the product, offer it as a service (e.g. leasing, renting, or sharing platforms).

6. Reuse and Second Life. Promote reuse through second-hand shops, resale platforms, or upcycling ideas.

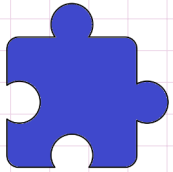
7. Smart Energy and Local Production. Use clean energy (like solar) and make products closer to where they’re used to lower emissions.

8. Design for Recovery. Make sure materials can be separated, recovered, and re-used after the product’s life ends.

Circular Business Card Game

Modular Design

Design your product so it can be taken apart, repaired, or upgraded easily. Replace one part instead of the whole thing!



Natural & Bio-based Materials

Use renewable, biodegradable materials like starch, mycelium, or food waste. Think bio-based, not plastic.



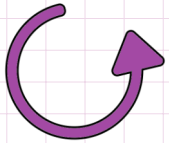
Repair & Maintenance



Include instructions or spare parts so users can fix the product themselves and extend its life.

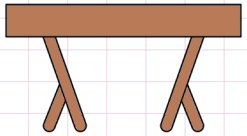
Take-Back System

Create a return system so your product comes back after use and can be reused or refilled.



Product-as-a-Service

Offer your product as a rental or subscription — not something to own and throw away.



Second Life & Upcycling

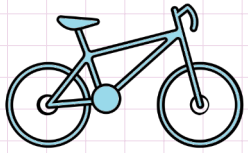


Can your product become something else when it's done? Give it a second life through creative reuse.

Release

Smart Delivery & Return

Deliver and collect products using clean energy or local distribution methods.



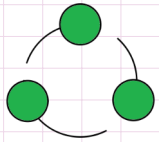
Local & Community-Made

Create your product using local knowledge, ingredients, or partnerships with your school or town.

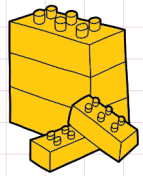


Reuse & Sharing

Set up a system for borrowing, sharing, or donating your product instead of buying new.



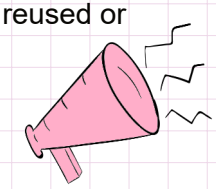
Design for Disassembly



Make sure parts and materials can be separated easily for recycling or composting after use.

Circular Storytelling

Add a label or QR code that tells users how the product was made and how it should be reused or returned.



Custom Circular Idea

Invent your own strategy! Think beyond the box and suggest a new circular solution for your product.



These cards introduce core circular economy strategies in a playful and inspiring way. Use them to guide students as they imagine how their product or material could become part of a sustainable business or system. Each card represents one idea they can include in their final circular business map.

Release

Circular Business Mapping Activity

This worksheet guides students through the process of imagining and sketching how their bio-based product could exist in the real world as part of a sustainable, circular business model.

Step 1: Name Your Business or Idea Give your circular product or business a name that captures its purpose, materials, or values.

Step 2: What Problem Are You Solving? Explain what waste, environmental issue, or user problem your product is trying to solve.

Step 3: What Is Your Product Made Of? Describe the materials and ingredients you used. Are they bio-based? Recycled? Local?

Step 4: How Will It Be Used? Who is your customer or user? How will they use it? Is it designed for everyday life, school, home, transport, etc.?

Release

Step 5: Circular Strategies (Choose 2–3 Cards) From the RECIBIOS Circular Innovation Cards, pick at least two ideas you want to include in your business model. Write them here and explain how you would apply them.

Idea 1:

How will you use it?

Idea 2:

How will you use it?

Step 6: Draw Your Circular Business Map Use the space below to sketch your circular system. Show how the product is made, used, reused, collected, repaired, or transformed. Get creative! Use arrows, icons, and labels to bring your idea to life.

Drawing space

Release

Circular Business Pitch

After mapping out their circular business model, students will now have the opportunity to present their idea to the class in a short, creative pitch. This activity gives students a chance to celebrate their progress, reflect on their journey, and practice real-world communication skills.

What is a Circular Pitch? A circular pitch is a short 2–3 minute presentation where students act as young innovators, explaining their product idea and how it fits into a sustainable, circular economy. They can pitch to their classmates as if they were speaking to future users, investors, or change-makers.

What to Include in the Pitch? Here are the suggested elements each team should cover in their presentation:

1. Product Name and Purpose
What is your product called? What problem does it solve?

2. Materials Used
What bio-based or sustainable materials did you use to make it?

3. How the Product Works
Who uses it and how?

4. Your Circular Strategies
Which ideas from the Circular Innovation Cards did you apply? How does your product stay in a circular loop?

5. Visual Aid
Use your business map, your prototype, or test material to show what you created.

6. What You Learned
Share one challenge you faced and one thing you are proud of.

(Optional) 7. A Slogan or Tagline
Create a fun or powerful message that communicates your product's purpose.

Purpose of the Pitch: The goal is not to be perfect. As we already written in a previous chapter, the purpose is to create *safe places to fail* and prepare students for the outside world. It's to show creative thinking, connect your idea to real-world problems, and practice presenting ideas with passion and clarity.

Teacher Tips

- Let students present in a relaxed and supportive atmosphere.

- Optionally, invite guest listeners (e.g. other teachers, school leaders, parents).

- Allow space for peer feedback or a classroom vote for the most creative, most circular, or most unexpected idea.

Celebrate every idea!

Wrapping Up the Release Phase

From creative ideas to circular futures

As the Release Phase comes to a close, students have completed a full learning journey, from exploring sustainability and materials, to making and testing prototypes, and finally imagining how their ideas could function in the real world. This phase invited students to dream big, think systemically, and communicate clearly. It brought together all of the project's core values: creativity, collaboration, sustainability, and action.

By designing their own circular business models, students have learned that sustainability doesn't stop at the product. It lives in how we use, reuse, share, and reimagine everything around us. They've also learned that even small ideas can be powerful when shared with purpose.

What Students Have Achieved During the Release Phase, students:

- Learned about the principles of circular economy and circular business models

- Used design thinking to develop ideas beyond the object or prototype

- Explored real-world strategies for repair, reuse, return, and circular storytelling

- Sketched and shared a circular business map

- Practiced public speaking through their pitch presentations

Reflection and Celebration To end this journey on a meaningful note, take time for open classroom discussion or journaling. Ask students:

- What did you enjoy most about the project?

- How did your thinking change from the beginning to the end?

- If you could improve one thing about your circular idea, what would it be?

- What's one thing you'd like to apply from this experience in your everyday life?

Optionally, invite students to give "eco-awards" for the most creative pitch, most inspiring reuse idea, or funniest moment in the Make Phase.

Final Message to Students

You are now part of a new generation of circular thinkers. You've imagined, made, tested, and shared. Most importantly, you've started thinking differently about how we design the future. Keep exploring, keep questioning, and never stop creating solutions that respect people and the planet.

The journey doesn't end here! It continues with every choice you make.



Figure: *Students experimenting with new materials inside classroom.*

Final Students Evaluation Form. Reflecting on the bioeconomy learning journey.

Now that you have completed the RECIBIOS project, we would love to hear about your experience. Please take a few minutes to answer the questions below. Your feedback will help us improve future activities and inspire even better learning adventures for other students like you!

1. How much did you enjoy the RECIBIOS project overall?

- ☐ A lot
- ☐ Quite a bit
- ☐ A little
- ☐ Not at all

2. How much did you learn about bioeconomy and circular economy?

- ☐ A lot
- ☐ Quite a bit
- ☐ A little
- ☐ Nothing new

3. Which phase did you enjoy the most?

- ☐ Preparation
- ☐ Understand
- ☐ Define
- ☐ Make
- ☐ Release

4. What was your favorite activity or experiment?

- -

- -

5. What was the most surprising or interesting thing you learned?

- -

- -

6. Do you feel more confident now about creating sustainable solutions?

- ☐ Yes
- ☐ Maybe
- ☐ Not sure
- ☐ No

7. Would you like to do more projects like this in the future?

- ☐ Yes
- ☐ Maybe
- ☐ Not really

8. What would you improve or change about the project?

- -

- -

9. Do you think your school should continue working on bioeconomy topics?

- ☐ Yes
- ☐ Not sure
- ☐ No

10. Any other thoughts, ideas, or feedback you'd like to share?

FINAL REMARKS

Dear Educators,

As you reach the end of this handbook, we want to thank you for your curiosity, openness, and dedication to bringing innovation and sustainability into your classroom. The RECIBIOS Playbook was designed to offer you inspiration, creativity, and practical tools, but it is not meant to be followed rigidly.

Each classroom is different. Each group of students brings its own energy, background knowledge, and rhythm of learning. That's why the entire learning pathway presented here can and should be adapted to your school's needs, timeframes, and local context. Whether you choose to implement the full program or select only a few activities from each phase, your creativity as a teacher is key to shaping a meaningful and fun experience.

We also recommend closing the learning journey by giving students the opportunity to reflect on their experience. You can do this through open discussion, creative journaling, or by inviting them to complete a short online questionnaire. This feedback will not only help students consolidate their learning but will also support you in improving future implementations of this project.

Let this not be the end, but the beginning of a new kind of learning where materials, systems, and sustainability are explored with wonder, hands-on experimentation, and purpose. You are planting the seeds of tomorrow's thinkers, innovators, and changemakers.

With warm regards,

The RECIBIOS Team


RHIZO
EduQuest.
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the European Union