3ee

INSTRUCTIONS FOR FABRICATION

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3ee, is an **advanced biodiversity monitoring system that uses acoustic sensors to identify and classify pollinator species in the environment**. Our sensor is able to carefully detect surrounding **sounds, recording** and **analysing the frequencies** in order to accurately **identify the various pollinator species.**

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Distributed Design

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1. 3ee.

General Description

1.1 What is 3ee?

A perfect solution for monitoring the biodiversity

Our main focus comes from a not balanced food ecosystem caused by unbalanced biodiversity and its importance, which effects not just one kind but all living creatures.

3ee, is an **advanced biodiversity monitoring system that uses acoustic sensors to identify and classify pollinator species in the environment**. Our sensor is able to carefully detect surrounding **sounds, recording** and **analysing the frequencies** in order to accurately **identify the various pollinator species.** This innovative technology is integrated into a versatile **bughotel** that can be positioned in different areas. We provide a complete solution for understanding and conserving biodiversity.

System Overview: device and elements

The project involves the creation of a set of **sensors** within a structure that will form cavities to form the cells of our bug hotel. The creation of the niches to suit the tastes of the respective inhabitants will be managed by the frame of the structure, which will be separately fitted with **plugs** and filled with the necessary materials. The structure will have **frontal protection** against animals and a configuration that will encourage the **growth of moss**, helping to attract insects.

An innovative aspect of this design is the flexibility in the insertion of the different parts, which can be positioned according to the user's preferences. In addition, these components can also be integrated on existing monitoring structures, allowing only a part of the monitoring system in use to be expanded or improved.

1.2 Starting Point

A not balanced food ecosystem

Where there are bees there is no biodiversity. Our main focus comes from a not balanced food ecosystem caused by unbalanced biodiversity and its importance, which effects not just one kind but all living creatures.

Bees

Bees not only provide honey but are also irreplaceable as pollinators of many plants in agriculture, fruit growing and horticulture. (1) A high number of bees (Apis mellifera) deaths in the early 2000's led to an **uncontrolled increase** in bee populations due to misguided marketing and advertising and between 2011 and 2021 beehives number increased from 81.4 million to 101.6 million. (2?)

Environment

The current overpopulation of Apis mellifera poses numerous **risks to the environment** and, specifically, to thousands of other species pollinating insects with which western bees compete for the same resources. Wild bees to flowers ratio was four times higher than that of honey bees to flowers, and nowadays became the same.

In fact, apart from **honey bees** - the only group that feeds a **multi-billion dollar industry** and needs no help - there are over **20,000 species** of wild bees and other pollinator insects that are found and that are slowly decreasing. So this information leds us to monutor the situation of the system: the opportunity.

1.3 Opportunity

A balanced ecosystem

Coming from **'How to map and monitor?'** question in our minds, we identified an important elements on local dimention to be able to map the system and focus on that concept to focus more on micro and biodiversity.

It is **mapping the number of other insects,** in specific areas, with public values and approximations. We wanted to emphasise that it is not only large areas that are important, but also micro-areas, and we have taken into account the correct mapping of these regions and their inhabitants, mostly bees and insects.

2.How does the system work ?

2.1 The main characters of the system

The system for balanced ecosystem includes four main elements:

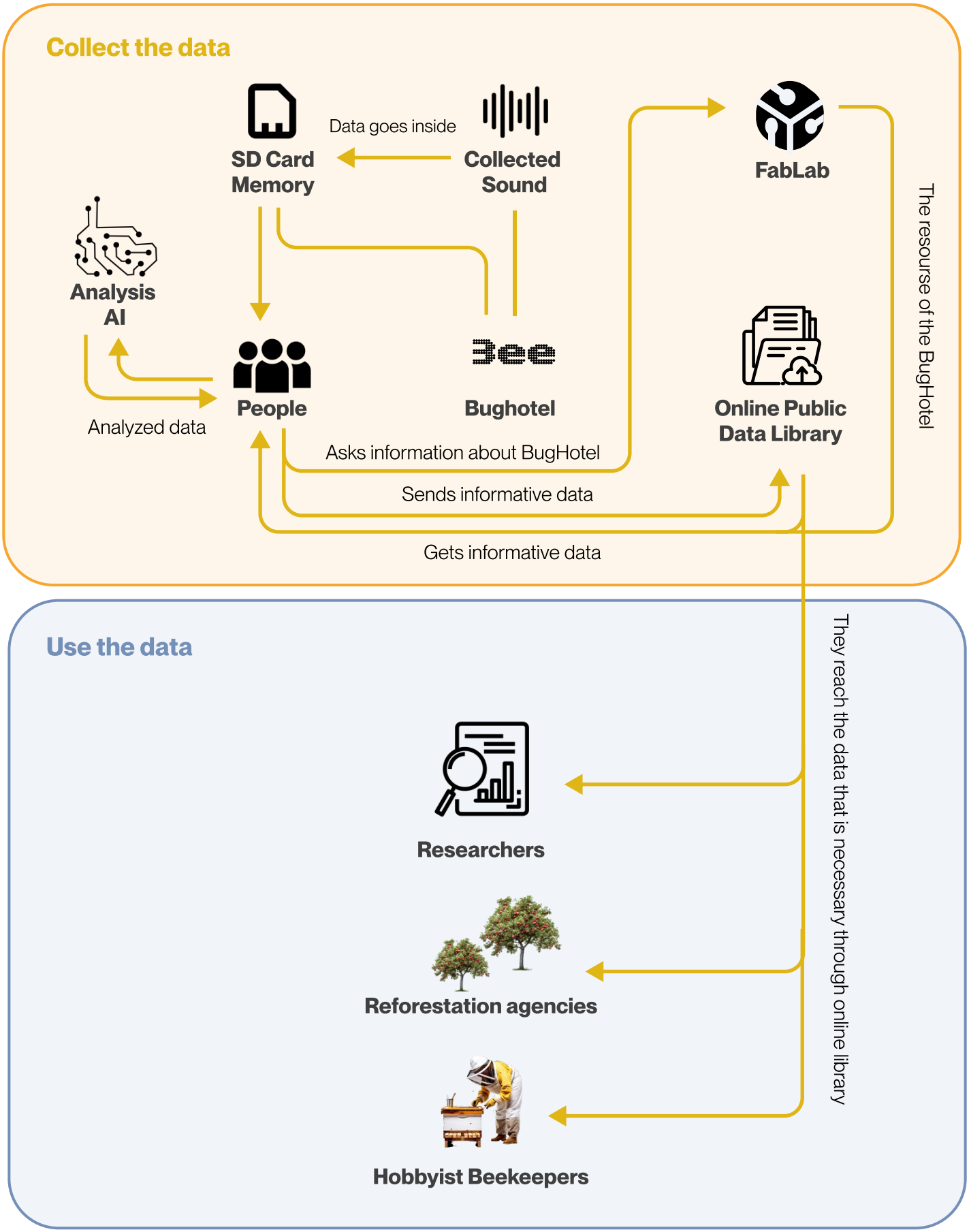
Hobbyist Beekeepers: Helping beekeepers on their personal projects on directly monitoring and producing honey indirectly at the same time which is a big opportunity thanks to the ready made/diy product that this project is suggesting.

People working in the gardening: As a personal hobby, an area is created for the protection and observation of insects including bees, which at the same time makes people's gardens fertile.

Local companies: Honey bees became also a kind of living trophy that companies wish to display, as a sort of **'greenwashing'** linked to a popular **desire to do environmentally sustainable initiatives**. One of the most popular and visible ways is to buy some beehive and place them on the top of the company's building.

2.2 System Map

What to use the data for?



2.3 The Bughotel

Real touchpoint and the product of the system

The bughotel can be used from companies as **'apis melliflora'** beehives are used nowadays to advertize their **sustainable action** and behaviour to position them on the rooftop of their companies or on the facade. The idea is to **design through digital fabrication,** an element that can be seen and can identificate that company as **"it's doing sustainable actions".**

3. The BugHotel.

What do you have with 3ee BugHotel and its development

3.1 Bill of materials

COMPONENTS	PART NUMBER	LINK	PRICE	COMMENTS
Battery	1	Link Battery	€12.90	
MicroBoard	1	Link	€14.51	Mouser
Microphone 20Hz-20Mhz	1	Link	€7.39	Mouser
Sd connector (micro)	1	Link SD	€14.51	Mouser
Capacitor 100uF	1	Link to Capacitor	€0.2	Adafruit
Jumper Wires	Multiple	Link to Wires	€9	
Matrix Board	1	Commonly found components	N / D	
Clay	650 gr	Commonly found components	€2.5	
Moss	-	Commonly found components	N / D	
Micro SD card max 32Gb	1	Link	€6.6	
Magnets	9	Commonly found components	N / D	
Threaded Inserts of M3 1/2 and M4	5	Commonly found components	N / D	
			€67.61	**Total**

The BugHotel provides an opportunity to monitor insects while creating a living habitat for them, which directly affects biodiversity. The list contains materials that are quite simple and easy to repair which we continued to take care of a lot.

3.2 Right material, right dimension

What material is it?

At the beginning of the project we saw many options of materials to build the BugHotel for the **manufacturing**, including plastic, terracotta, bricks, corrugated cardboard, clay, recovered timber and many more, but the most important thing we had to consider was our guests.
Each guest must be provided with the most suitable type of shelter for the purpose, which must always be **dry, sheltered from the wind and exposed to the warmth of the sun**. (3) The Bug Hotel will in fact have to provide a shelter for the guests who it and adapt to their needs; while some guests will guests will use it for shelter during the cold season, others will use it to house their offspring.

The Holes

In order for all the expected guests to find sufficient accommodation, it was important to drill holes of **various diameters and depths**. It will therefore be useful to equip oneself with drill bits (wood for logs and wall for any bricks) of various diameters: from 3 to 10 mm and when drilling the holes, it was useful to try to tilt them slightly upwards, so as to facilitate the exit of any rainwater that may penetrate as much as possible.

Material

So we focused on the shape and durability of the BugHotel at the same time, which led us to go with more **natural** elements such as wood, (which was eliminated because of its low strength if it is untreated) and our best choice **ceramic clay**.

The form questions started from the beginning, even during printing procedures to have the perfect adaptable shape of the BugHotel. By combining the final requirments the BugHotel created in **18cm X 9cm in ceramic clay.**

For the manufacturing the shape in a perfect order, it is going to be 3D shaped and printed with the high technology.

procedure photo during the first 3D print, 2 February 2024

Once the Bug Hotel has been built, it needs to be filled with materials that will serve as accommodation for the insects. Basically, any type of material (natural or artificial) that is hollow or capable of providing 'small crevices' is suitable for the purpose is important.

If we consider the **natural pieces** of the BugHotel to attract the insects, best options came from the insects itself, considering each insects and their prefereble leaves and woods such as bamboo reeds, wamp reeds, branches with a soft or spongy interior, which insects can easily remove, logs, mud (to be drilled during drying), empty snail shells, pine cones, straw or hay and one of the favortes; dried leaves and stones.

To make it more specified, bamboo reeds and common reeds are ideal for **bees**, while grass stems cut under a knot are crucial. It is also important to drill the holes (4-12mm) evenly on the chosen surface to maximize available accommodation, with a length of around 12-20cm.

For chrysope, ladybirds and earwigs, the shape should be weathered and filled with straw. **Moisture** is crucial for attracting **earwigs**. It is recommended to have a wooden door or perforated brick at the entrance. So this information itself supports the material ceramic clay at the same time by possibility to have a moisturised area for the insects.

Instead **butterflies** require sheltered **cavities, wooden hatches** with vertical slits for wing protection, and vertical, dry herbaceous stems to support the insect. These elements should be considered when designing a BugHotel suitable for Vanessa butterflies, caterpillars, and chrysalises.

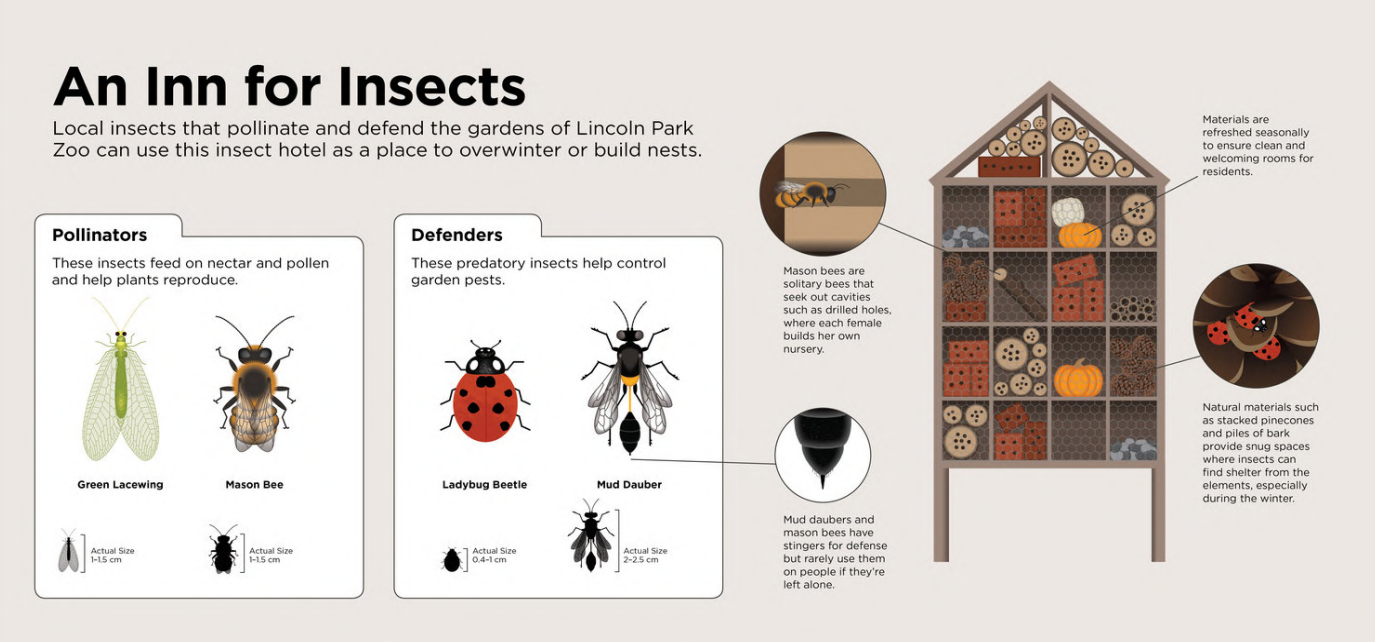


Photo: Lincoln Park Zoo

3.3 Shape Evolution
Giving the form

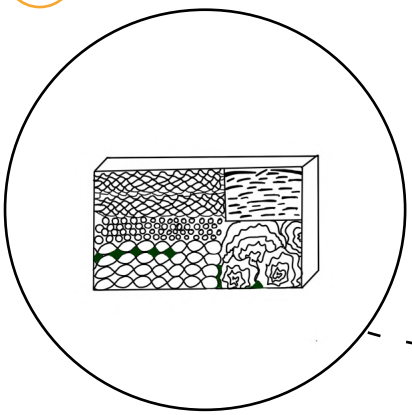
1 Instead **butterflies** require sheltered **cavities, wooden hatches** with vertical slits for wing protection, and vertical, dry herbaceous stems to support the insect. These elements should be considered when designing a BugHotel suitable for Vanessa butterflies, caterpillars, and chrysalises.

2 The conception of the shape of our product is rooted in an understanding of the **multiple modules** required to adapt to **different types of bugs**. Initially, we were inspired by the structure of existing bug hotels and studied their components, thus modelling an initial shape that followed a simple parallelepiped.

3 Subsequently, after identifying the different modules needed, such as holes for bees, pine cones, straw and small pieces of wood, we introduced a second version that proposed small compartments to house moss, used to retain water and attract insects.

4 At a later stage, we turned our attention to reducing the material in order to **decrease the overall weight**, while at the same time considering the inclusion of the central electronic component for biodiversity monitoring.

1



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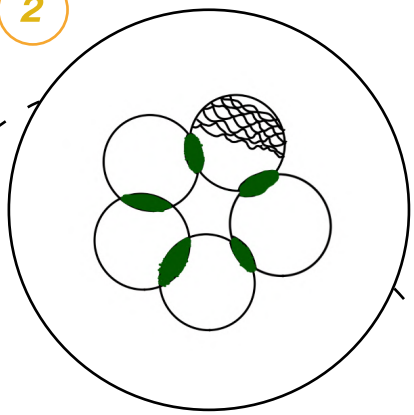

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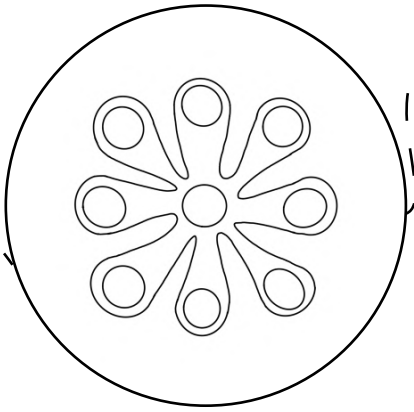

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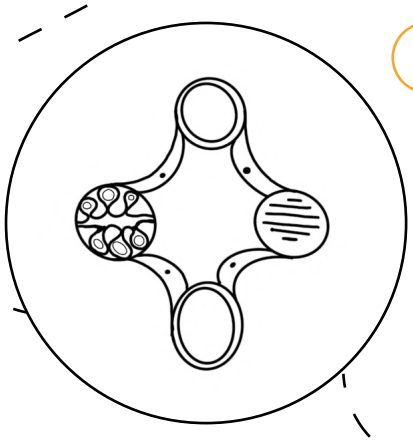

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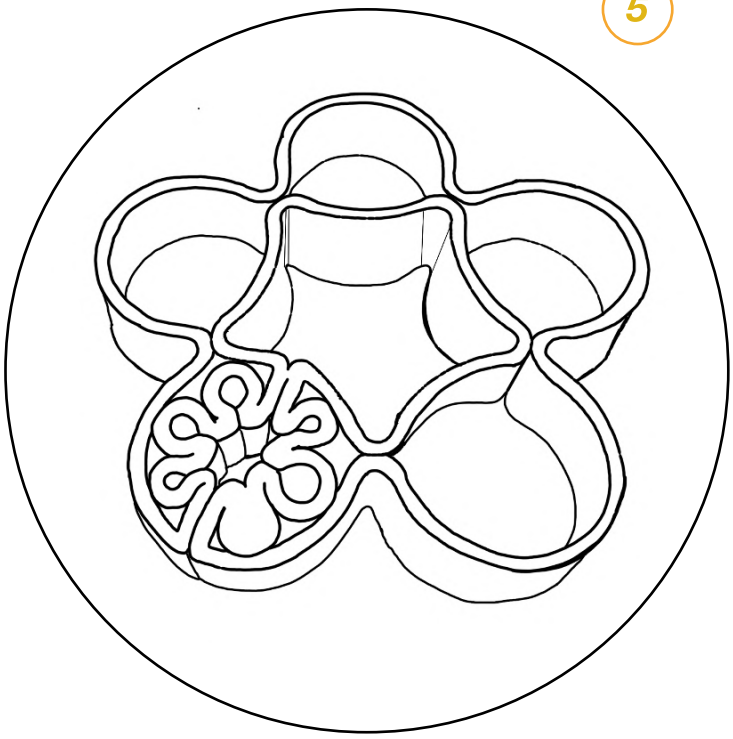


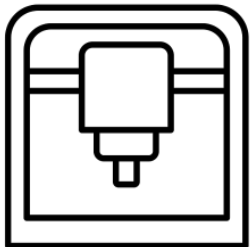
5

The final shape we developed represents an optimal **balance** between the amount of **material** (and thus weight), the flexibility of having **several compartments** to accommodate a variety of insect species, and the possibility of centrally **placing the electronic modules** for **optimal detection**. The **moss** is placed in the outer cavities.

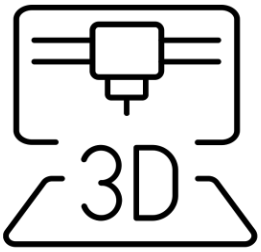
4. Instructions for making 3EE BugHotel and its components.

4.1 Tools to use

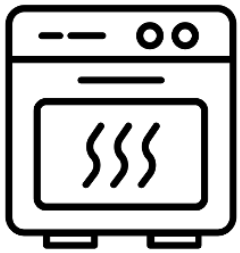
- 3D File



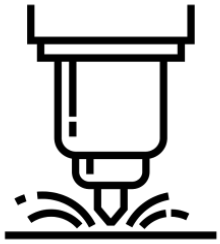
- 3D Clay Stamper



- 3D Printer

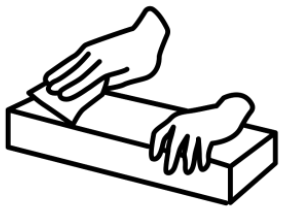


- Ceramic kiln

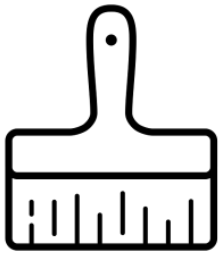


- Laser-cut Machine

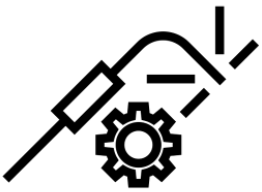
- Screwdriver



- Sandpaper



- Glaze



- Welding

- Moss

- Glue

and lots of love!

4.2 Main Clay Structure

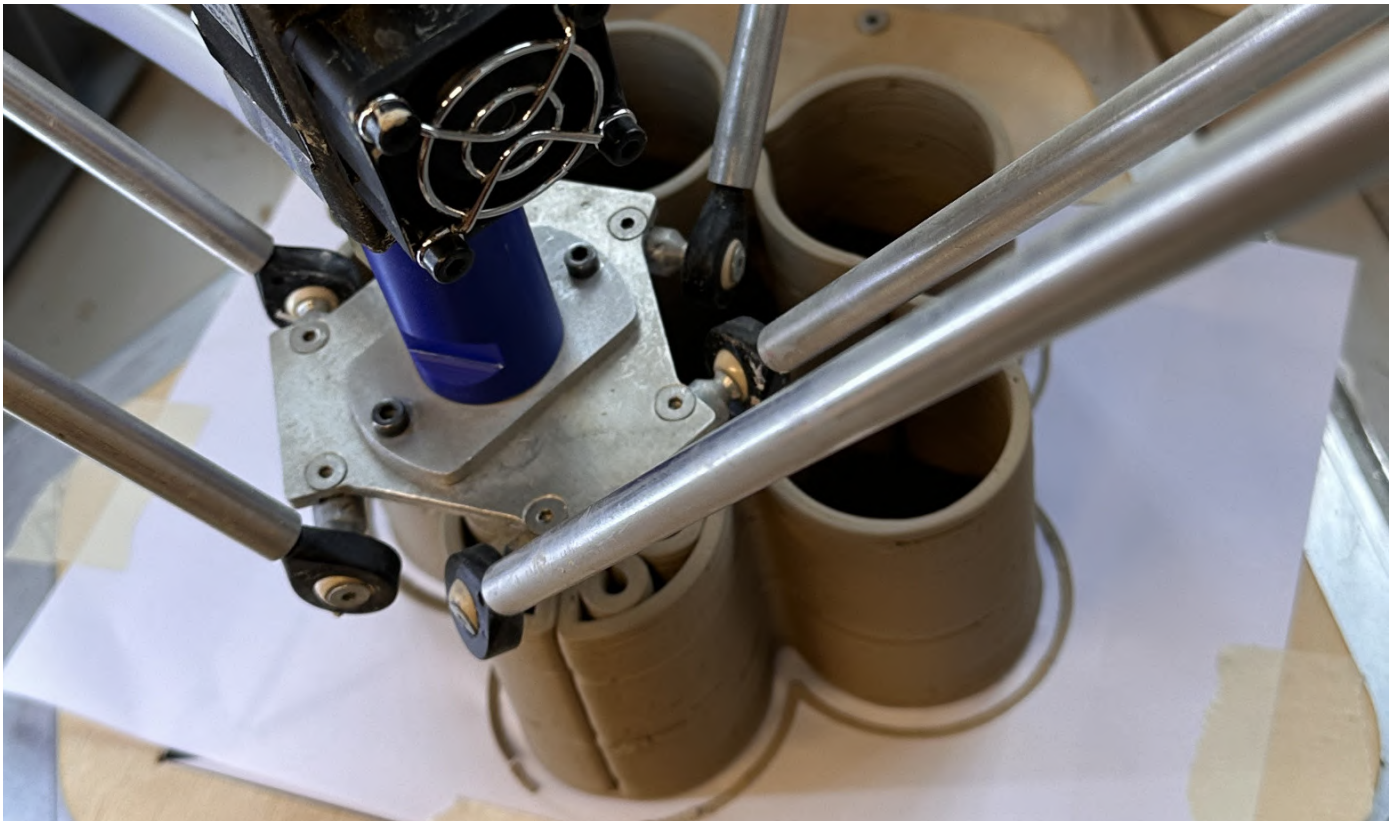
The main element that makes up the bug hotel itself is a 3D-printed clay structure. This is characterised by **five different compartments**, each dedicated to housing a different species of insects. Only one compartment features the printed clay itself, while the other four are empty and will need to be filled with material or a butterfly plug later.

4.2.1 How to make it?

1. Download the 3D file. “3ee_Clay”

   Link to download the 3D file

2. Print the piece on a 3D clay printer using a 4mm nozzle.

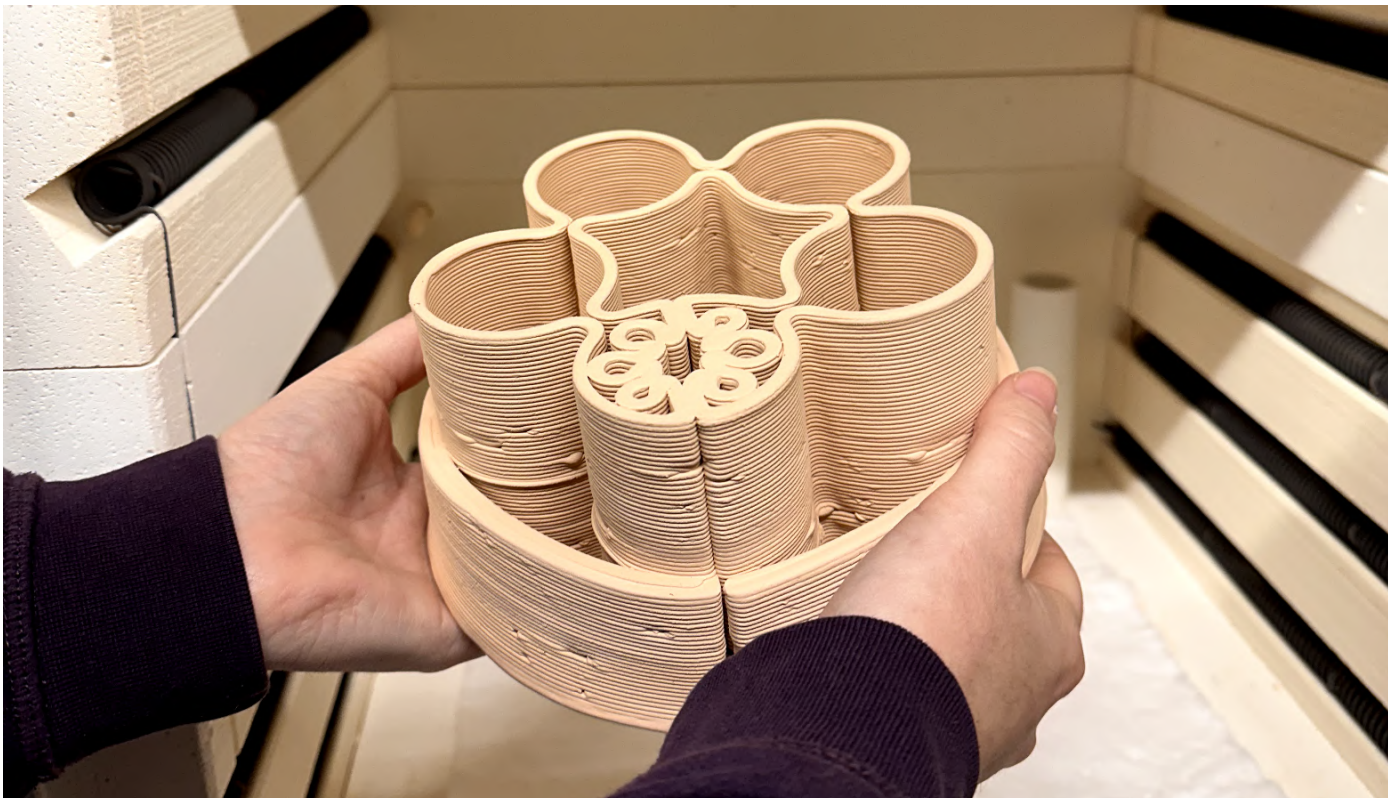


Don’t forget to check the machine all the time for possible mistakes.
We don’t want to waste material and time.

3. Cover the printed piece and let it dry for a few days.

4. Once the piece has dried, proceed to firing in the kiln.

Careful with the timing and heat of the kiln; it is important to not cook less or try to take it off before it is cooled.



5. Glaze it.

Once you have the clay piece, use crystalline glaze to glaze it, making sure not to glaze the inner cavities of the bug hotel, only the outer ones. Enamelling protects the piece, **preventing it from absorbing moisture** and compromising the properties of the material from the walls exposed to the outside and those in contact with moss.

Do it **two** times and clean the top as much as you can with a wet sponge so the top wouldn't be glazed.

6. Repeat the baking process.

Careful with the timing and heat of the kiln; it is important to not cook less or try to take it off before it is cooled.

7. Voila! The main structure is ready!

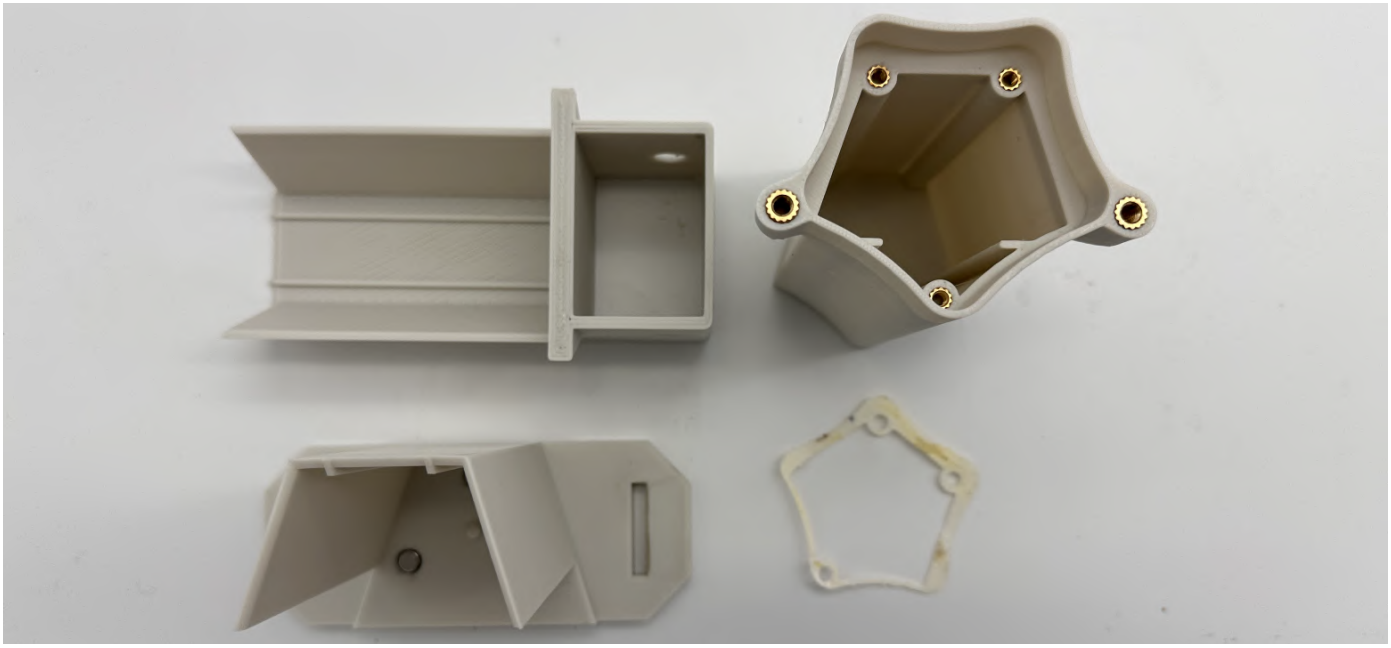
4.3 Central Support

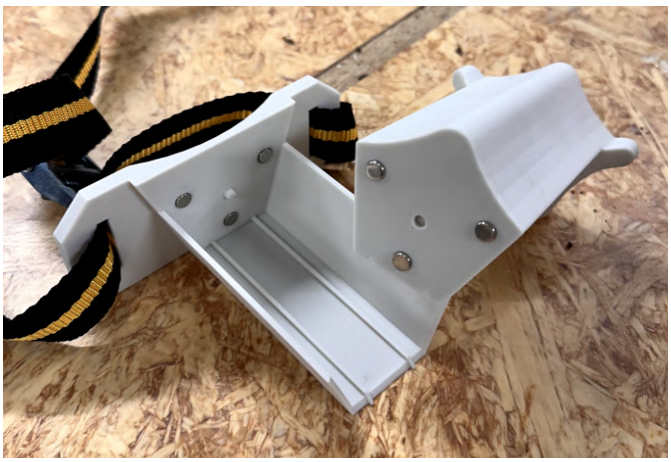
The central element has a threefold function: to support the clay part, to allow it to be fixed by means of straps and to contain the electronic component module.
The part assembly is produced by xxx 3D printing.

4.3.1 How to manufacture it?

1. Download the 3D model.
   “3ee_Device+Lid+Gasket” “3ee_PoleMonting_Belt” “3ee_PoleMonting_Viti”
   Link to download
2. Once the clay piece has been manufactured, measure the space available in the centre hole.
3. In the 3D model of the central support, if needed, modify the circumference in which the hexagon is inscribed so that it can be inserted into the main structure. Make sure that there is sufficient space to insert the electronics.

Note well: The part must be produced after the clay element is manufactured, as the dimensions may vary due to shrinkage during drying.

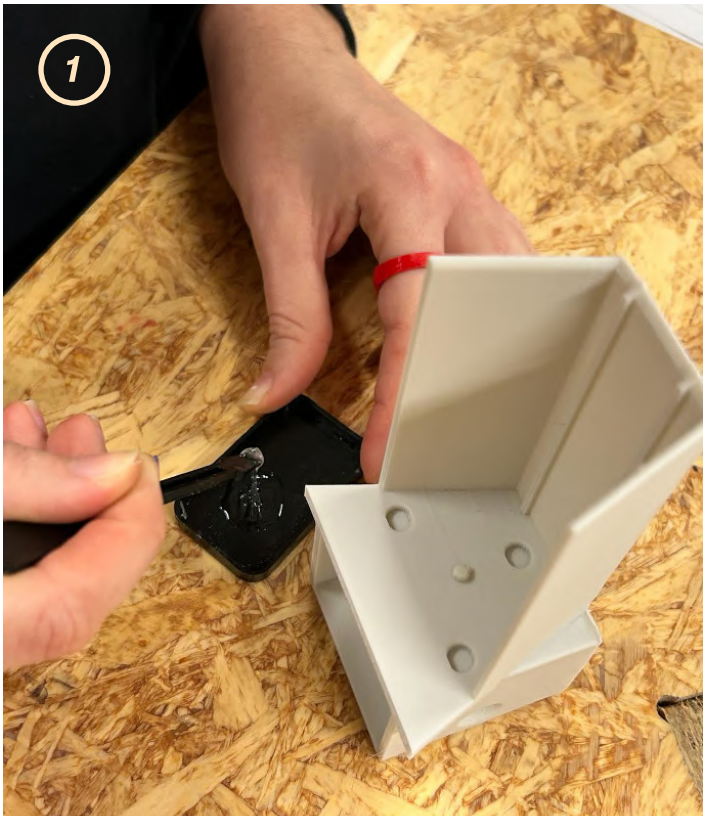


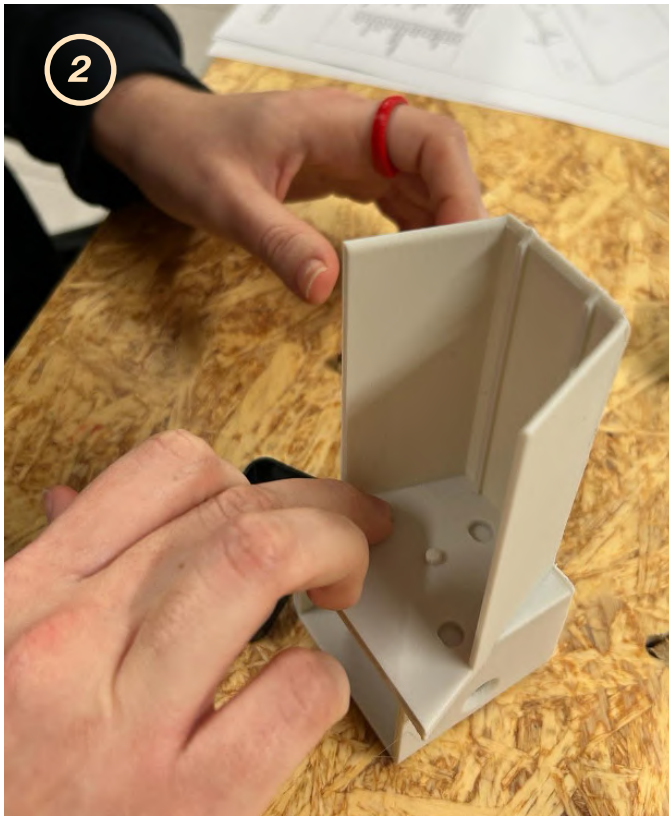


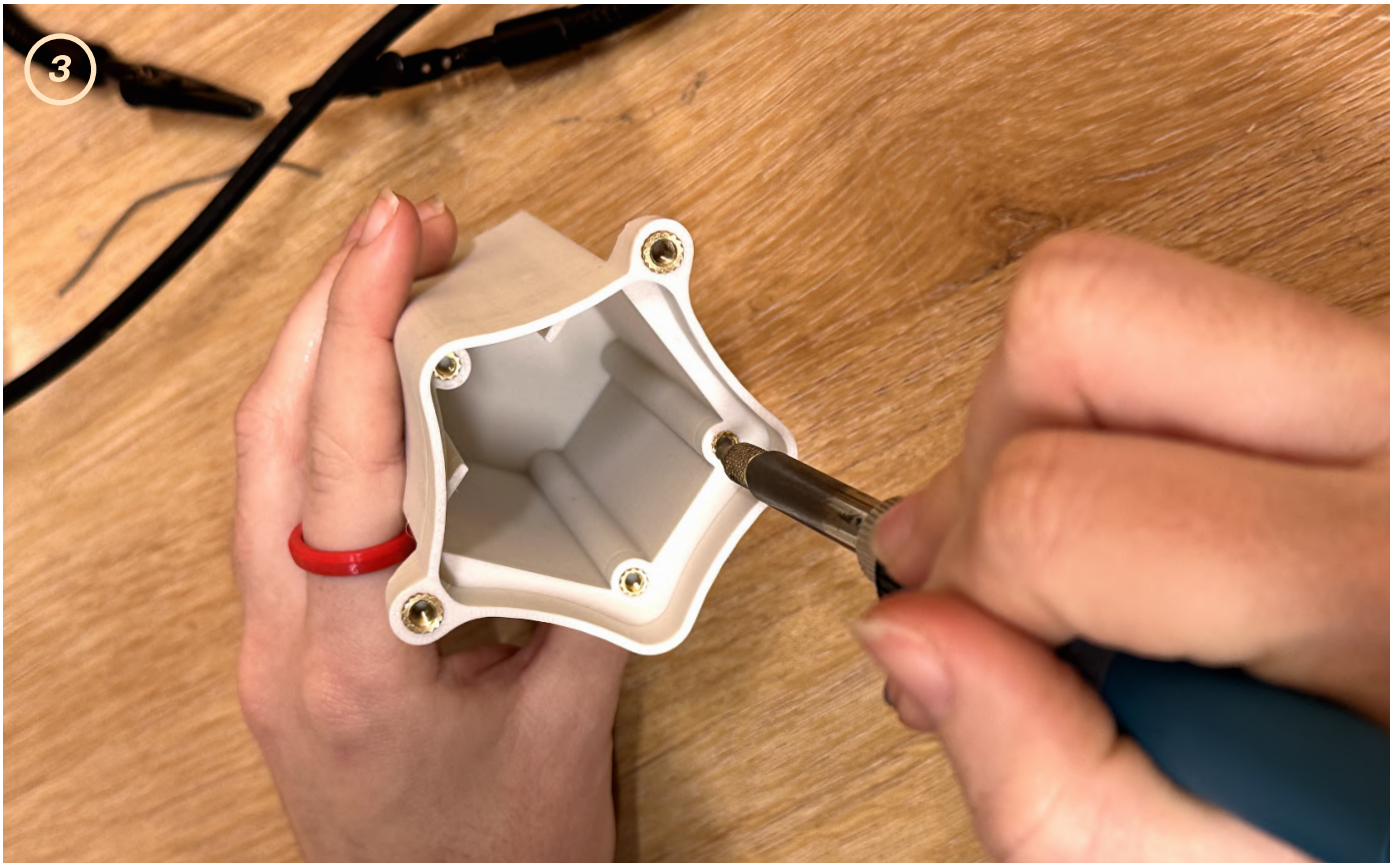
4.3.2 How to assembly it?

To make it tight.

1. Prepare the glue
2. Put the glue in the holes and place the magnets
3. Insert threaded inserts and weld them in place so they are tight and strong.





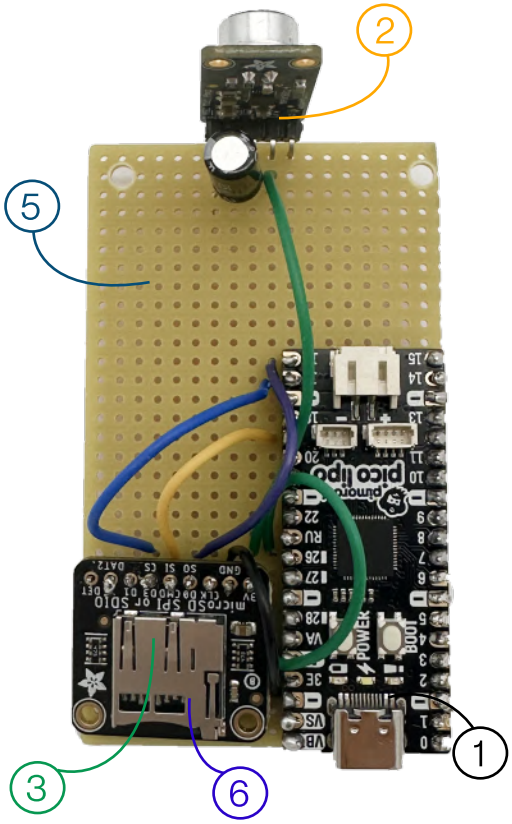


4.4 Assembly of Electronic Components

The electronic part is intended to pick up the sounds produced by the insects via a microphone and store the data on an SD card, which will then be used to transfer it to a computer.

Required components:

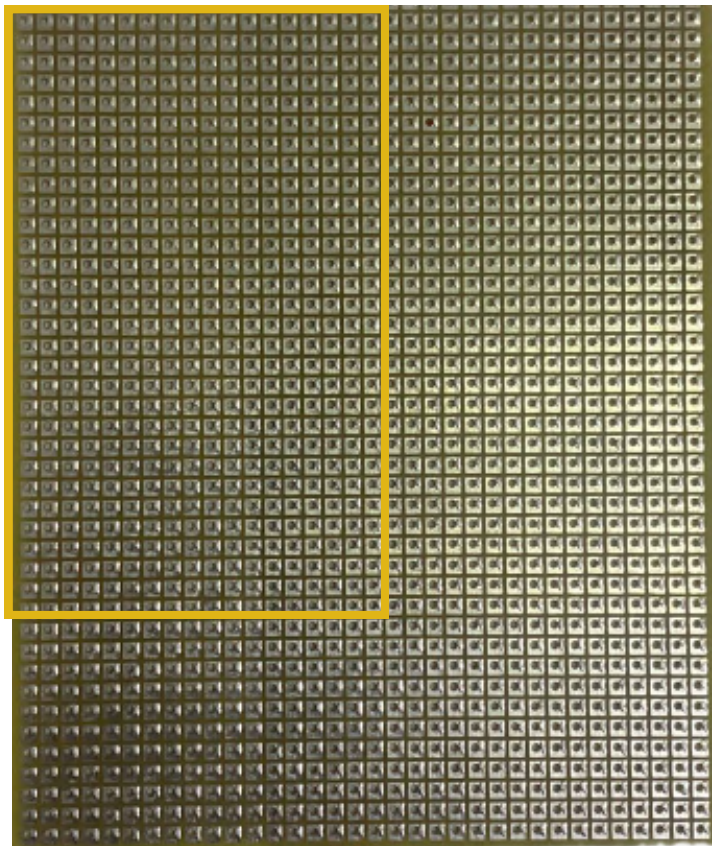
1. Microcontroller (we used Pico Lipo 16 MB)
2. Microphone
3. SD module
4. Battery
5. Matrix Board
6. Card
7. Jumper wires
8. Welding



4.3.1 How to build the electronic part?

1. We start with putting the pieces in the right place and identify where to weld them.
2. Here we have put the matrix board, microphone, sd module and the crucial part the microcontroller. Don't forget to put the card inside SD Module.

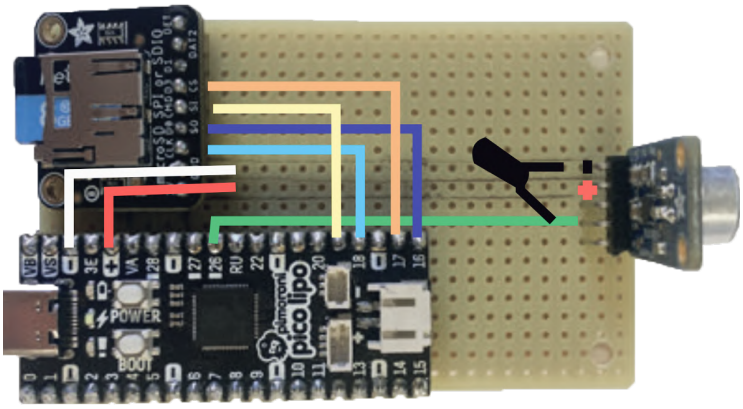
*Remember to cut the matrix board, counting **how many pins** you are going to need to connect all your components.*



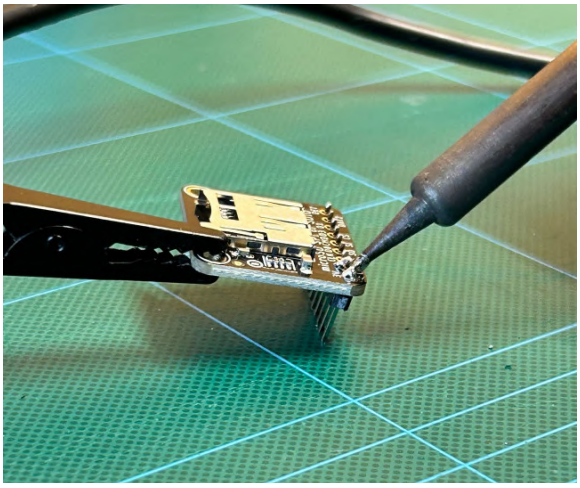
3. Do the welding with the jumper wires.

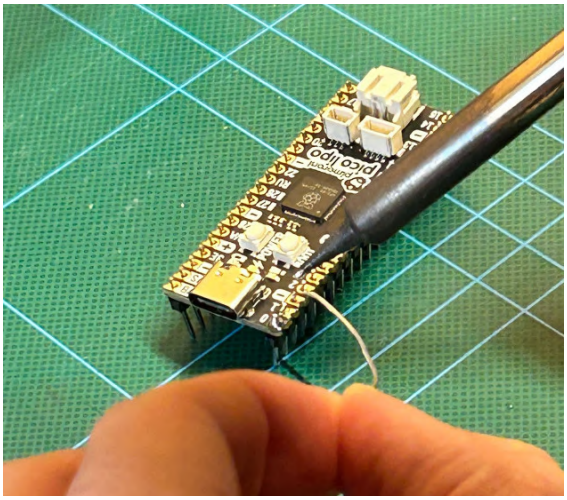
Don't forget to be careful with the heat of the weldering machine.

Don't forget the wire the components with wires, different colors are different wires to connect the components together!

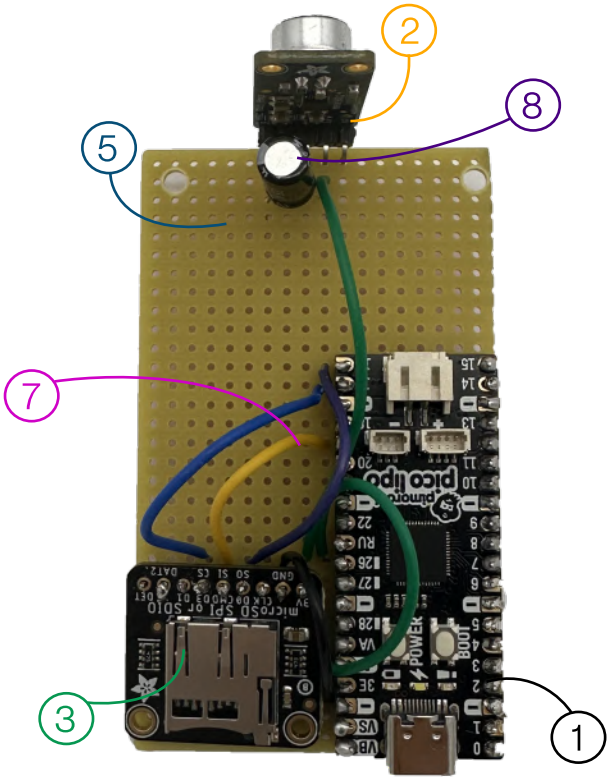


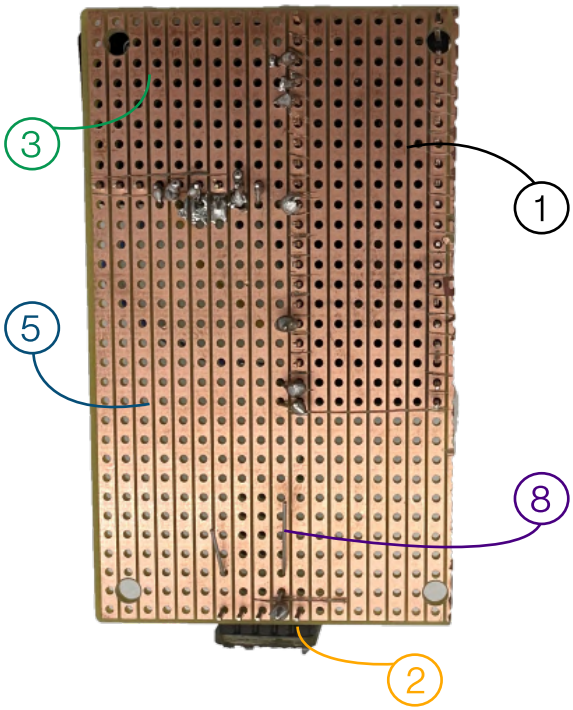
Welding process:





*note: this should be the **final** welded matrix board that you added the components:*

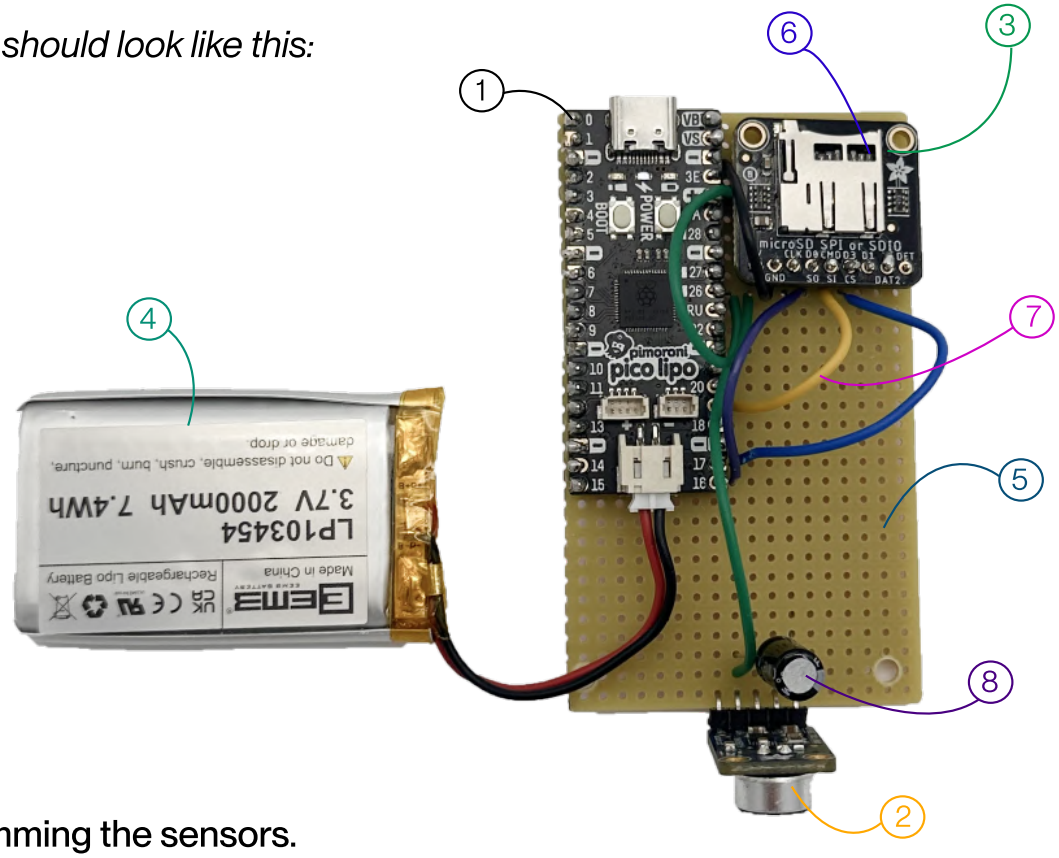




4. Connect the battery with the microcontroller.

Careful with the + and - of the battery, they should be sticked in the same way.

Final result should look like this:



5. Programming the sensors.

Test to see if everything works properly and if it records audio

1. Download the code. </>

4.5 Laser Cut Pieces

Frontal protection is to protect insects from birds. This takes the form of a laser-cut panel that follows the shape of the hotel bug and is positioned X centimetres in front of the modules.

Three lids in opaque plexiglass:

Lid 1 is to insert microphone.

Lid 2 and **lid 3** are layers to have a proper distance of microphone from outside world, to prevent water, dust and other 'outside' materials.

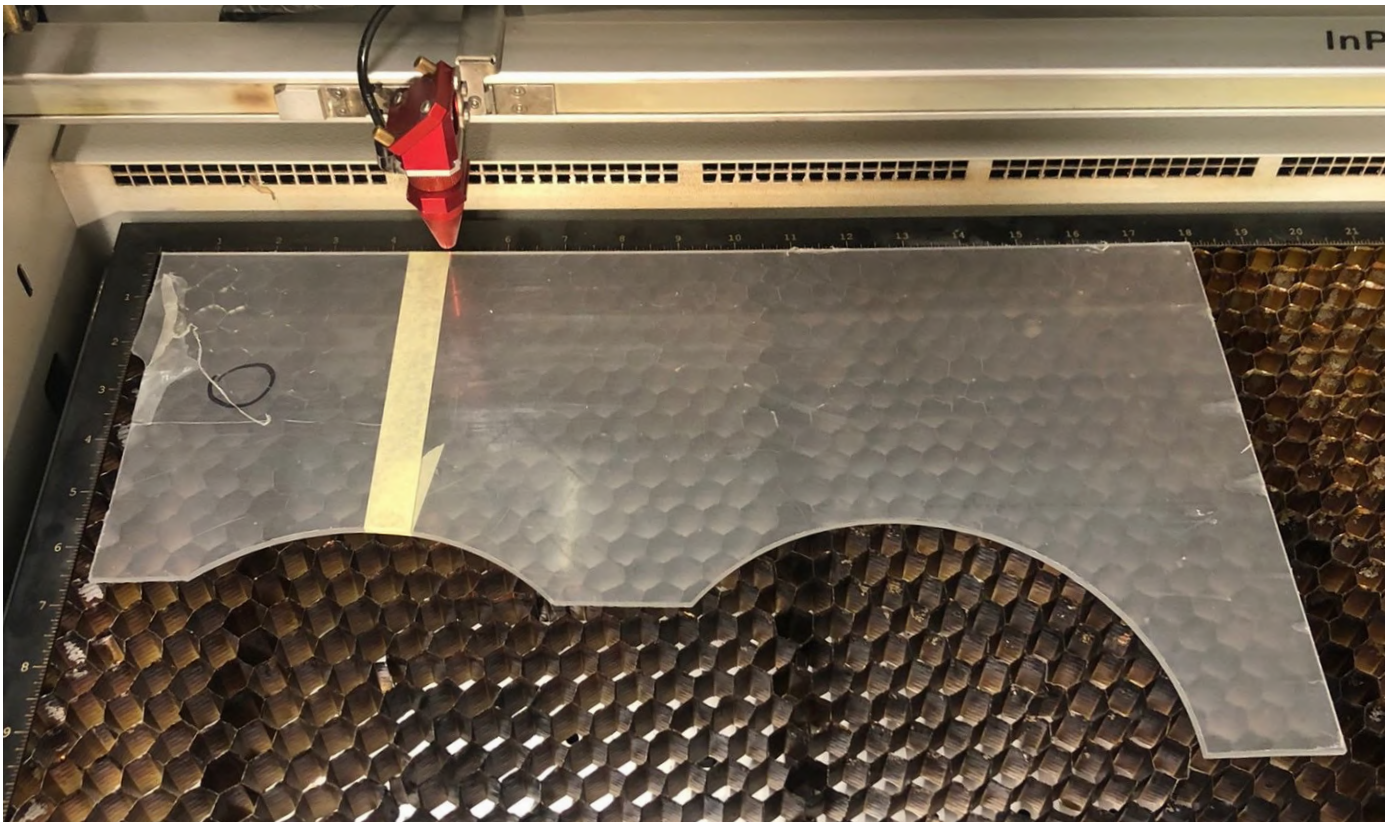
Butterfly lid is to put inside the clay printed BugHotel, to protect the butterfly hole and make it attactive for butterflies and it is made of 3mm wood.

4.5.1 How to make it?

1. Download '3ee_Laser_Cut' file

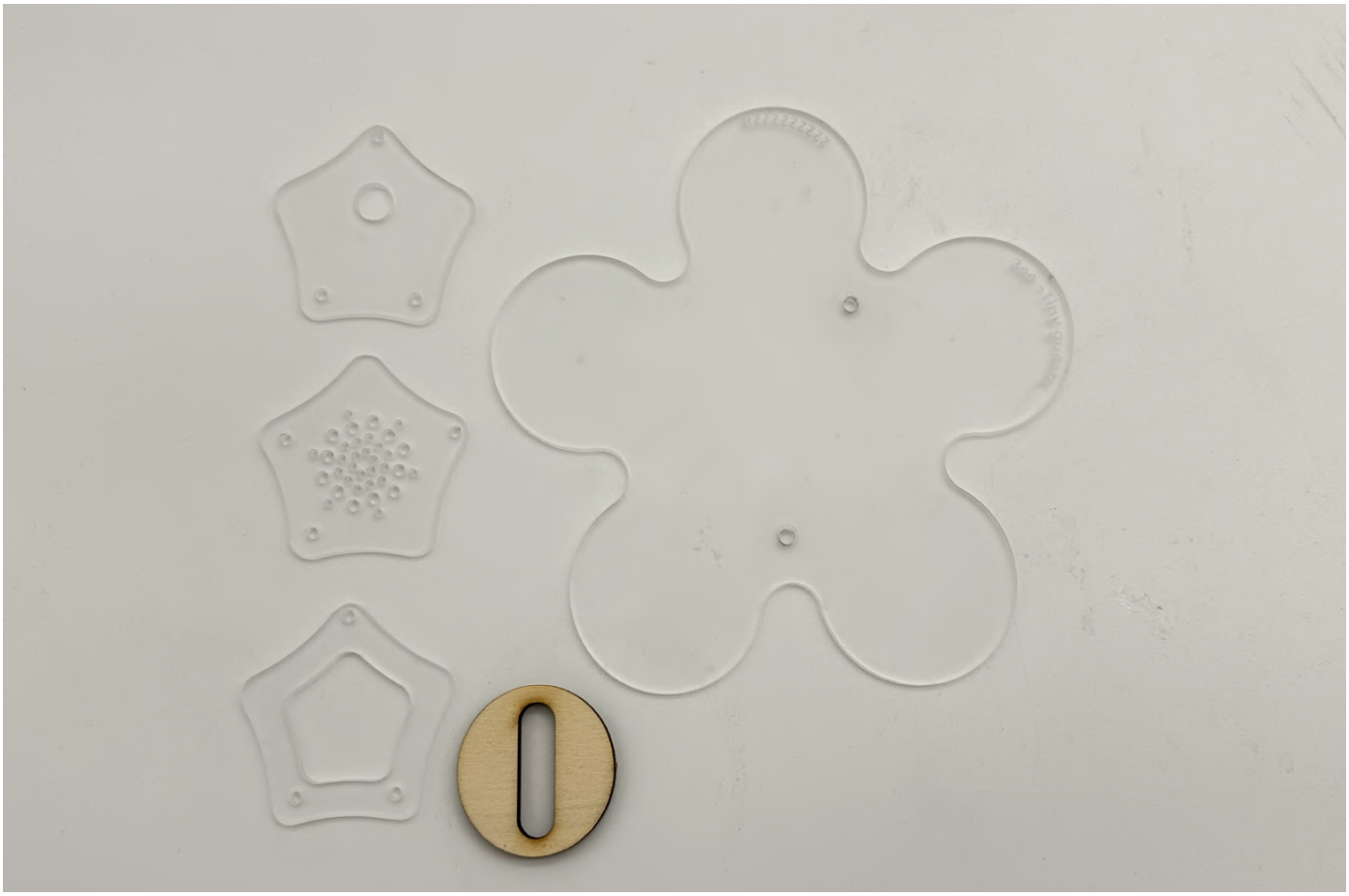
Link to download the pieces indicated in the file.

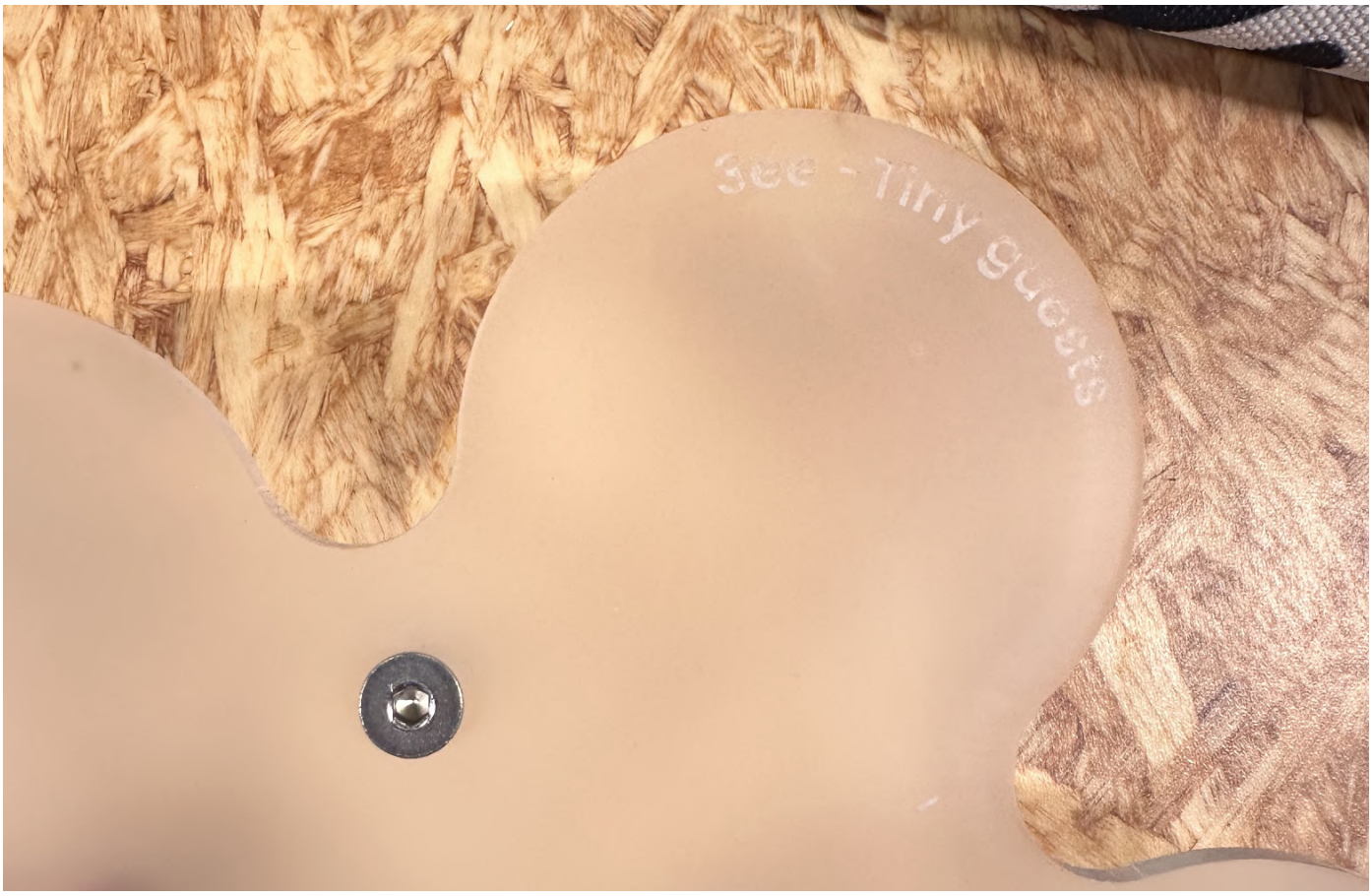
2. Laser-cut a sheet of 3mm thickness (opaque plexiglass)



3. Print the pieces in right temperature and time to have the perfect laser cut.

These are the pieces that you'll get:



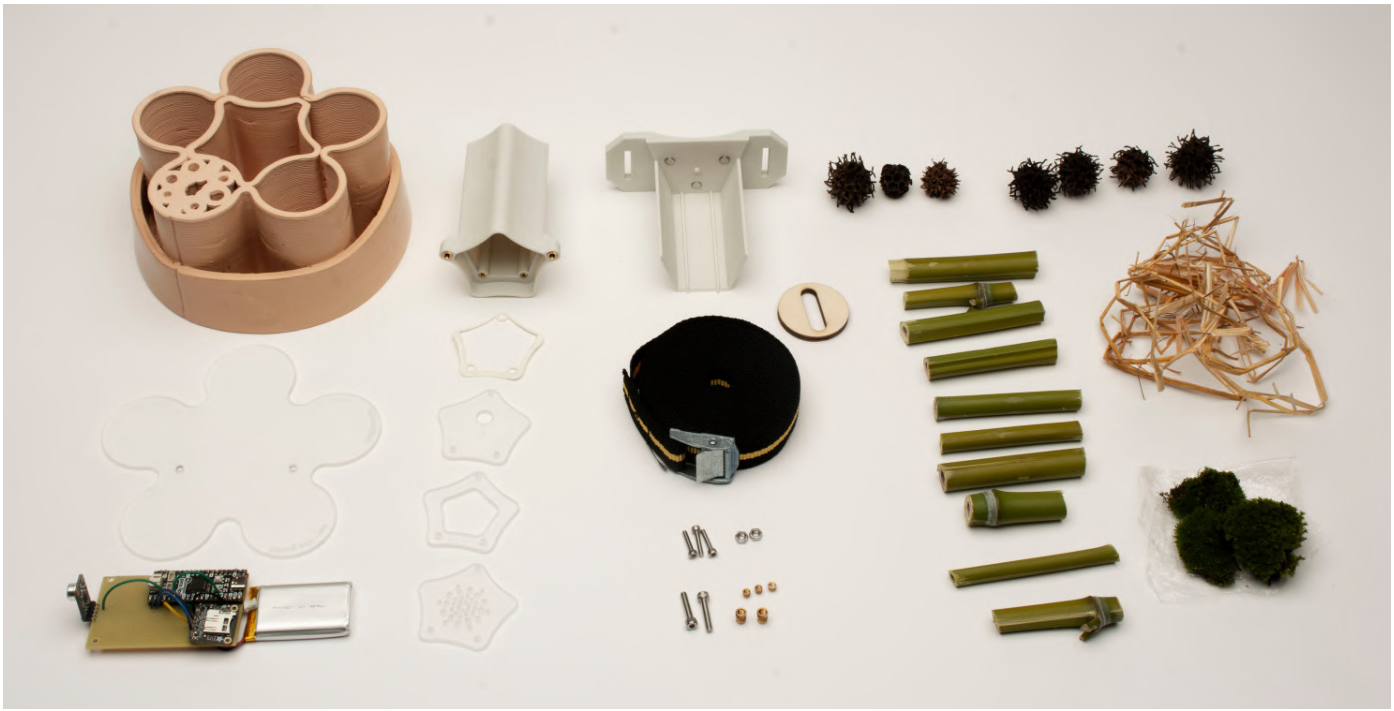


Look at the little laser cut name of the BugHotel!

4.5.2 Recommendations

Be aware of unexpected large milimeters. To be able to prevent the misplacement, try to make the pieces smoother by using sandpaper.

In this point you should have all the elements ready to assembly!



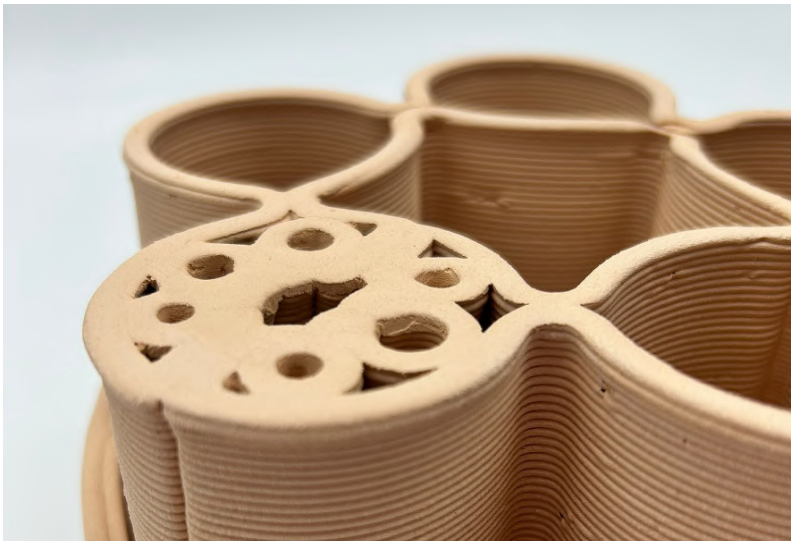
4.6 Insect Modules

Which insect, what material?

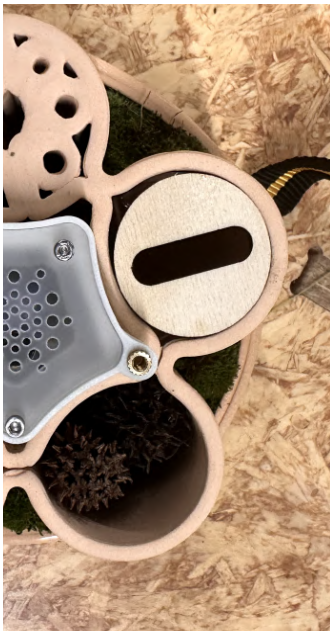
There are five modules in the bug hotel to house different types of insects. One of these, for bees, is built together with the structure itself by means of clay moulding. The other four are presented as containers into which different types of material can be placed.

4.6.1 Modules

Bees: Moulded directly in clay

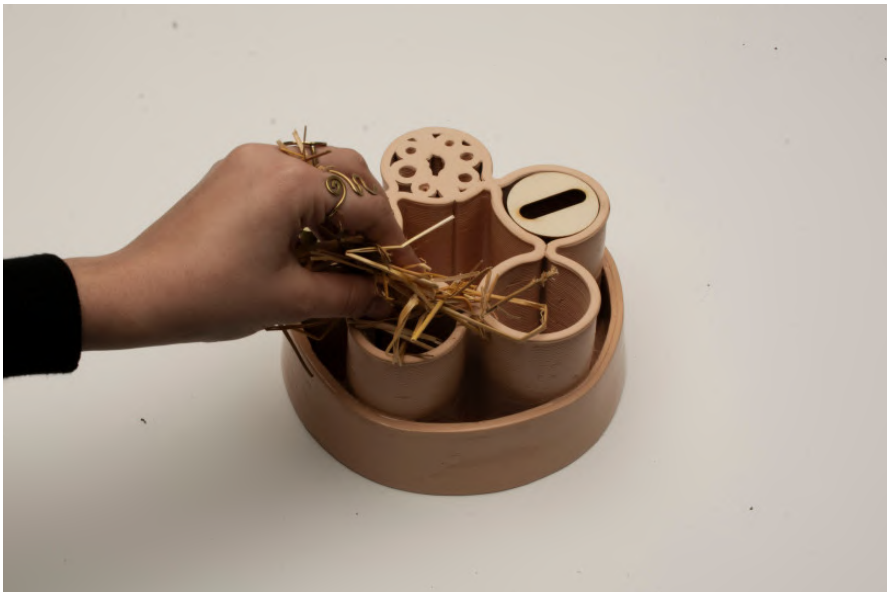


Butterflies: Laser-cut the butterfly lid (explained in the 4.5.1) out of 3mm wood. It is important to have a vertical hole in the material to allow the entrance of the butterflies and not other insects.



Spider mites, mealybugs and aphids: Bamboo sticks

Beetles, centipedes and woodlice: Wood, loose bark and straws.

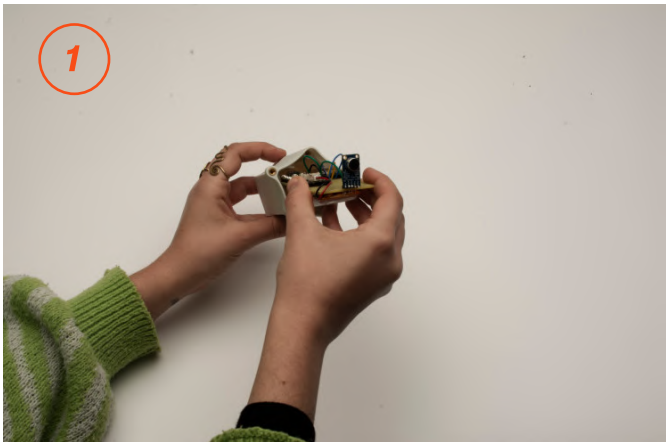


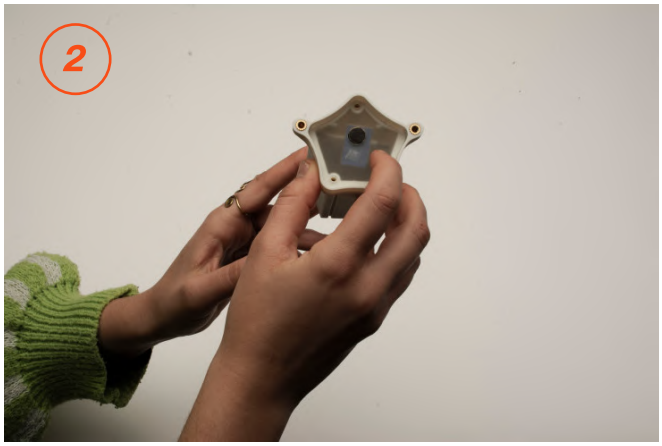
Ladybugs: Insert small pine cones and dry leaves.

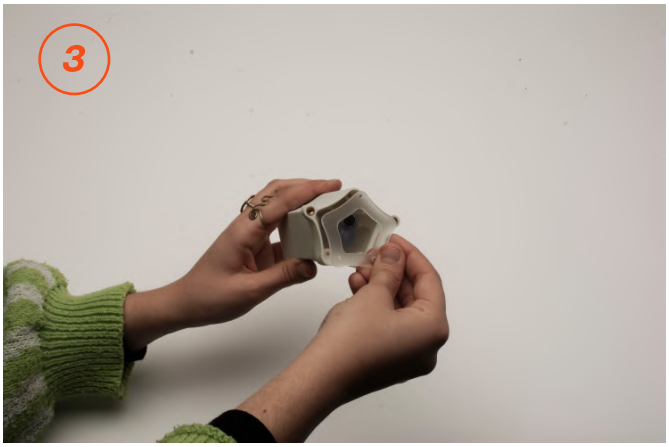
4.7 Assembly of the final bugshotel

Let's put them together!

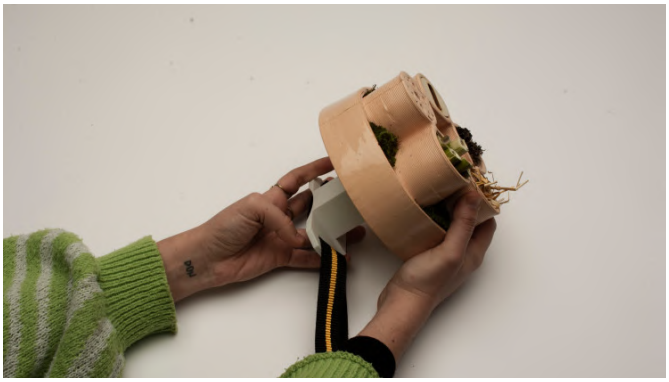
1. Insert the electronic component in the 3D printed support.
2. Place Lid 1 over the microphone.
3. Place Lid 2 and Lid 3.
4. Use screws to fix the elements in place



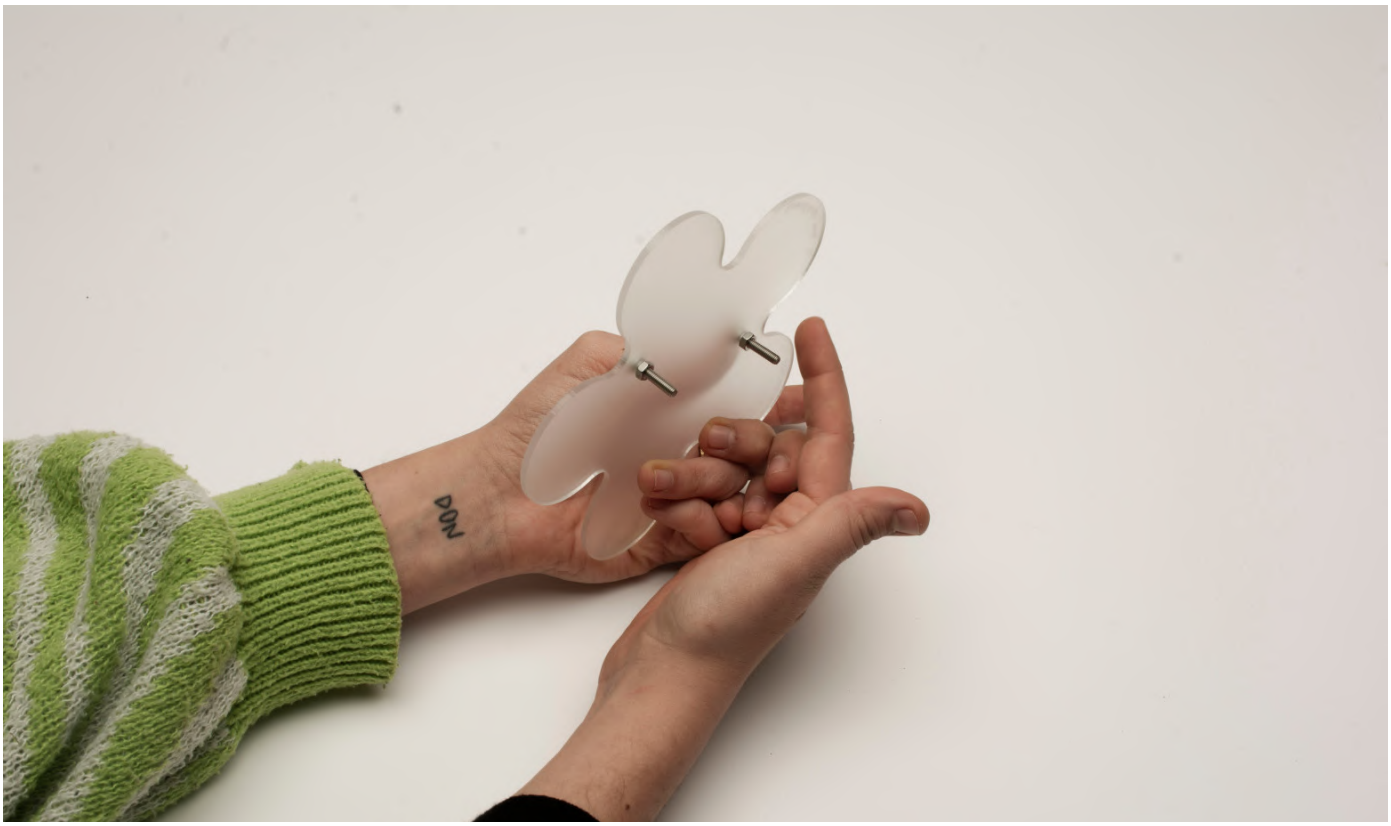




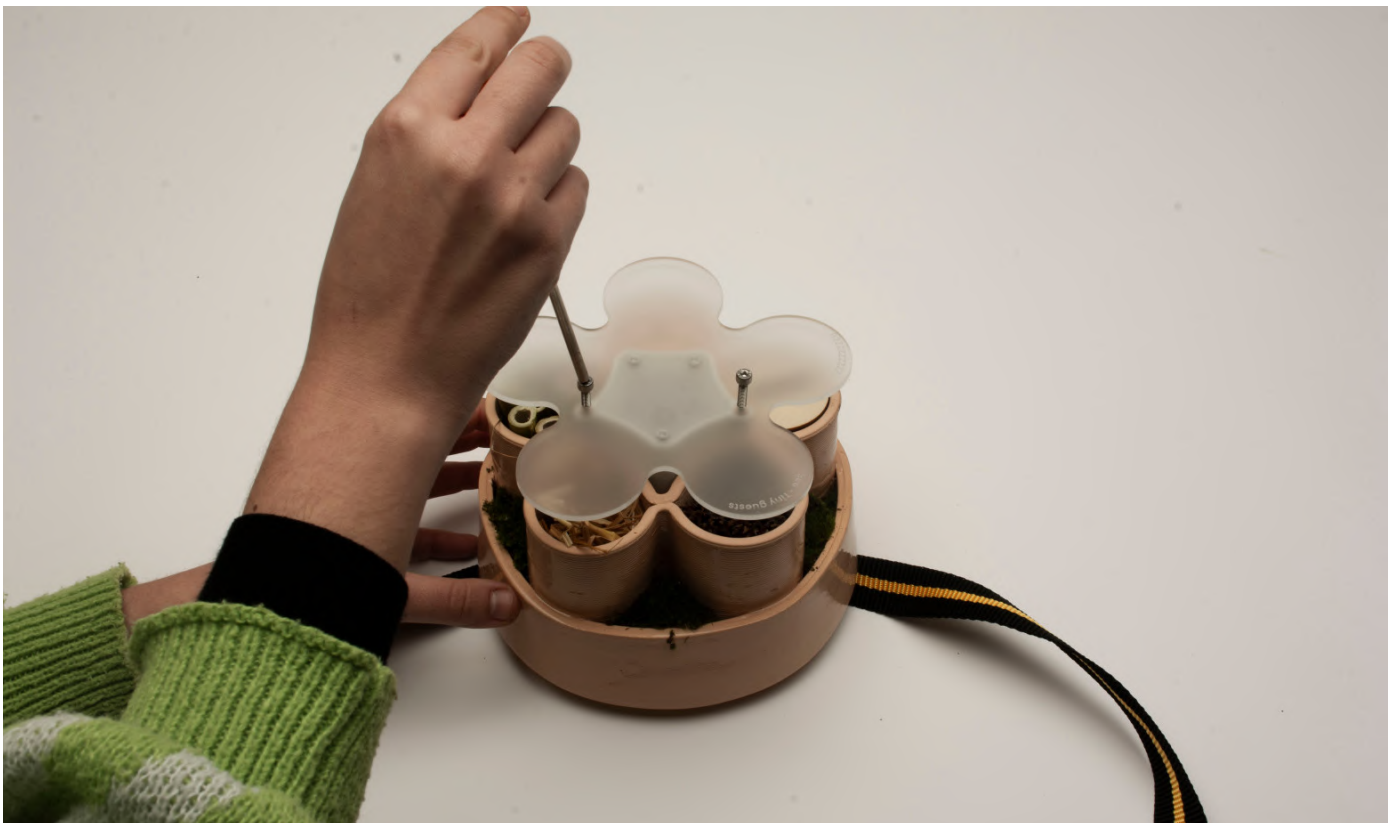
5. Insert the 3D printed support in the main clay element.



6. Insert the screws in the frontal protection and use them to attach it to the 3D printed support.



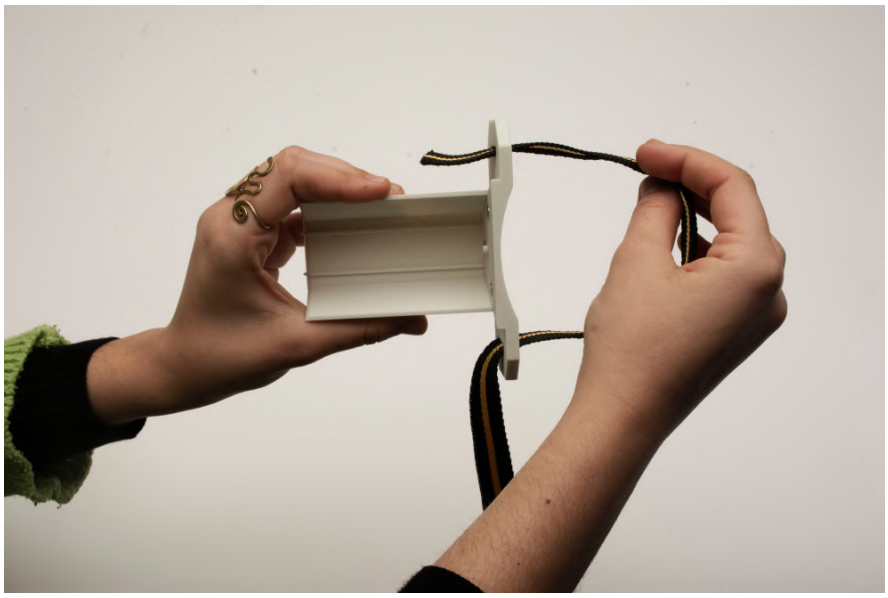
7. Use screws to fix the frontal piece and viola!



4.8 Arranging the belt

How to place it?

1. Get the belt in the right direction and place it, as you see on the photo, in the 3D printed piece.



2. Place the 3EE BugHotel on the tree or the structure that you want to hang, and pull the belt to make it tight!
   Note to position it height 1.5 metres!

4.9 Other Details

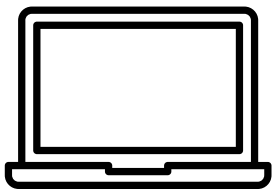
To attract more insects and give them an efficient environment to monitor, we created a design that allows moss to grow outside so it can produce its own water, which attracts more insects.
For better moss growth, we recommend applying a paste made of yoghurt and dried moss between the clay and the moss, to make it adhere well to the product and allow it to continue growing and not die or dry out.

3EE BugHotel with grown moss

5. How to use 3EE BugHotel .

5.1 Tools to use

- Screwdriver



- Computer

and lots of love!

5.2 Operation

Once activated (by connecting it to the battery) and positioned, the product will record an 8-second audio every 15 minutes, saving it as a file and storing it on the SD card. The user can retrieve the data by removing the cover with a screwdriver and pulling out only the device in order to open and retrieve the SD card. Downloading files from the SD card should be done at least every 1/2 week to monitor.

5.3 Maintenance

Check the condition of the product once or twice a month, checking if it has fallen down and inspecting the growth of moss in the cracks and filling the holes with new material such as straw, pine cones and bamboo. Be sure to recharge the sensor battery every fortnight.

6. Analysis

Case study research was carried out in order to understand how to analyse the data once it had been collected. A number of opportunities and techniques emerged from the research. The first opportunity seems to be the use of Machine Learning (ML) and a support vector machine (SVM) as discussed in the paper 'Automated classification of bees and hornets using acoustic analysis of their flight sounds', while the second seems to be CNN models combined with Log Mel-Spectrogram representations and strong data augmentation as discussed in the paper 'Automatic acoustic recognition of pollinating bee species can be highly improved by Deep Learning models accompanied by pre-training and strong data augmentation'.

The project is therefore proposed as an open source opportunity to combine the skills and background of designers and developers, who, with the appropriate knowledge, can implement the system for analysing the data collected through our Bugs Hotel.

For any problems please contact us!!!

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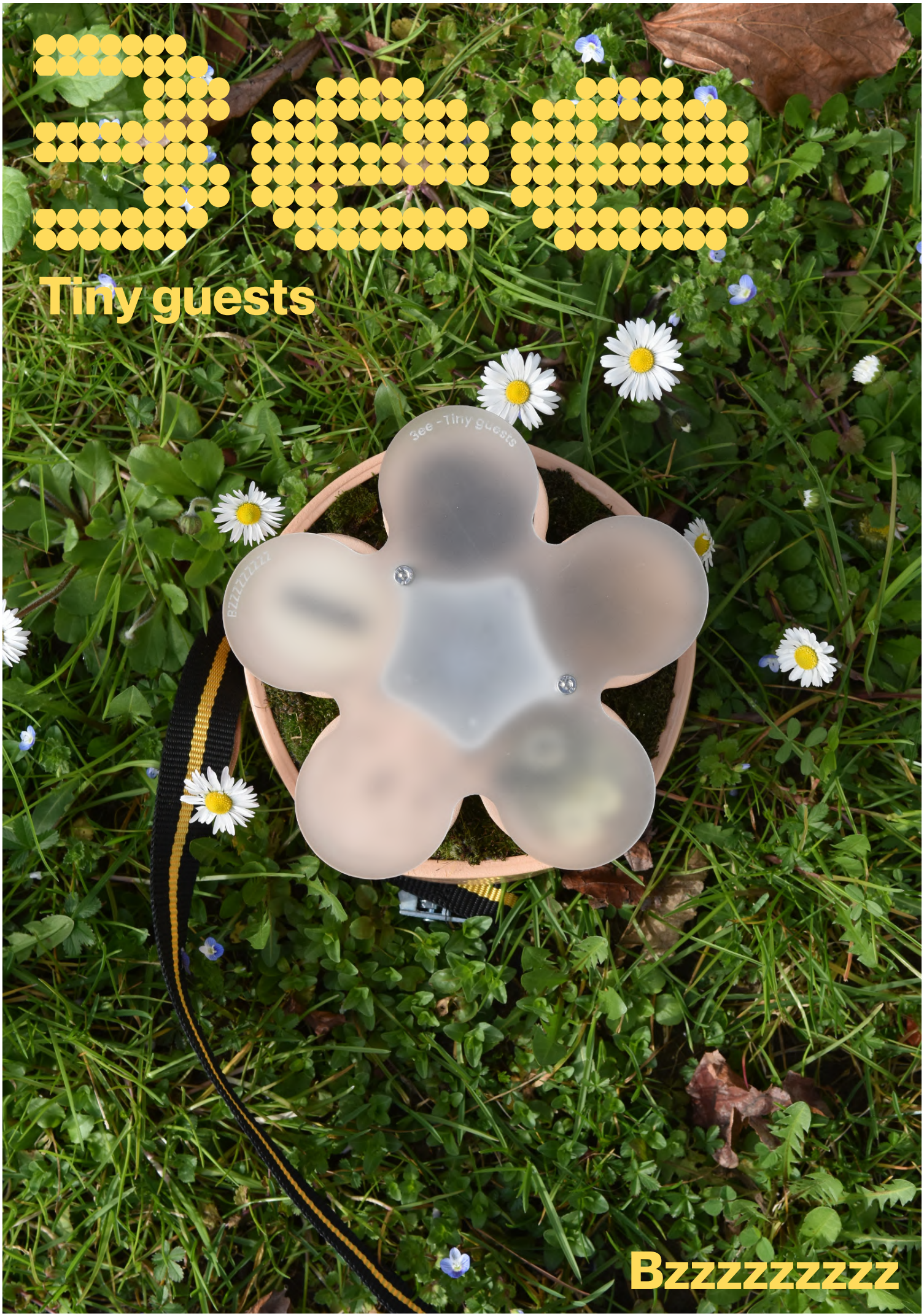
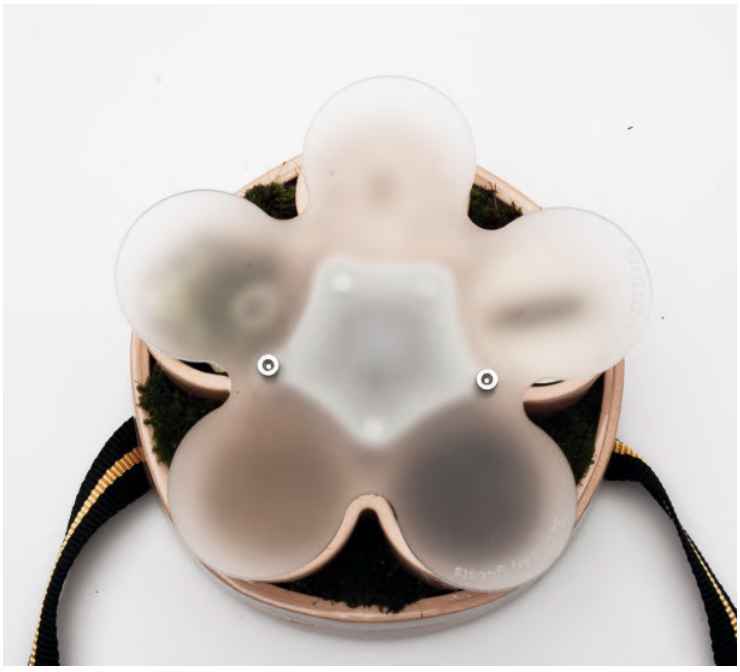
4. https://www.bioapi.it/inizia-da-qui
5. https://www.idroponica.it/blog/12-20/come-coltivare-il-muschio-la-guida.html
6. https://www.sciencedirect.com/science/article/pii/S0048969722029801

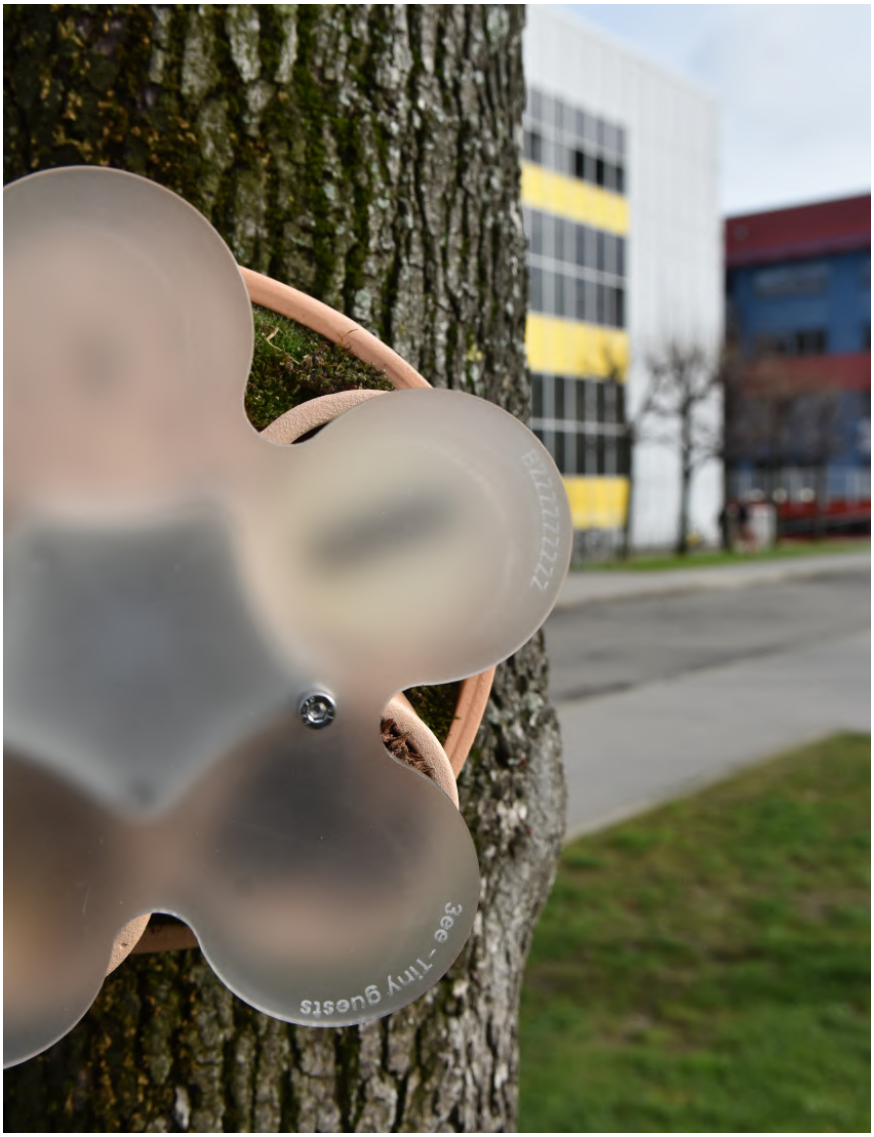
Tiny guests



The sun is shining, place your BugHotel!
Milano Bovisa - Politecnico di Milano - Main Circle
27/02/2024


BZZZZZZZZZ
Bee - Tiny Guests





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