TRAINING MANUAL

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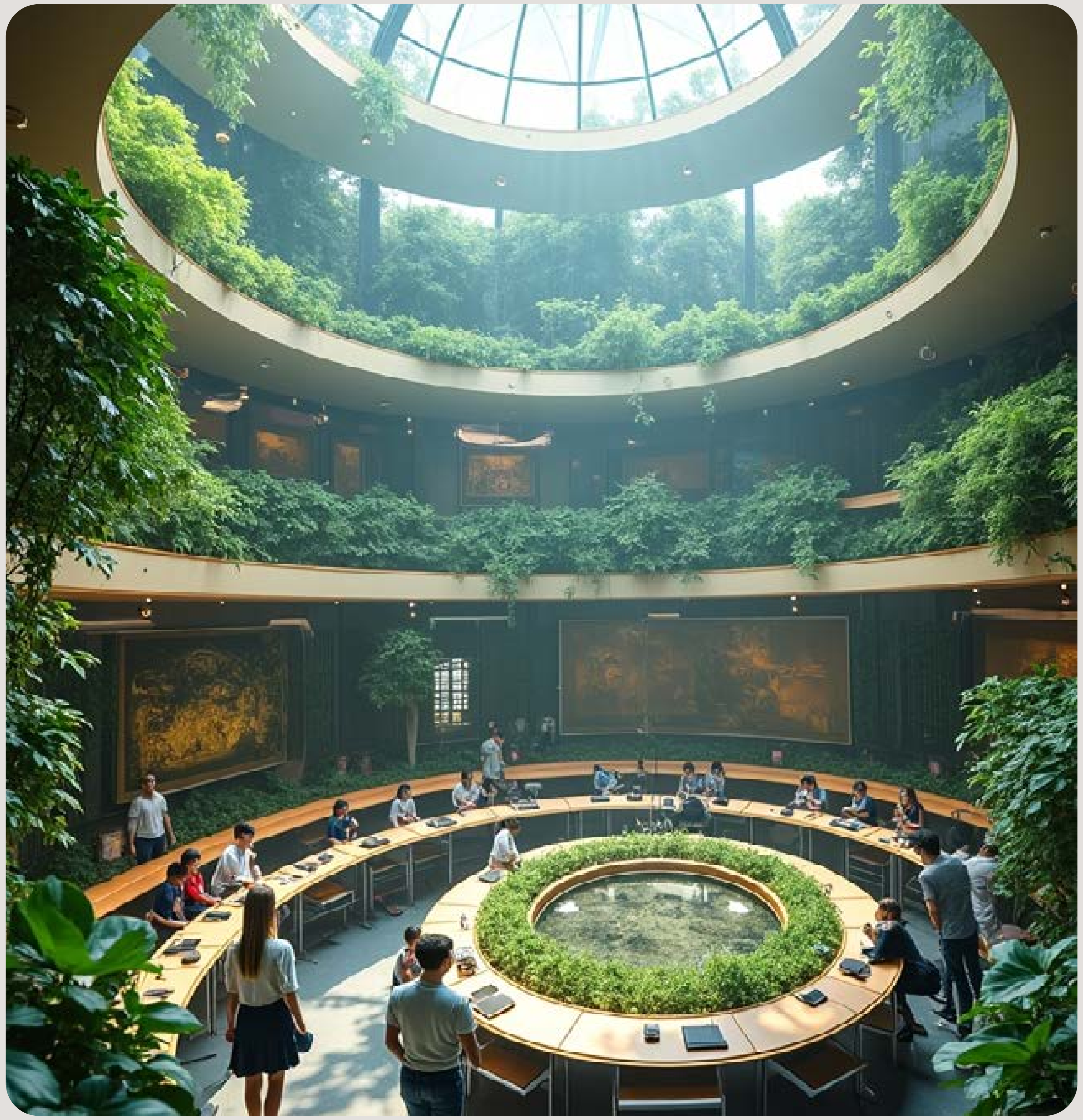

INTRODUCTION

Training Manual Purpose

The training manual serves as a guide on how to implement the Biodesign Modules and provides additional insights that would be beneficial for trainers implementing courses focusing on biodesign. In addition, the training manual is set up for educators to train themselves, in order to be able to implement the modules. This document accompanies the CoCoon Biodesign Modules (D3.4) and A Model of Student Curriculum (D3.3) where more details are provided on how to potentially structure a course on Biodesign for different levels of learners.

Target Group

The Training Manual is aimed at educators or professionals wanting to implement Biodesign courses in their educational programme or within their institution. The manual caters to trainers with varying levels of experience in Biodesign: from those with little knowledge on Biodesign, but eager to start integrating Biodesign concepts, to professionals who are already teaching Biodesign, who may want to expand their knowledge across the field. These professionals may include:

- Higher Education Teachers
- Vocational Education & Training Teachers
- Adult Learner Teachers
- Industry Ambassadors
- Lab Managers (e.g. Fab Lab Managers, studio managers)
- Professionals engaged in trainings

This is not aimed to be an exclusive list. The Training Manual is an open-source document for all trainers who are already in the field of Biodesign or wish to explore this field.

How to use the Training Manual

The Training Manual should be used as an accompanying document to the CoCoon Biodesign Modules and A Model of Student Curriculum. This manual serves as a guide for trainers. However, the modules or course structure should be adapted to meet the needs and requirements of the course or implementing institution. There is not one strict format on how to implement the CoCoon Modules, and therefore trainers have the creative freedom to adapt the learnings. It is important that before the trainers carry out the modules, that they have undertaken the modules themselves. This will allow trainers to identify any potential challenges or adaptations required before teaching.

The training manual is split into three parts. The first section "Guidelines for Teaching Biodesign" provides additional information for trainers with regards to health and safety, biosafety levels, bioFABLAB levels, organisational and equipment requirements and the role of the trainers. The second section focuses on "Methodologies for Teaching Biodesign", providing a general overview of approaches that have been used to develop the modules and methodologies for implementation. The final section "Training Curriculum" suggests approaches on how the modules could be used for training trainers.

It provides an overview of the modules in terms of learning objectives, output and skills and competencies acquired, as well as an overview of what can be done in certain timeframes. At the end of the document, a bibliography can be found with platforms focusing on biodesign with further educational resources.

GUIDELINES FOR TEACHING BIODESIGN

Given the nature of the modules, certain safety protocols should be followed, and certain equipment and tools will be required to carry out the modules. This section of the Training Manual summarises and outlines specific spatial requirements, tools, and equipment that will be required to carry out the modules. This should be used as a general overview. Always refer to the Biodesign Module for specific details and requirements.

Health and Safety

When undertaking the Biodesign Modules, it is imperative that both trainers and learners carefully follow health and safety protocols. While none of the modules exceed Biosafety Level 1, care should always be taken when working with living organisms, chemicals, machines etc. Specific health and safety requirements are outlined in each module; however, should the implementing institution have additional health and safety requirements, these too should be followed. Trainers must be well aware of the procedures and be able to implement any protocols, if necessary. Trainers should refer to their institutional, local, and national guidelines regarding health and safety requirements before undertaking the modules.

Why Health & Safety?

Health and safety guidelines are in place for a number of reasons, such as:

1-To protect individuals' health and well-being;

2-To protect individuals and the working environment from contamination or environmental harm;

3-To prevent accidents and injuries;

4-Ensuring the safe handling of organisms, chemicals, tools and equipment;

5-To comply with local, national, and international regulations.

Biosafety Levels

Awareness and understanding of the Biosafety Levels is very important when working with living or once living organisms. Biosafety aims at reducing the risk of exposure and contamination from potentially harmful organisms. There are four defined Biosafety Levels (BSL) that are outlined below. None of the CoCoon modules exceed BSL-1; however, one should always take care when working with living organisms. It is important that all trainers are aware of the biosafety levels and implement the relevant protocols. A suggested reading is the World Health Organization's *Laboratory Biosafety Manual* for further information on space requirements and personal protective equipment.

Biosafety Level[1]	Brief Description
BSL-1	The organisms you are working with are not known to cause disease and are recognised to have minimal potential hazards to those working with the organism and the environment. Standard laboratory practices should be followed and personal protective equipment should be worn as needed. The lab should be separated by doors from other working areas.
BSL-2	BSL-2 builds upon BSL-1; however, the indigenous organisms used in this BSL can pose moderate hazards to humans and the environment. Diseases associated with these organisms range in severity. Access to the lab is restricted when working with the organisms and personal protective equipment must be worn. Methods for decontamination must be available and a biological safety cabinet must be used for aerosols or splashes that can cause infection.
BSL-3	BSL-3 builds upon BSL-2, but includes both indigenous and exotic organisms that can cause serious or potentially lethal disease through respiration. Access to the lab is restricted and controlled at all times, and personal protective equipment must be worn. All work takes place in a biological safety cabinet. Clean air must be brought into the lab and air cannot be recirculated. Access to the lab is through two sets of doors
BSL-4	BSL-4 builds upon BSL-3. It is the highest level of biological safety with very few laboratories around the world. These organisms are considered dangerous and exotic, and are usually fatal as they do not have treatments or vaccines. These labs are restricted and isolated with systems in place to supply and exhaust the air. Full protective equipment must be worn such as a full body, air supplied suit. Decontamination procedures must be in place, and humans must change clothes when entering and shower when exiting.

[1] *https://www.cdc.gov/training/quicklearns/biosafety/*

For work involving BSL-1 organisms, such as non-harmful bacteria, a sterile lab is not strictly necessary, but a clean and controlled workspace is essential. Trainers and learners can conduct these activities in a well-maintained studio or similar environment outside of a traditional laboratory, provided the space is organised and protocols are in place to minimise contamination and ensure safety. Ensure that surfaces are disinfected before and after work, and avoid areas where food is prepared or consumed. Additionally, restrict access to the workspace during experiments to avoid unintentional exposure or contamination of materials.

BioFABLAB Levels

The BioFABLAB Levels were defined in CoCoon to help innovators, designers, and makers understand the type of equipment required, but also the level of sterilisation needed to work with different organisms. For more detailed information on the BioFABLAB levels please refer to the *CoCoon Deliverable 2.3.*

The BioFABLAB Levels are summarised based on Deliverable 2.3 as follows:

Level	Description
1 - DIY Kitchen Lab	•Accessible and ideal for at-home biodesign projects. •Utilises everyday kitchen equipment and hand tools. **Safety:** Projects at this level do not require a biosafety classification, making them safe and easy to undertake in a home environment.
2 - BioFABLAB	•Access to digital fabrication tools like 3D printers and laser cutters. •Includes tools from biology classrooms. **Safety:** Projects often fall under biosafety level 1 (BSL-1) and require a basic understanding of biology or design, making them highly applicable for educational purposes and design innovation.
3 - Bio Research Lab	•Research-grade infrastructure for intricate experiments. •Controlled environmental conditions for working with microorganisms. **Safety:** Involves protocols that fall under biosafety level 1 (BSL-1) and higher, requiring precision equipment and high-level expertise.

Infrastructural Setup

The modules have been designed to be easily replicated. However, some of the modules require specific types of spaces to be able to complete the modules or access to specific equipment. This is particularly true for modules that work with living organisms that must be cultivated, grown or harvested, or those that require a high level of sterilisation. In this section, an overview has been provided of the spatial requirements and equipment needed for the different modules. Please refer to specific modules for more detailed information and a full list of requirements.

The Space

The matrix below outlines particular spatial requirements for each module and outlines typically what type of bioFABLAB the module is undertaken in.

	Spatial Requirements			bioFABLAB Levels		
MODULE (Below)	**Work Bench**	**Cultivation Area – Garden**	**Sterile Workspace**	**DIY Kitchen Lab**	**BioFABLAB**	**Bio Research Lab**
SCOBY Biomaterial	x	x		x		
Plant Dyes and Pigments	x			x		
Cyanobacteria - Anthotype	x	x		x		
Pits & Peels - Food Waste Biomaterials	x		x	x		
Pods - Food Waste Biomaterials	x		x	x		
Bio Foam	x			x		
Mycelium Composite	x	x	x	x	x	
Mycelium Leather	x	x		x	x	
Yeastogram	x	x		x	x	
Root Textile	x	x		x	x	
Plant Biophotovoltaics	x	x		x	x	
Supernutrient Bricks	x	x	x	x	x	
Bioluminescent Light in a Bottle	x	x		x	x	
Form-Casting Biomineralised Material	x	x	x		x	x
Creative Hydroseeding	x	x		x		

Tools & Equipment

The matrix below outlines very specific equipment or tools required for the completion of the modules that may not be found in every lab or classroom. It is important that trainers can acquire access to these tools and equipment to ensure the successful completion of the modules. In some cases modules could be adapted or can be tested to find alternative methods. For a detailed and complete list of tools, equipment and materials required, please directly refer to the specific CoCoon Module.

	Specific Tools/Equipment						
MODULE (Below)	**Digital Fabrication Machines**	**Oven**	**Autoclave / Pressure Cooker**	**Hot Plate / Stove**	**Bunsen Burner/ Flame**	**Incubator**	**Pumps / Sprays**
SCOBY Biomaterial	Optional	Optional		Required		Optional	
Plant Dyes and Pigments	Optional			Required			
Cyanobacteria - Anthotype	Optional					Optional (if growing live culture)	Air Pump Required (if growing live culture)
Pits & Peels - Food Waste Biomaterials	Optional	Optional		Required			
Pods - Food Waste Biomaterials	Optional	Optional		Required			
Bio Foam	Optional	Optional		Optional			
Mycelium Composite	Optional	Required	Required		Required	Optional	
Mycelium Leather	Optional	Required	Required	Optional	Required	Optional	
Yeastogram	Optional		Optional	Required			
Plant Biophotovoltaics	Optional						
Root Textile	Required	Optional					
Supernutrient Bricks	Optional	Required	Required	Optional	Optional		
Bioluminescent Light in a Bottle	Optional		Optional		Optional		
Form-Casting Biomineralised Material	Required		Required		Optional	Required	Air Pump Required
Creative Hydroseeding							Hydro-seeding Spray Pump

Trainers Role

The role of the trainer will vary depending on the implementing institution or the nature/level of the learners in question. The modules are designed to be followed directly by the learners themselves, under little to no supervision depending on the nature/level of the learners.

The role of the trainer may include, but is not limited to:

- Facilitating the transfer of knowledge. In addition to the practical activity of the modules, trainers should have a theoretical understanding of the processes to be able to further explain the processes occurring in the modules to their learners.
- Guiding learners through the modules while fostering critical thinking skills and creative skills. Learners should feel empowered to undertake the modules and implement them.
- Making sure that health and safety protocols are being followed. This includes health and safety procedures outlined in the module, in the institutional guidelines and national/international guidelines.
- Providing hands on training.
- Evaluating and providing feedback to learners. As a trainer, providing feedback and evaluating the development of the prototype will help the learners to reflect critically on the work they have done.
- Trainers are not present to micromanage each step of the modules. Learners should learn by doing - facing challenges, problem solving and overcoming them.
- To develop a curriculum that fits the needs of the learners and the institution. In Deliverable 3.3, trainers can learn more on how to build a curriculum for their learners depending on the level of education.

Notes on Module Implementation

Trainers should try and test the module before giving them to the learners. This allows trainers to troubleshoot any issues that may arise or to adapt the module to fit their requirements, space and equipment.
It is foreseen that trainers will provide additional theoretical input in relation to the module. It is important to adapt the content to fit the level of the learners.

METHODOLOGIES FOR TEACHING BIODESIGN

In this section, one can find overviews of the methodologies identified for the implementation of the Biodesign Modules. The modules have been developed using the methodologies of learning by doing and procedural instructions as baselines, to allow those with little to no experience in biodesign to develop new interests and skills. Additional methodologies have also been identified for the implementation of the modules. This is not aimed to be an exclusive list. As stated before, the structure and any adaptations should meet the needs and requirements of the course or implementing institution.

Learning by Doing

Learning by doing is a methodology that focuses on a hands-on approach to learning - experiential learning. Rather than learners sitting in a lecture, they will take an active approach to learning, conducting experiments, critically reflecting on the processes they have been through and learning from their mistakes. Learners are encouraged to actively be involved in their learning process, finding solutions to their problems, suggesting new approaches, etc. Simultaneously, learners will acquire knowledge while developing practical and digital skills.

Each module focuses on the methodology of learning by doing, as learners initially follow the step by step procedural instructions, actively taking part in experimentation to learn about certain biological concepts. Once they understand the basic principles of the modules, learners can iterate, modify and adapt recipes and procedures based on their design intentions, challenges or successes. Learners are encouraged to think beyond the module; hence the final chapter of each module focuses on inspiration and future possibilities. The module acts as a starting point for the learner to introduce themselves to different organisms or biological concepts.

The starting point for learning by doing may vary depending on the expected output or goals of the learning. Below are some methods selected by the CoCoon consortium as possible starting points for introducing the modules to learners and triggering their hands-on approach to learning.

Problem-based Learning

Problem-based learning is a method whereby learners are given real-world problems to address or solve with the output being a solution to the problem. This allows learners to engage with issues beyond the classroom and improves teamwork as they often work in groups. The skills acquired are transferable to many fields and most importantly beyond the classroom walls. Key skills to be developed include problem solving skills and critical thinking skills.

Module Example:
Problem: Textile waste has become a huge global problem due to the mass production of synthetic fabrics to keep up with the demands of fast fashion. Modules that could start to address this problem include the mycelium leather and root textiles.

Inquiry-based Learning

Inquiry-based learning capitalises on the curiosity of learners where students are encouraged to ask and formulate good questions. Learners should be able to define what information or resources they require to address their question, evaluate their work and learnings and share (Queen's University, 2024).

Module Example:
Inquiry: To what extent can bacterial biomineralisation be scaled up?
The learners could start with the module Form-Casting Biomineralised Material, and as they achieve success and understand the process, they can begin to explore how to address the question.

Exploratory Learning

Exploratory learning is an approach to learning that encourages learners to explore and understand relationships through the exploration of environments. Skills that will be developed include observation and communicative skills (Freitas & Neumann, 2009).

Module Example:
Exploration: To understand how mycelium behaves and grows, and apply this to design.
The learner could begin by observing mushrooms in their environment, understanding the behaviour of the mushroom and mycelium. For example, observing how long it takes for the mushroom to fruit and under what conditions. Learners may then want to set up a similar environment and work with the modules Mycelium Composite or Supernutrient Bricks after understanding humidity and light requirements.

Phenomenon-based Learning

Phenomenon-based learning (PhBL) is an educational approach that centers on exploring real-world phenomena through interdisciplinary study. Instead of compartmentalising knowledge into traditional subjects, PhBL encourages students to investigate topics holistically, integrating insights from various disciplines to understand complex issues comprehensively (Silander, 2019). Learners are encouraged to wonder why things are happening, that leads them to making hands-on projects, observing, exploring, gathering data and interpreting the data. This active engagement gives the learner an opportunity to make connections to prior knowledge, develops communication, collaboration and creative thinking skills.

Module Example:
Phenomenon: Glowing organisms lighting up the seas.
Starting with the phenomenon, the learners could explore why the organisms are glowing and utilise the Bioluminescent Light in a Bottle module to further explore the phenomenon. Learners could be encouraged to observe and monitor the process, collecting data that then could be applied to a design solution.

Project-based Learning

Project-based learning allows students to construct hands-on prototypes to solve a problem. The final output demonstrates that the students have understood the content. Often the process begins by identifying a problem and agreeing on a solution. The project focuses on the development and refinement of the prototype (Boston University, 2024). This is where the students will demonstrate their understanding of the content.

Module Example:
Project: To develop a series of bioceramics games utilising food waste.
Learners could start with the modules Pits & Peels - Food Waste Biomaterials and Pods - Food Waste Biomaterials, exploring different recipes, and then develop a recipe for a particular type of food waste. Once the recipe is refined, the idea can be prototyped and refined.

Procedural Instructions

As explained by Elsa Eiriksdottir and Richard Catrambone (2011) in their paper "Procedural Instructions, Principles, and Examples: How to Structure Instructions for Procedural Tasks to Enhance Performance, Learning, and Transfer", procedural instructions are a series of steps outlining the way in which a task could be completed. They are often accompanied by principles - rules to follow, and/or examples of how the task will be carried out. The intention is for all the steps to be read before starting to give a clear picture of the task. The instructions are usually split into two approaches. The first being specific instructions, aimed at helping the initial performance, in the modules case, someone who has never worked with an organism or is new to the field. The second is general instructions aimed at promoting problem solving and the transfer of knowledge.
The Biodesign Modules have been developed by utilising specific instructions for the procedural steps. In addition, principles have been outlined throughout the module to help guide the prototype development.

A particular example of working with the selected organism further helps to elaborate the procedural steps in the CoCoon Biodesign Modules.

Module Example:
The learner decides to go on the path of exploratory learning and wants to explore and understand how mycelium behaves and grows. By applying and following the procedural step-by-step instructions in the CoCoon Mycelium Modules, the learner can start the progress of their exploratory learning and proceed with their independent exploration.

BIOMODULES PEDAGOGICAL CURRICULUM FOR TEACHERS | EDUCATORS

Mission Statement

The Biomodules Pedagogical Curriculum for Teachers | Educators is not intended to be a fixed for trainers, rather it provides an overview of what is covered in the modules and what a trainer would get out of undertaking the different Biodesign Modules. Following the module overviews is an overview of time, giving insights how trainers can train themselves given the time they have available. Trainers can decide to focus on one module or one organism, or decide to train themselves with multiple organisms and modules. This decision must be taken by the trainer depending on interests, time available as well as access to resources and equipment.

General Learning Objectives

•To introduce trainers to approaches of working with living and nonliving organisms in the field of Biodesign.
•To introduce and understand biological concepts through a practical activity.
•To be able to reflect and replicate or adapt the modules to the trainers requirements and/or limitations.
•To teach the biodesign concepts to learners, whether students or professionals.

General Skills to be Acquired

•Problem solving skills
•Critical thinking and reflection skills
•Practical skills - fabrication and (bio)design
•Creative thinking and artistic expression.

Module Matrix

The module matrix provides an overview of the Biodesign Modules to help trainers understand the output as well as the topics covered, expected learning outcomes and skills or competencies that will be acquired. When selecting the modules the overviews below should be cross checked with the organisational setup to ensure the trainers have access to the correct facilities and equipment.

SCOBY Biomaterial Module 1	**Time: 2-3 weeks**
Expected Learning Outcomes	•To be able to set-up, grow, and care for SCOBY culture through DIY means. •To understand and manipulate environmental conditions to achieve design outcomes. •To reflect on the agency of the non-human organism in creative processes.
Topic(s) Covered	•Setting-up DIY growing conditions for SCOBY. •Biological mechanisms of SCOBY growth. •Further exploration & application possibilities.
Expected Output	•A grown SCOBY biomaterial.
Skills/Competencies to be Acquired	•Caring for a living organism to support growth. •DIY workarounds.

Plant Dyes & Pigments Module 2	Time: 4 days
Expected Learning Outcomes	•To be able to prepare fibres for dyeing using alum. •To extract colours from plants, and turn them into dyes and pigments. •To understand the role of pH in shifting colour profiles. • To apply natural colours within circular and local contexts.
Topic(s) Covered	•Science behind natural colour extraction. •Mordanting cotton fabric. •Creating a dye bath from plants. •Extracting pigment from leftover dye bath. •Application of natural colours on fabrics and other mediums.
Expected Output	•Plant-dyed cotton textile. •Grinded plant-based pigment.
Skills/Competencies to be Acquired	•Understanding local plant species and their colour properties. •Eco-awareness and care.

Cyanobacteria Anthotype Module 3	Time: 1 weeks
Expected Learning Outcomes	•To create a spirulina emulsion for coating paper and image exposure as a sustainable alternative to photochemical processes. •To understand how to cultivate a live spirulina subculture. •To understand ecological and biological systems involved in anthotype processes.
Topic(s) Covered	•Create a cyanobacteria emulsion. •Expose image using UV light. •Science of UV printing (anthotype). •Further exploration possibilities.
Expected Output	•Exposed anthotype prints.
Skills/Competencies to be Acquired	•Set-up of UV exposure system. •Caring for living organism.

Pits & Peels - Food Waste Biomaterials Module 4	**Time: 4 days**
Expected Learning Outcomes	•To be able to map and analyse local material resources and food waste. •To reflect on the material's life cycle. •To transform food waste into a biodegradable composite. •To learn about caring, as well as small and slow production.
Topic(s) Covered	•Social and natural ecosystems. •Circularity and the concept of waste/residues. •Various recipes for bioceramic development.
Expected Output	•A bioceramic.
Skills/Competencies to be Acquired	•Design and fabrication skills. •Eco-awareness.

Pods - Food Waste Biomaterials Module 5	**Time: 4 days**
Expected Learning Outcomes	•To be able to map and analyse local material resources and food waste. •To reflect on the material's life cycle. •To transform food waste into a biodegradable composite. •To learn about caring, as well as small and slow production.
Topic(s) Covered	•Social and natural ecosystems. •Circularity and the concept of waste/residues. •Various recipes for bioceramic development.
Expected Output	•A bioceramic.
Skills/Competencies to be Acquired	•Design and fabrication skills. •Eco-awareness.

Biofoam **Module 6**	**Time: 1 week**
Expected Learning Outcomes	•To be able to make a paper pulp that can be transformed into a biofoam.
Topic(s) Covered	•What is cellulose? •How to make and work with paper pulp. •Different recipes to achieve different foam structures
Expected Output	•Biofoam samples.
Skills/Competencies to be Acquired	•DIY skills. •Creative skills for utilising paper waste.

Mycelium Composite **Module 7**	**Time: 3 week**
Expected Learning Outcomes	•To understand how to utilise mycelium growth to create a biocomposite. To be able to make a mycelium growth bag.
Topic(s) Covered	•Working with mycelium. •Lab practices for mycelium.
Expected Output	•A mycelium composite object.
Skills/Competencies to be Acquired	•Caring for a living organism. •Setting up and working in a sterile environment.

Mycelium Leather **Module 8**	**Time: 1.5 months**
Expected Learning Outcomes	•To understand the process of turning mycelium into leather. •To be able to post process the mycelium to obtain leather-like properties.
Topic(s) Covered	•Working with mycelium. •How to make a selective growth medium. •Lab practices for mycelium.
Expected Output	•A piece of mycelium leather.
Skills/Competencies to be Acquired	•Caring for a living organism. •Setting up and working in a sterile environment.

Yeastogram **Module 9**	**Time: 3 days**
Expected Learning Outcomes	•To understand how yeast works and apply the properties of yeast to create art. •To make a selective growth medium, •To develop your own yeastogram.
Topic(s) Covered	•What is Yeast? •Growth mediums for yeast. •The process of photography. •Stencil making. •How to make a UV lightbox.
Expected Output	•Petridish Yeastogram.
Skills/Competencies to be Acquired	•Design and fabrication skills. •Integration of art and biology.

Plant Biophotovoltaics Module 10	**Time: 1 month +**
Expected Learning Outcomes	•To understand how to utilise a plant's natural processes to provide ecosystem services. •To be able to set up a biophotovoltaic system. •To be able to set up a biophotovoltaic circuit and power an LED.
Topic(s) Covered	•What is a biophotovoltaic system? •How to set up your biophotovoltaic system and power an LED. •Applications of biophotovoltaics.
Expected Output	•Plant pot with a functioning biophotovoltaic system.
Skills/Competencies to be Acquired	•Basic fabrication skills. •Setting up an electrical circuit.

Root Textiles Module 11	**Time: 1.5 weeks**
Expected Learning Outcomes	•To develop a biodegradable textile utilising the roots of plants. •To understand how the plants growth behaviours can be utilised in design, specifically the behaviour of root networks.
Topic(s) Covered	•Developing a mold and appropriate pattern for the textile. •How to grow the textile - substrates and conditions. •Suggestions on how to push the research forward.
Expected Output	•A grown root textile.
Skills/Competencies to be Acquired	•Design for digital fabrication. •Caring for a living organism.

Supernutrient Bricks Module 12	Time: 1-2 months
Expected Learning Outcomes	•To understand the mushroom life cycle. •To be able to extract multiple ecosystem services from the life cycle of the mushroom - food and a biomaterial.
Topic(s) Covered	•Wnoculating your own medium. •How to fruit mushrooms. •Possibilities of mycelium in architecture and construction.
Expected Output	•A Lego-like mycelium brick.
Skills/Competencies to be Acquired	•Basic (digital) fabrication skills. •Caring for a living organism. •Setting up and working in a sterile environment.

Bioluminescent Light in a Bottle Module 13	Time: 6 days
Expected Learning Outcomes	•To understand the biology of Pyrocystis fusiformis and its bioluminescent properties. •How to create and maintain growth media for bioluminescent algae. •Optimise growth conditions for sustained bioluminescence.
Topic(s) Covered	•Dinoflagellate biology and bioluminescence mechanisms. •Growth media preparation and maintenance. •Optimal environmental conditions for algae growth.
Expected Output	•A living light in a bottle.
Skills/Competencies to be Acquired	•Caring for a living organism. •Media preparation and feeding strategies. •Optimisation of light and temperature conditions for growth.

Form-Casting Biomineralised Material Module 14	Time: 12 days
Expected Learning Outcomes	•To understand the principles of bacterial biomineralisation and its application in material production. •To learn how to cultivate Sporosarcina pasteurii and optimise growth conditions for urease activity. •Design and fabricate moulds for biomineralised material casting.
Topic(s) Covered	•Bacterial cultivation and growth conditions. •Biomineralisation principles and applications. •Preparation of nutrient and cementation media. •Design and fabrication of molds for microbial processes.
Expected Output	•A biomineralised panel or cast form.
Skills/Competencies to be Acquired	•Microbiological techniques for bacterial culture and media preparation. •Understanding of biomineralisation process. •Practical considerations in mould design and fabrication. •Handling and disposal of biological and chemical waste in compliance with safety protocols.

Creative Hydroseeding Module 15	Time: 0.5-1 year
Expected Learning Outcomes	•To understand plant growth rates and requirements. •To learn about native plant diversity and ecology. •To understand the strategies for environmental restoration.
Topic(s) Covered	•Opportunities for the landscape - land art to land restoration. •How to develop the slurry seed mixture from the seed selection to the glue development. •Plant biology.
Expected Output	•Organic glue development. •A slurry seed mixture for different surfaces.
Skills/Competencies to be Acquired	•Problem solving and interdisciplinary learning. •Caring for a living organism.

Structuring the Modules for Trainers

Following the **Model Student Curriculum Framework** outlined in Deliverable 3.3 Model Student Curriculum, the approach to learning follows the steps outlined below for professionals which can be applied for the trainers. Below are the suggested phases of learning, including how to utilise or integrate the modules.

Phase	Description	How to utilise the module
Active Experimentation	Professionals start with experimental projects that apply advanced biodesign concepts, such as developing a biodesign solution for a specific industry problem. Examples include using biofabrication techniques for sustainable packaging or creating bio-based electronics for environmental applications.	In the About section of the modules, either a specific problem is outlined or the context in which the module exploration is relevant. In addition, following the module through from start to finish will provide the foundations for understanding the biodesign concepts.
Concrete Experience	These experiments lead to tangible prototypes or solutions that are tested in real-world settings. Professionals may pilot their innovations in a commercial or industrial context, gathering performance data and user feedback.	Based on the modules, trainers can experiment through prototyping, and then test these prototypes for specific results. For example, the Supernutrient Brick might be adapted with different forms which then could to be tested for structural properties.
Reflective Observation	After testing, they assess the effectiveness of their designs, reflect on what improvements could be made, and consider how these solutions impact the ecosystem or meet sustainability goals.	At every stage of the learning from initial tests to more concrete prototypes and testing, it is important to reflect on the learnings and findings. In addition, critically reflecting on the larger context and impact is important.
Abstract Conceptualization	Based on these observations, they refine their understanding of biodesign principles and update their approach, contributing new insights and potentially influencing industry standards or biodesign practices	Based on the reflection, it is the trainers role to adapt the module as needed before implementing them with their students.

Time is an important factor to consider when training oneself, especially in the case of the modules working with living organisms. Living organisms always provide a level of unpredictability that must be taken into consideration when beginning to work with them. Below is an overview of what can be achieved in different timeframes, to help visualise the time required. Examples are provided in relation to the modules developed, but also suggestions for resources available online.

Timeframe	**What can be accomplished in the timeframe?**	**Utilising the CoCoon Biodesign Modules**
2 minutes	•Watch a short video online on biodesign concepts related to the selected module. •Sketch out a biodesign prototype concept.	Choose which module to complete
2 hours	•Read a paper(s) on relevant biodesign concepts. Check out the *CoCoon Deliverable 2.2* for a state of the art. •Investigate further certain biological concepts relevant to the selected module. •Watch online videos to enhance your biodesign knowledge. •Start detailing out your biodesign prototype.	Read through a module to understand the process. An introduction workshop into bioceramics.
2 days	•Conduct initial material tests. •Set up a prototype. •Gather materials, tools and equipment for conducting the biodesign modules.	Complete: Pits & Peels - Food Waste Biomaterials, Pods - Food Waste Biomaterials
2 weeks	•The majority of the CoCoon Modules can be completed in a two week period. •Deepen your understanding of biodesign processes through a practical activity. •Critically reflect on the methods and processes of the modules. •Conduct further research into theoretical biodesign principles.	Complete: Root Textiles, SCOBY Biomaterial, Cyanobacteria Anthotype, Yeastogram, Biofoam, Form - Casting Biomineralised Material, Bioluminescent Light in a Bottle
2 months	•Set up a series of tests for the prototypes. •Develop multiple prototypes by replicating the processes and maybe varying certain aspects. •Develop an application for biodesign research.	Complete: Supernutrient Bricks, Plant Biophotovoltaics, Mycelium Leather, Mycelium Composite. Monitor and collect data regarding living prototypes such as the Plant Biophotovoltaics Module.
2 semesters	•Knowledge-based for understanding biodesign. •Learning scenarios designed. Based on an overall learning project process to support a project-based learning challenge. •Set up a series of tests for the prototypes.	Complete: Supernutrient Bricks, Plant Biophotovoltaics, Mycelium Leather, Mycelium Composite. Monitor and collect data regarding living prototypes such as the Plant Biophotovoltaics Module.
2 years	•Develop a strong knowledge and understanding on biodesign. •Publish your work and findings in scientific papers. •Set up a new Biodesign Course.	Complete: Creative Hydroseeding Complete many iterations of the CoCoon Biodesign Modules, replicating and adapting to push forward the research.

Conclusion

This document serves as a guide and overview for the trainers who want to train themselves and/or implement the CoCoon Biodesign Modules with their learners. Further information to complement the implementation of the CoCoon Biodesign Modules is provided to summarise in one place key information for the trainers. The Training Curriculum allows trainers to pick and choose the modules that are most relevant for their own development training based on interest, skills to be developed or time available.

By combining this Training Manual with the D3.3 Student Model Curriculum and the CoCoon Biodesign Modules, trainers will not only be able to train themselves, but also set up a biodesign course for different levels of students. The goal is to encourage more exploration in the field of biodesign and to demonstrate that working with living and nonliving organisms does not always require a complex set up.

Bibliography

The bibliography provides a list of platforms for possible further reading for trainers in the field of biodesign and education who wish to grow their knowledge in biodesign.

Biodesigned: *https://www.biodesigned.org/*
Biocreative Index: *https://www.biocreativeindex.com/about*
Biodesign Academy: *https://www.biodesign.academy/*
Biodesign Challenge: *https://www.biodesignchallenge.org/resources*
Laboratory biosafety manual, 4th edition, 2021, by the World Health Organisation: *https://www.who.int/publications/i/item/9789240011311*

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