| blu:m |

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Politecnico Di Milano - School of Design
Product Service System Design
Innovation Studio - a.y. 2021/2022

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PSSD PRODUCT-SERVICE SYSTEM DESIGN

IS INNOVATION STUDIO

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.01 Scenario

Higher Education in 2037

Scenario .01

Scenario

Higher Education in 2037

Imagine Milan in 2037. Continuous growth in the demand for higher education will lead to an increase in the number of students every year. To meet this growing demand, institutions should anticipate and increase the number of places to accommodate a larger number of students. This requires investing in new buildings and classrooms.

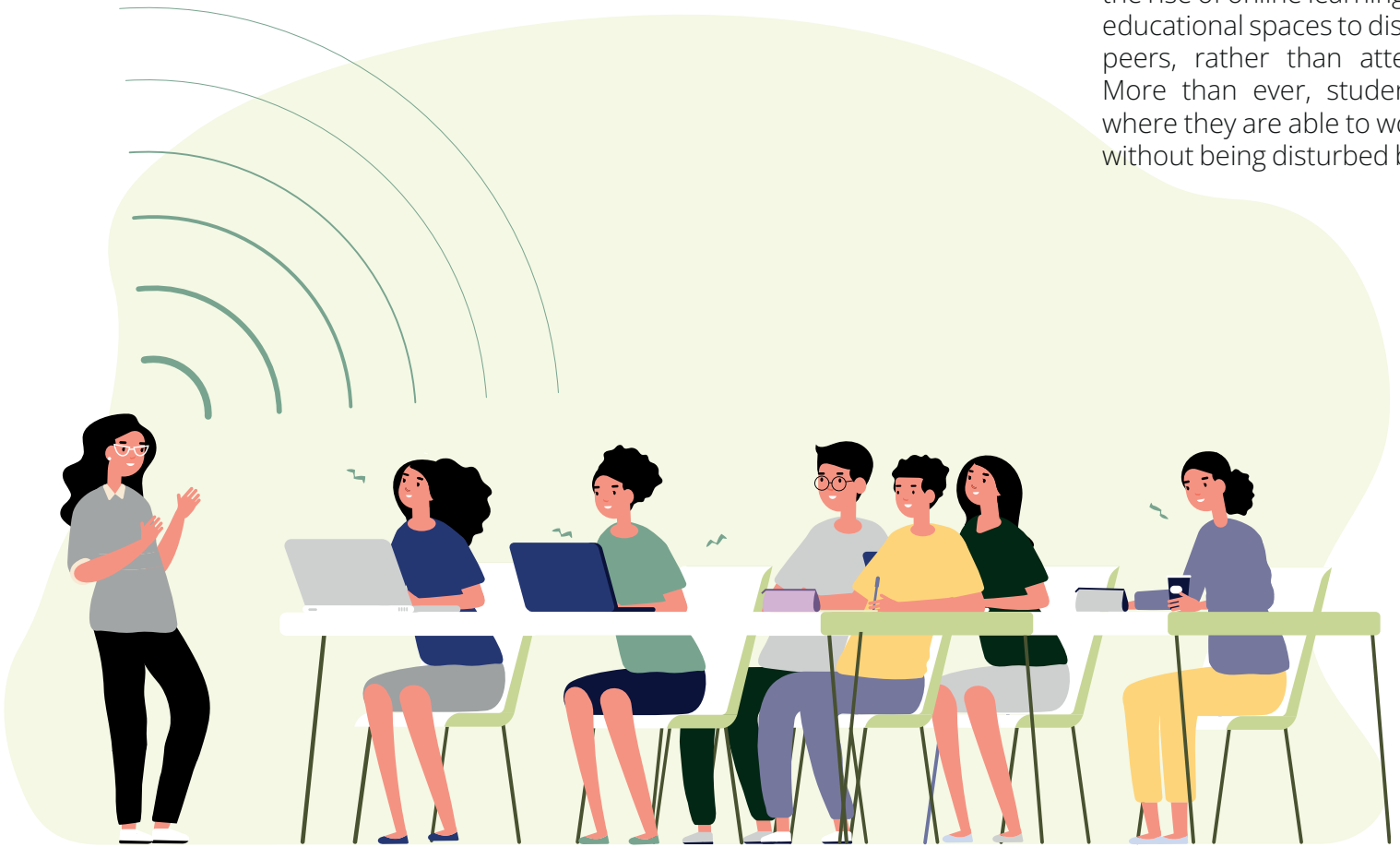
Students working on computers discussing a project messing around eating and chatting

Scenario .01

As the increase rate in the number of students supercedes the pace of construction, it will result in overcrowded classrooms which will create a poor learning environment for students. Educational insitutions will have low-quality classroom soundscapes due to the large number of students and a lack of investment in the room's acoustic performance.

In parallel, the way we learn is also shifting. With the rise of online learning, students mainly attend educational spaces to discuss and learn with their peers, rather than attending frontal lectures. More than ever, students need environments where they are able to work and discuss together without being disturbed by excessive noise levels.

Professor giving a lecture



In this context, we envision the redesigning of universities to improve its educational spaces by providing flexible and conducive learning environments for teachers and students. Well-designed classroom acoustics are essential for their well-being and productivity. In 2037, universities will be aware of this necessity and the importance of sounds in education and offering educational spaces with a well-balanced soundscape will be a new priority.

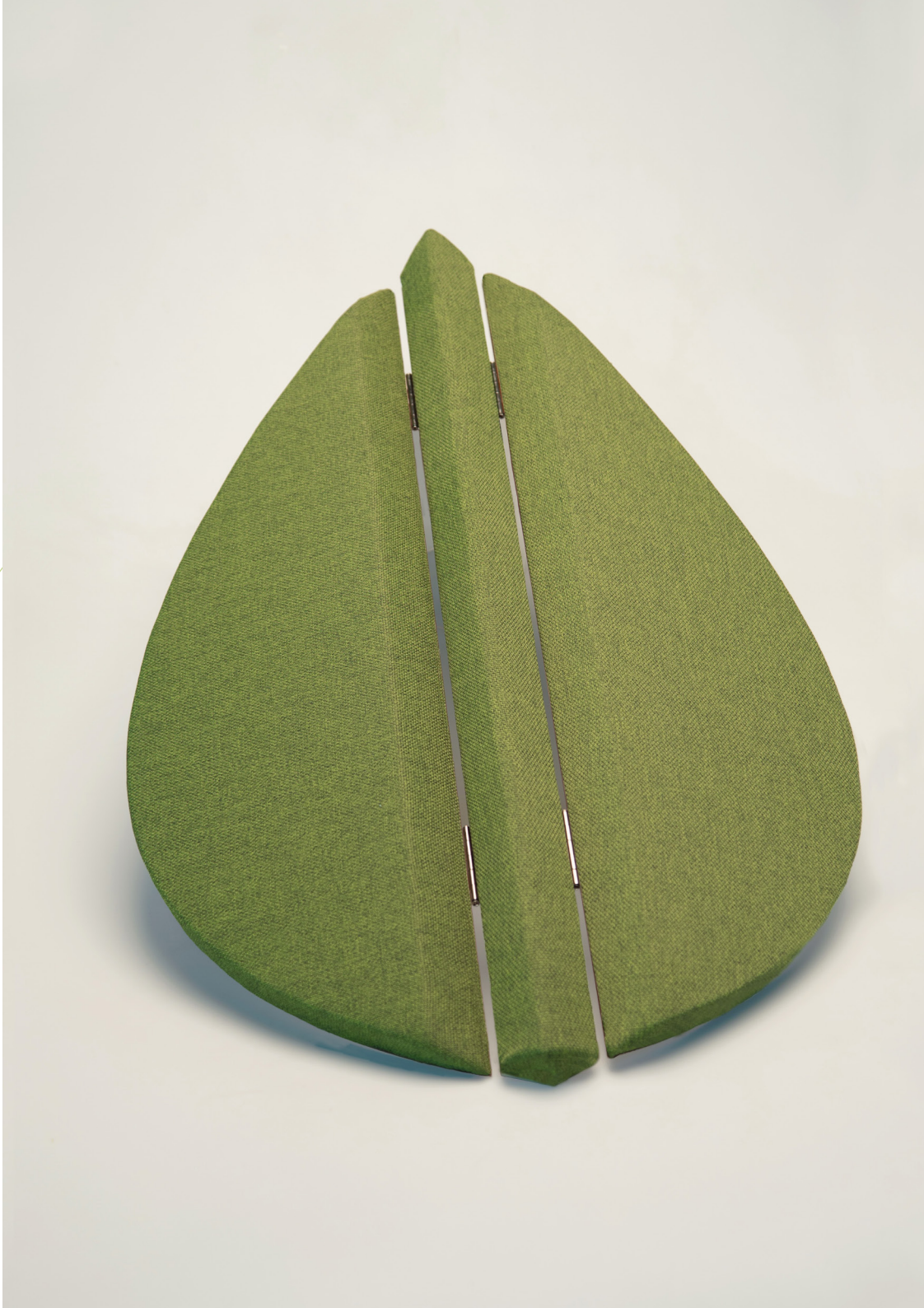
HMW improve the classrooms' soundscape so that it can be flexible and adaptable based on the students and the professors' needs ?

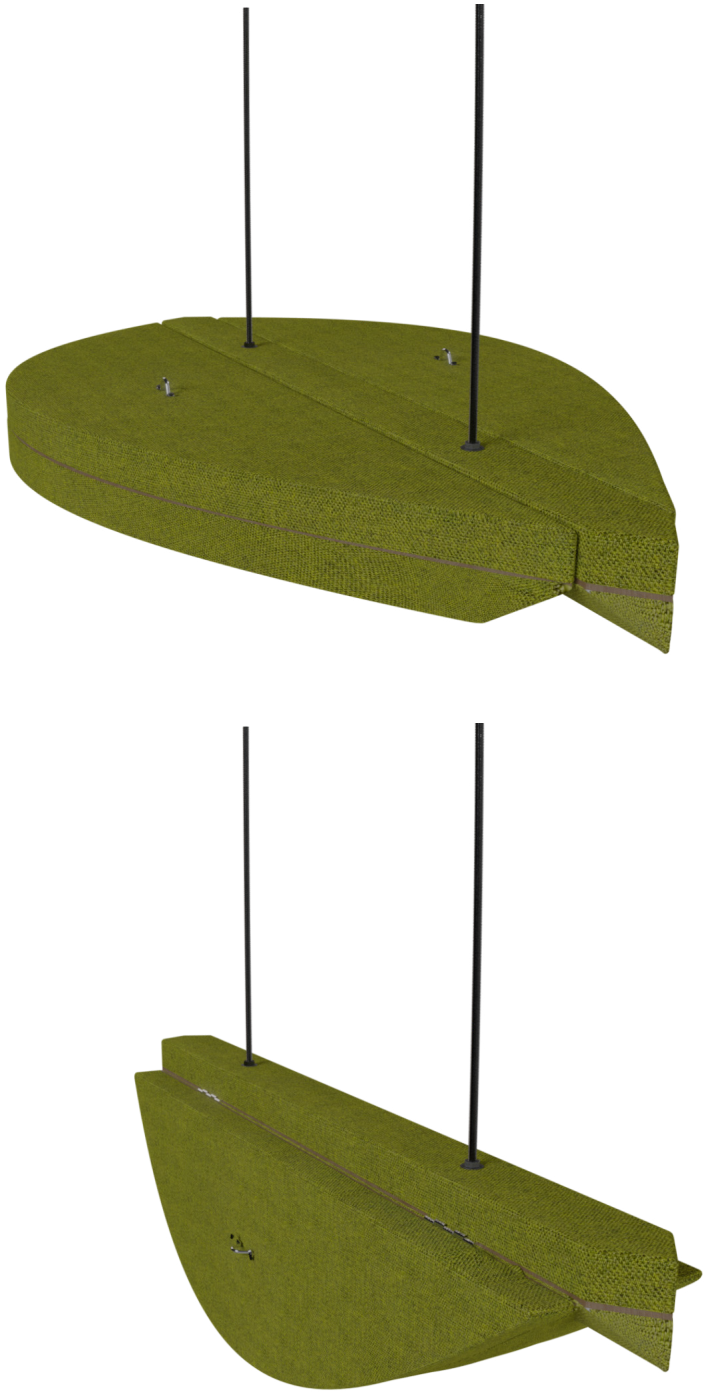
.02 Product

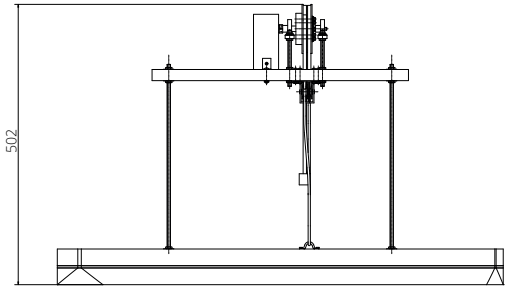
Our Acoustic Panels

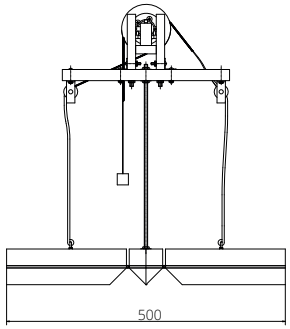
OUR ACOUSTIC PANELS

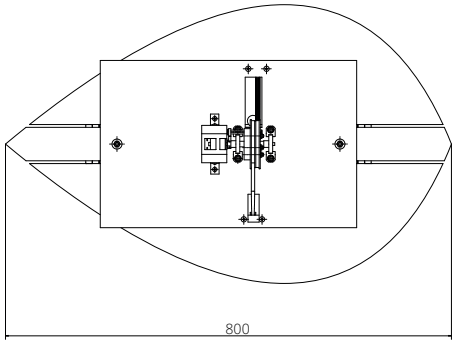
Inspired by the appeasing sound of leaves rustling in the wind, we've opted for a simple leaf shape for our acoustic panels. Similar to the mimosa leaf movement, our acoustic panels open and close in reaction to the sound level of a space, allowing to control sound level and reverberation to create adaptable learning environments. As students fill the classroom the ceiling gradually becomes covered with our vegetation-inspired panels, which open up to reveal their inner material. |Blu:m| panels bring awareness to the sound level through its shapeshift, as they deploy over the ceiling area of a busy classroom.

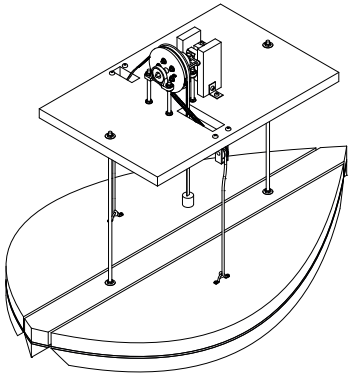




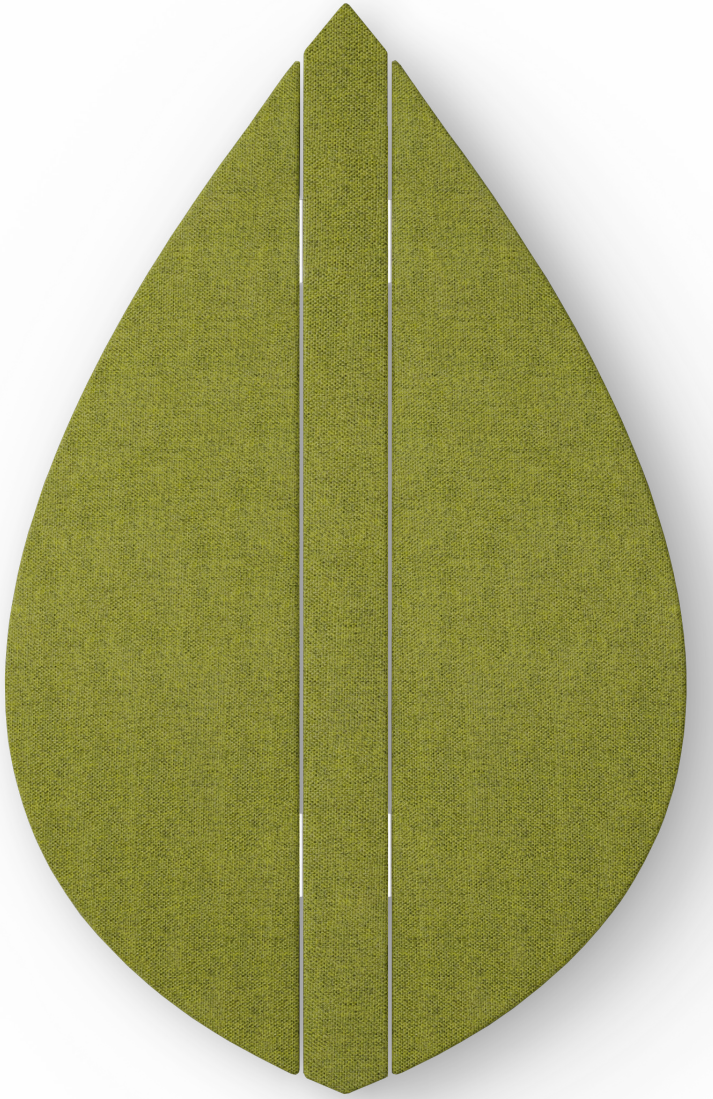


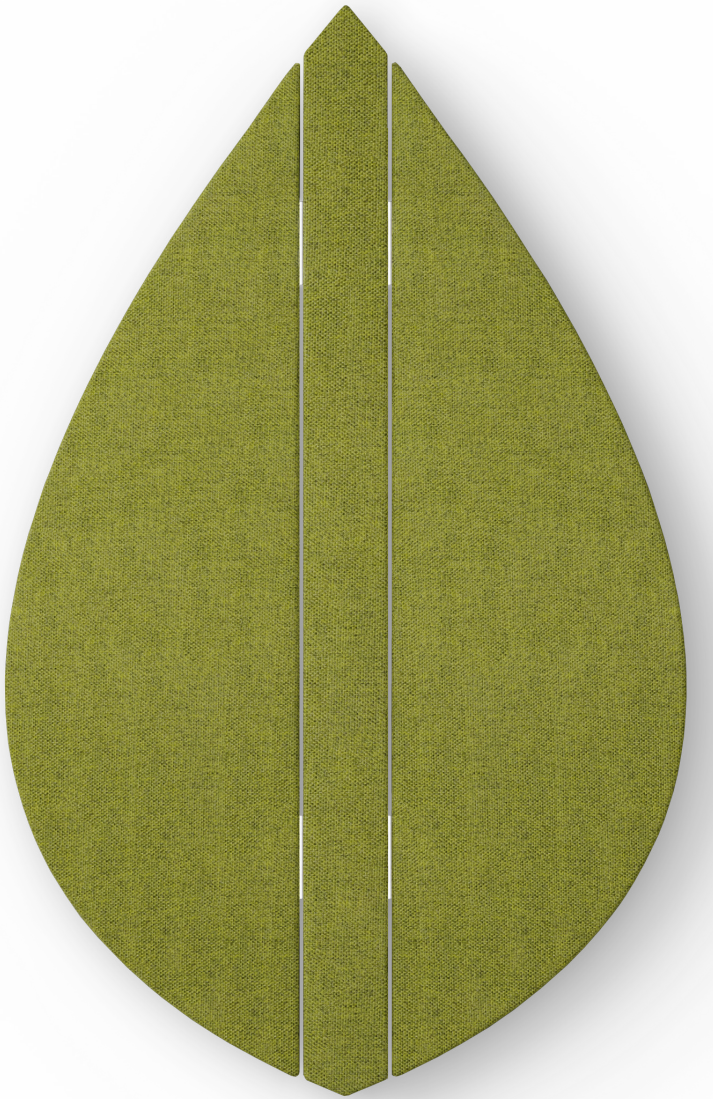






Our leaf-shaped panels are made of a thin layer of plywood covered by Caimi Brevetti patented sound-absorbing polyester, creating lightweight structures to hang from the ceiling. The material developed by Caimi Brevetti is composed of varying density polyester fibres, that works to absorb different sound frequencies. This material is optimised to create acoustically balanced space for humans. The polyester layer is covered by coloured sound-absorbing polyester fabric for a pleasant and soft finish.



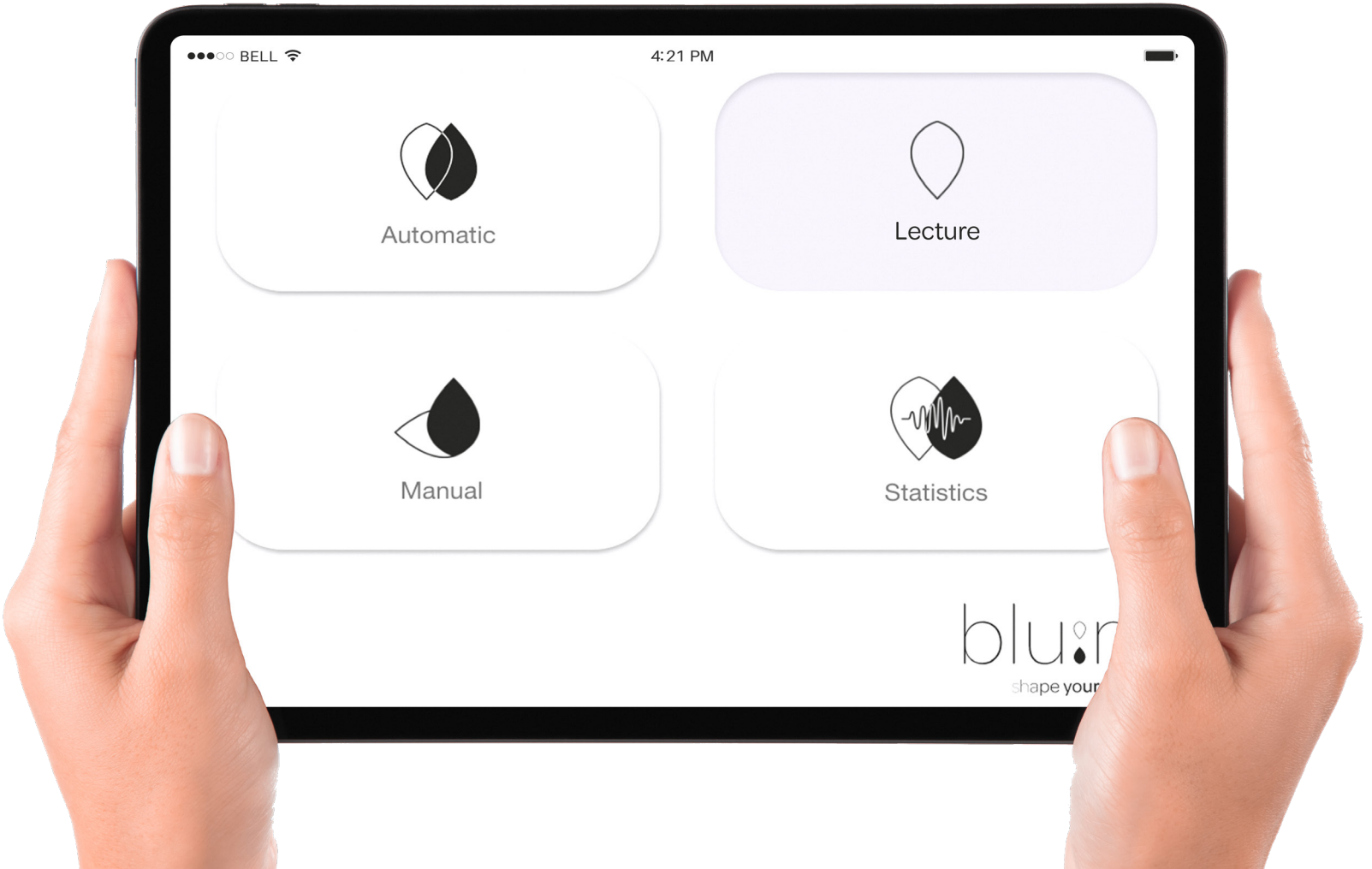


Product .02

In Class System

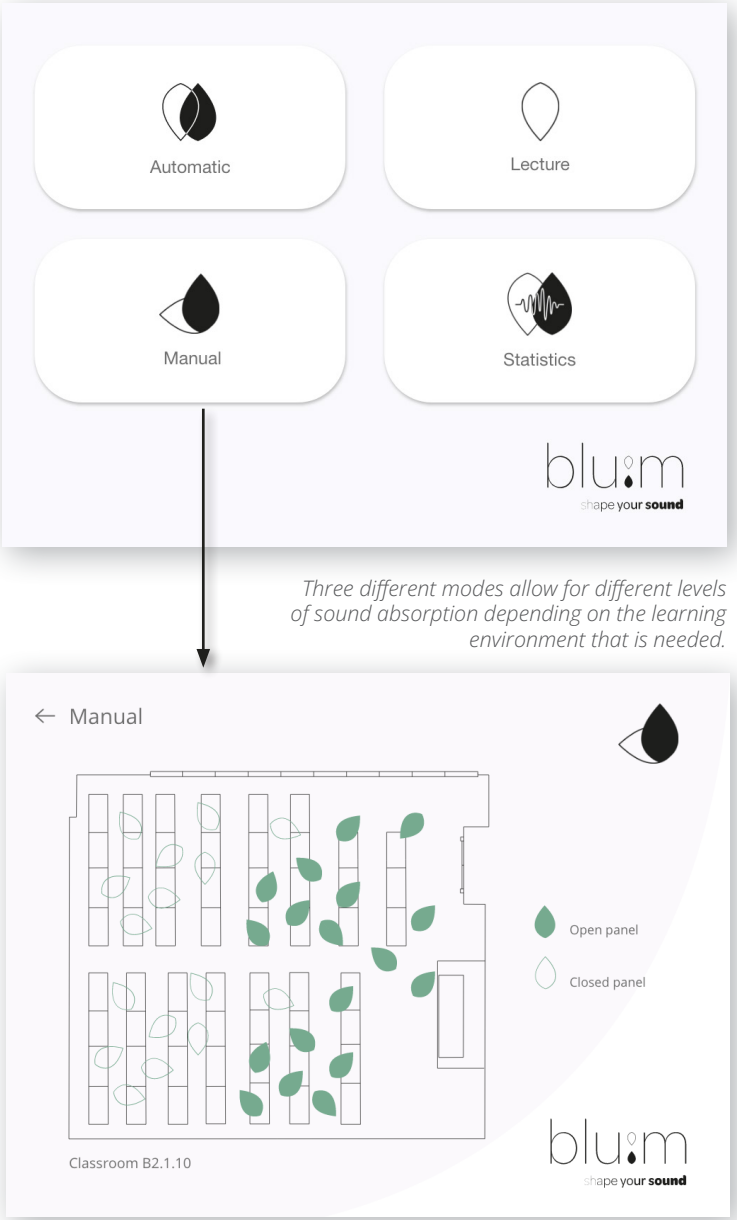
Our system guarantees flexible and adapted soundscapes for classrooms. With both a manual and automatic mode, professors or students will be able to adjust the panels in function of their needs.

Adaptability and awareness are the key traits of our product-service-system as we provide feedback both in terms of the visual interation the panels and statistics provided.



An interactive device mounted on the wall of the classroom allows the users to interact with the system. It can be used to turn the system on or off, change the system's setting, adjust any of the panels, and view the current sound levels in the room that are displayed on a graph.

The system has three settings: the automatic mode, the manual mode and the lecture mode. When put in *automatic mode*, sound sensors will identify the source and position of sound and measure its level in the room. The system will adjust the sound panels accordingly to create the most optimal soundscape. The *manual mode* allows you to manually oper, or close specific panels to achieve your desired sound level. The *lecture mode* creates the best conditions for giving a lecture, so everyone in the room is able to hear the lecturer clearly.



Three different modes allow for different levels of sound absorption depending on the learning environment that is needed.

Manual mode allows professors and teachers to manually manage the sound within a classroom.

Why

Sound is a primary influencer of our well-being in a space, as our appraisal of the space is determined by the sounds that constitute it. Every space has its characteristic soundscape, making it pleasant or unpleasant, stimulating or not, depending of the frequencies and decibels emitted and echoed in it. The acoustic requirements of a space thus depend on its purpose: whether sound should be amplified or dampened.

In the context of higher education, spaces are increasingly required to become multi-functional as ways of teaching vacillate between traditional lectures, group work and individual study. These different types of learning call for adaptable systems with varying levels of sound absorption. For a conducive learning, soundscape acoustics in which you can hear your classmates but you are not disturbed by the sound of drilling outside the window.

Materials

The sound-absorbing panel is made of variable-density polyester fibers and is covered by Snowsound-Fiber 3 Melange Snowcustom fabric, which is made up of soft acoustic polyester fibers that are inherently fire proof and interconnected. The interaction between the Snowsound Fiber fibers and the air allows to control the reverberation by precisely adjusting the acoustic response of the environment, allowing to reduce the disturbing acoustic reverberation in the room.

CHARACTERISTICS

The materials can absorb:

- less low frequencies (below 500 Hz)
- progressively more mid frequencies (from 500 HZ to 2000 HZ)
- more higher frequencies (above 2000 HZ)

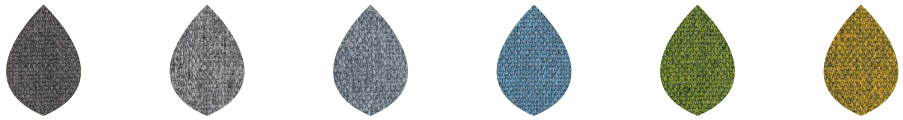
PROPERTIES

Greenguard certification: they have been tested for over 10,000 chemicals and do not emit significant levels of chemical pollutants.

Total recyclability of the product at the end of its life.

The use of high quality materials and workmanship makes it possible to extend the life of the products with consequent lower consumption of materials and energy.

Class 1 Italy of reaction fire and Euroclass B-s2, d0 or B-s1, d0, according to the type of material.



The materials used are entirely made by Caimi Brevetti

.03 Service

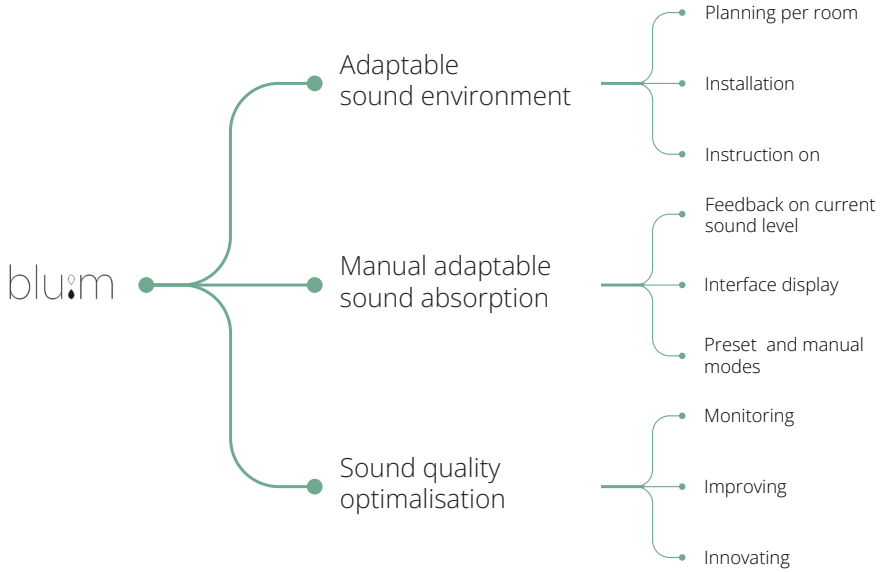
Our Service-System
Offering Map
Stakeholders Map
Service Map
Service Blueprint
Personas
CJ Maps
Business Model Canvas

Our Service-System

The purpose of our service is to provide **the optimal soundscape for different types of learning**. Universities will pay per academic year for the entire sound managing service. This includes the design, materials, installation, maintenance and upgrades of the system.

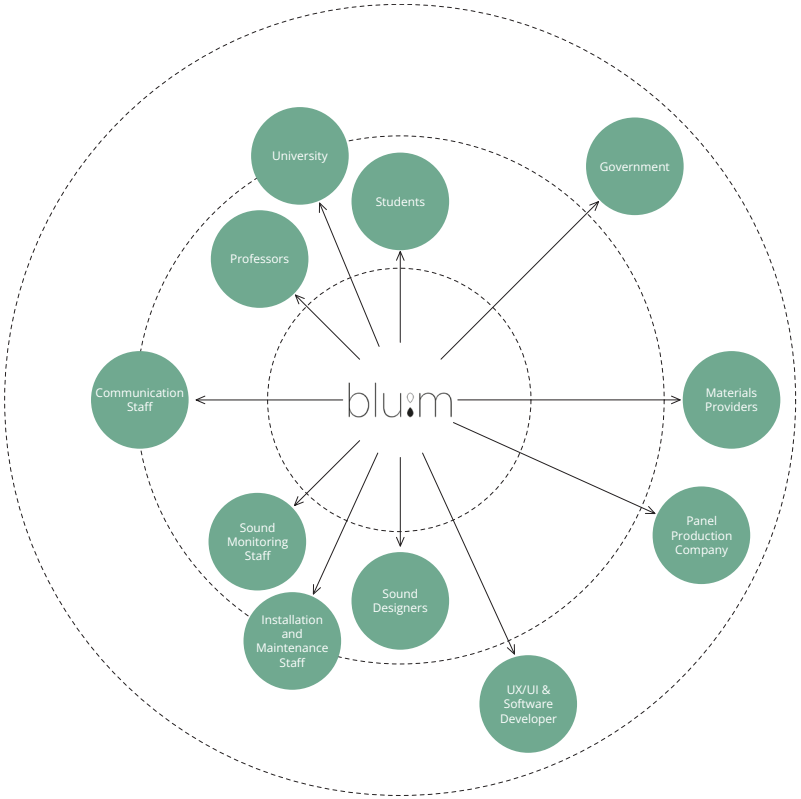
Sound designers plan each room individually. Depending on the material, properties, and the function of the room, they determine the number and size of the panels that should be used for that room. According to this design, the panels are installed in the designated places.

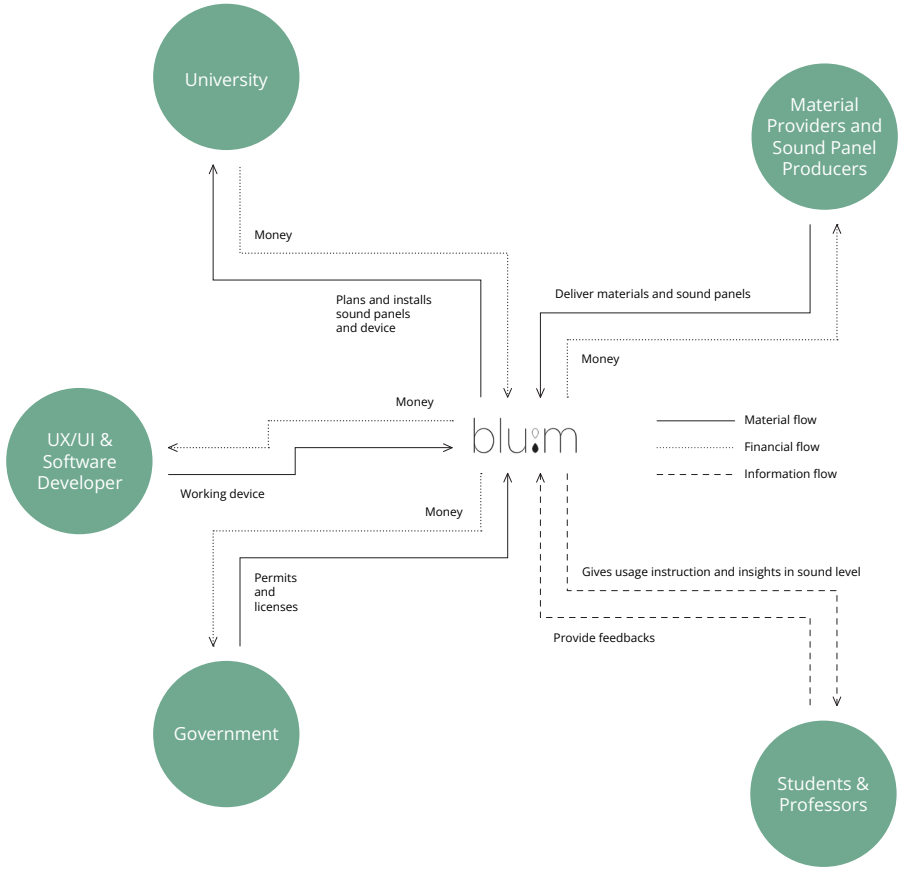
The data collected by the sound sensors will be stored in the company database and will be used to evaluate the effectiveness of the sound panels. This data will be used to optimize the soundscape of the classrom by redesigning the room and changing the type or amount of sound panels if needed in order to create the best soundscape.



Stakeholders Map

The Stakeholder Map identifies all the actors that are involved in our service. Close to the core are the most important stakeholders, which are the students and teachers who are directly interacting with the service. The sound designers, the installation plus maintenance and sound monitoring staff since they have an ongoing role in the service. In the third ring are the people with the more indirect role of providers of the service. These include the material providers, the software developers, the government and the panel production company.

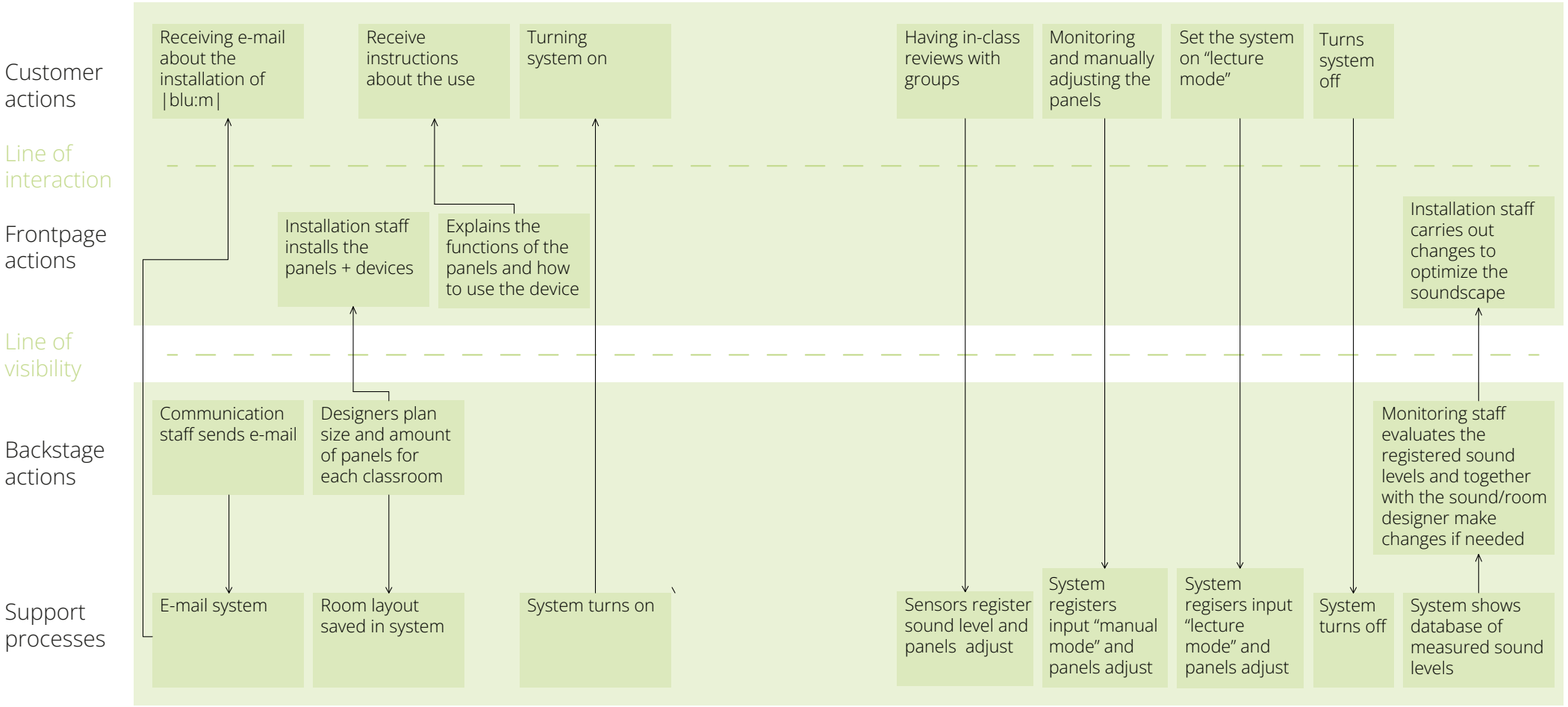




System Map

The System Map shows the value all the actors offer to the service, and what they get in return. It shows the material flows, the financial flows and the information flows.

Service Blueprint



Dario, 20

Personas

"Because i am not able to concentrate and work well in class, I have to catch up on a lot of work once I am home. This clashes with his social schedule and my sport activities"

Focus

– +

Technology-oriented

– +

Practical Theoretical

BIO

Dario is a 20-year-old architecture student at Politecnico di Milano studying in the Leonardo Campus. He is very ougoing and has a lot of friends. He's an energetic guy that plays football and goes to the gym three times a week. In class he often struggles to concentrate as he is easily distracted.

NEEDS

- Lectures alternated with group work sessions for a varied study day
- A pleasant work atmosphere with few distractions
- Flexibility and frequent breaks during the day to be able to stretch his legs

FRUSTRATIONS

He has trouble hearing the professor during lectures and gets easily distracted when working with his group mates. The only way to concentrate in class is to put his headphones on, but this is only possible during the individual work. He's a smart guy but he is not able to work well in class, this means he has to do a lot of work when he's at home.

Giulia, 47

Personas

BIO

Giulia is a 47-year-old professor who teaches urban planning at Polimi's Faculty of Architecture. Teaching for almost 10 years now, she pursues her learning by regularly attending conferences and lectures in her field. She likes the contact with her students the most, which is why she also supervises students during graduation. She sees their relationship as equivocal, learning from them as much as they learn from her. She lives in an apartment in Milan with her two daughters and husband.

"During tutorials, I will ask the TAs to try to ask the students to keep the ambient levels down, but this is also difficult since they are trying to work, discuss things... and at times all of that competes to a level of noise that is difficult."

Focus

– +

Technology-oriented

– +

Practical Theoretical

NEEDS

- Keeping up to date with her knowledge and constantly improving her courses
- A suited (sound) environment for different types of learning that she encourages in her courses: lectures, student reviews and student working in groups
- Being able to have lively discussions with her students

FRUSTRATIONS

Classes are often very noisy and it is difficult to hear students properly when doing reviews. When lecturing, she often finds it difficult to make herself heard properly, due to echoes and poor acoustics in the room. Classes are often chaotic which makes it hard for the students, as well as herself, to concentrate.

Dario

Age: 20 years old
Lives in: Milan, Italy
Study: architecture at Polimi

	PROBLEM		DISCOVERY		USE		
	Dario is working together with his group mates in a classroom on campus.	They are discussing some things about a project but Dario has trouble hearing them properly.	He notices something moving above him and he looks up.	He can hear his group mates more clearly now, and it is easier to discuss things again.	Dario wants to do some individual work, his group divided some tasks. He is distracted by his surroundings.	Dario walks to the tablet and adjusts the sound level to a lower volume.	He continues his individual work and is able to concentrate better.
	"We have a lot of work to do today, I hope it goes well today"	"I can't hear them, there is too much noise!"	"Huh what is that? I think something is moving."	"Wow it is much quieter suddenly, I can finally hear what they are saying."	"I want to finish this as quickly as possible. What is that sound? The surroundings are distracting me."	"Maybe I can change it so it will make the room even more quiet for me, I hope it works."	"I am happy that I am finally able to concentrate and get some work done"
	motivated, annoyed, curious, amazed, distracted, annoyed, hopeful, content						
	Classroom	Classroom	Blum sound panel	Blum sound panel	Classroom	Blum sound panel device	Blum sound panel

Service .03

Giulia

Age: 47 years old
Lives in: Milan, Italy
Job: professor at Polimi

	AWARENESS	DISCOVERY		USE					
	Gets an email about the new sound panels that are being installed with a date to receive instructions.	Has the appointment where she gets an explanation about the use of the sound panels.	Trying out the new product by interacting with the system.	Having in-class reviews with groups.	Notice the panels are adjusting.	Keeping an eye on the sound level in the room as displayed on the tablet.	Adjust when needed	Giving a lecture - set the system on 'lecture mode'	Turns system off when class has ended
	" This sounds interesting, it would be great if this would finally provide a solution for the noise problems in the classroom."	"I hope it won't be too complex to use, I can get confused by interacting with these systems."	"Let's try it out, and see if the panel reacts on my changes on the device." "Wow, it works!"	"It's always difficult to hear the students properly with all the noise in the room during reviews, hopefully it will be better with this system."	"Ah there they go! I can really notice the difference, much better than before."	"Interesting to see how the sound gets on a more constant level once the panels opened.	"I see the sound levels are rising a little, maybe adjust it a bit."	Let's put on the lecture mode.	" Time to turn them off again. They did a great job today by making my job more enjoyable."
	curious	worried	cautious	confident	content	intrigued	confident	determined	pleased
	Laptop	Classroom	Blum sound panel & Interactive device	Blum sound panel	Blum interactive device	Blum interactive device	Blum interactive device	Blum interactive device	Blum interactive device

Service .03

Business Model Canvas

KEY PARTNERSHIPS

With organisations and brands who invest in research to develop innovative materials and technology for acoustic control and sound absorption.

With sound absorption material manufacturers.

With architecture firms who specialise in educational buildings to create optimal layouts.

With designers who specialise in acoustic design to conceive new shapes and design for adaptable systems.

KEY ACTIVITIES

Production of the acoustic panels, installation, and yearly analysis of statistics collected by our sensors for every space they are in.

KEY RESOURCES

Human resources: Sound engineers, acoustic designers

VALUE PROPOSITION

Adjustable sound panels. Both Manual and automatic which allow for varying levels of sound absorptions with a space.

CUSTOMER SEGMENTS

Higher education institutions, academies, schools, universities, collaborative work spaces.

CUSTOMER RELATIONSHIPS

Initial introduction to university staff explaining how the system works when installed.
Personal assistance with email/call.

CHANNELS

Direct communications with institutions through our maintenance and follow up service.

COST STRUCTURE

The cost of production of the panels is paid over time by the institutions which opt for our service, which means there is a part of the initial cost of production that we advance. There is thus a marginal increase in our profit as the yearly subscription fee stays the same, yet the number of panels stays almost unchanged. The yearly fee also covers fixed cost of our staff and the variable costs of maintenance of the panels and potential reconfiguration.

REVENUE STREAMS

Institutions pay per academic year, with an initial set-up fee. This is a lease type service where we take care of the maintenace of our panels and review their layout yearly for optimal classroom acoustics.

.04 Communication

Who We Are
Communication Strategy
Visual Identity

WHO WE ARE

Vision

We believe sound is **essential** for learning.

We believe we learn by **communicating and listening**.

We believe educational spaces should be **adaptable**.

With |blu:m| we provide balanced and adaptable classroom soundscapes for learning during lectures, in groups and when studying alone.

Mission

Enabling educational institutions to **control the noise** in their spaces. Giving students and professors agency over classroom soundscapes, with a simple system which can be adjusted in function of the acoustic criteria of a space. We also want to bring **awareness** to noise pollution through a visual cue, as the ceiling surface area covered by sound absorbing panels will increase in function of sound levels.

Brand Statement

For teachers and students in higher education who need adaptable conditions to achieve optimal learning in different educational situations, |blu:m| is the solution that offers conducive soundscapes by providing them a sound-absorption system that adjusts itself in function of a space, and allows them to feel agency over how they want to learn.

Communication Strategy

Our product-service targets educational institutions. Our brand identity revolves aroud simplicity, conveying that something as complex as sound control can be made simple. Our communication strategy focuses on awareness of noise pollution and the importance of sound in education, to convey the importance of our offer/ service.

Certified classrooms. All our spaces have a plaque at the entrance to mark our service of sound control.

Naming

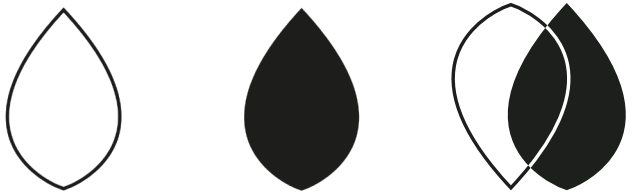
|blu:m|

|blu:m| is the phonetic spelling of bloom, evoking the act of flowering. We chose the **phonetic spelling** as we wanted our name to refer both to sound and nature, representing our concept, our product shape, as well as, its movement. Just like a flower our product blooms in order to absorb the sound of a classroom. The movement is insipired by that of mimosa plant whose leaves fold and droop when touched or shaken.

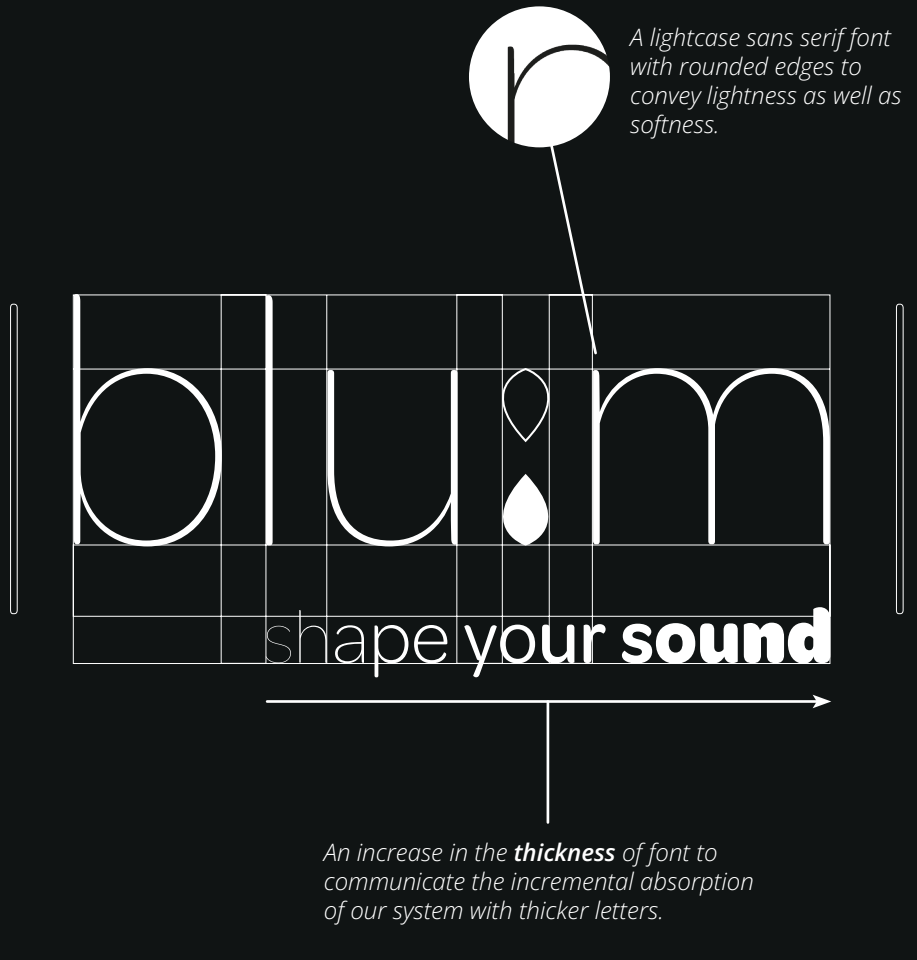
Logotype

For our logo we wanted to associate the natural leaf shape of our product with our concept of adaptable sound environments. This is why we chose the phonetic spelling of our product name, incorporating the leaf shape in the phonetic triangular colon.

The dual function of the product is represented by having one leaf as just an outline, representing the reverberating aspect of our product, and the other as filled, representing the absorbing qualities of the product. In the pictogram, these two elements come together as the two leaves overlap, emphasising adaptability of sound as the core element of our concept.



Reverberation Absorption Adaptability

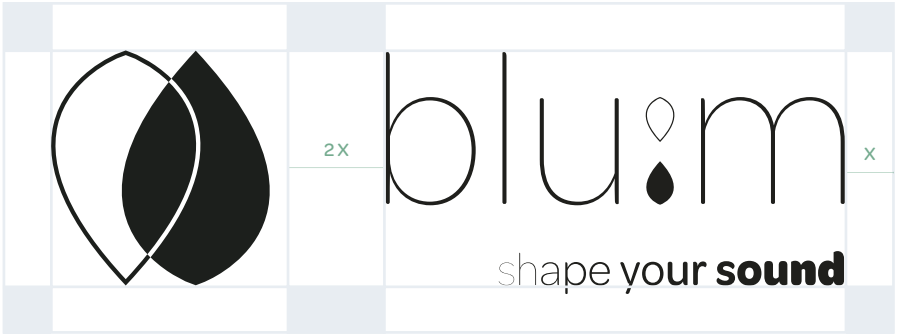


Application

Our logo is composed by an icon and a logotype of our name with our payoff written underneath. These two elements can be used separately or together depending on the context.

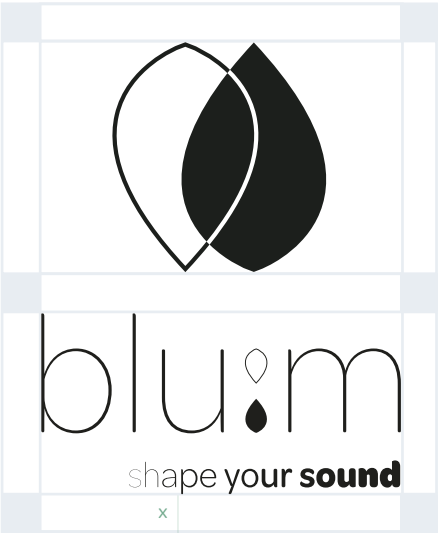
blu:m

shape your **sound**



blu:m

shape your **sound**



Payoff

shape your **sound**

Three words which explains what our product enables the user to do. The user is empowered through this phrase as they can shape their learning environment. The function of our product is rendered visually through the gradual increase in font weights, also putting the emphasis on the word “sound”.

Typeface

Omnes SemiCond

Omnes Font is a typeface with many variations, that belongs to the Sans-serif family. We chose it as we wanted a font with many weights to correspond with the adaptability of our product. The various weights, from hairline to black, also allow us to visually render the progressive absorption of the sound

Designed by Joshua Darden and released by Darden Studio, it is available with four different widhts such as namely standard, narrow, semicondensed, and condensed. Each widths available in nine weights with matching italics.

Hairline

Thin

Extralight

Light

Regular

Medium

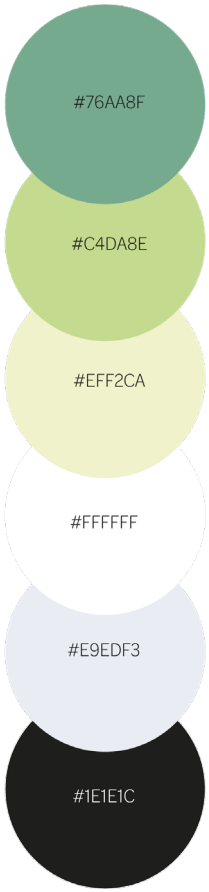
Semi Bold

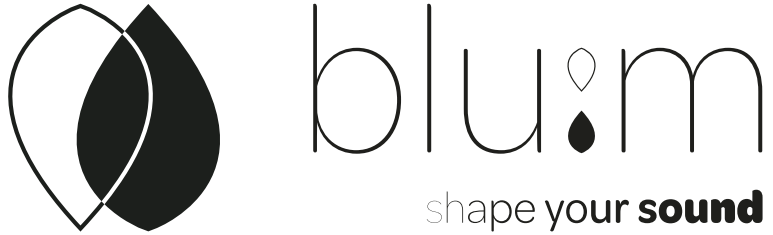
Bold

Black

Colour Palette

Our palette conveys nature and simplicity, alongside the dual function of our product with contrasting colours. The off-black and white are balanced with green tones to reminisce our leaf inspired shape as well as the appeasing sounds of nature and vegetation.





TEXTURE

To add dimension to our communication elements we've incorporated texture which reminds the absorbing polyester. This is to use as a background, giving a cushion like feel to our communication element.

.05 # Annex

Product Development
Caimi Brevetti
Mechanism
Discussion

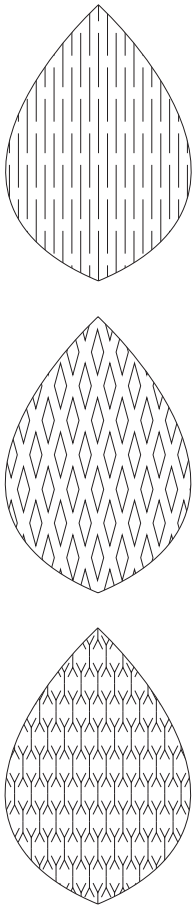
Product Development

SHAPE AND FORM

Once we had defined our concept of adaptable sound panels we started thinking of possible shapes and structures which would allow for this. Our first shapes were rather complex and imposing, requiring complex mechanisms to make them work. We used paper and metal wire to create our first prototypes, which resembled bulbs that opened to reveal the sound absorbing material. From this we simplified our shape to create a simple and elegant leaf.

WORKING THE PLYWOOD

The next step involved understanding how to work the plywood to develop our leaf shape. Using first cardboard, we tested different folds and cuts to obtain a curved leaf. We also tested on different thicknesses of plywood to find a balance between rigidity and flexibility. This was done by creating cuts in the wood, first by hand then by laser cut for preciseness. At the end we decided to not use any cuts, since in combination with Caimi's material, which is quite stiff, it would not make any difference in flexibility.



SOUND ABSORBING MATERIAL

In parallel to developing our wooden structure we researched and tested different options for sound absorption. By looking at what was being produced by acoustic brands, we saw that there were a variety of different materials that could be used, such as wool fiber, polyester, foam, felt, etc. We were initially interested in felt, as an eco-friendly and low-cost material, and we experimented with different ways to fold it. However, after some simple testing we were doubtful of how effective it would be to absorb enough sound, unless it covered most surfaces of a room. Our consultation with Caimi offered the solution to this dilemma, as he provided us with specially developed sound absorbing fabric that we could use, making our prototype functional.

Felt

Caimi's fabric

Caimi Brevetti

For our project we had the honour of receiving guidance and support from Caimi Brevetti, one of the most renown acoustic research and design firms in Italy. Driven by how to design for societal impact, Caimi Brevetti are continuously researching how to manage sound in spaces by developing sound absorbing material and designing acoustic panels. Over the years, they have created a wide line of acoustic furniture in collaboration with designers, winning numerous prizes and international recognition.

RESEARCH CENTER

In order to create the highest standard materials, Caimi have invested in a lab to research and test the quality of their products. With high precision tools they test their designs under different conditions and scales. Starting by observing how sound travels through small samples of their materials they move on to test their products in radically different sonic environments. These include in the reverberation room, to see how a product affects the echo of a room, as well as the anechoic chamber, which allows to test their design in a completely sound neutral environment. They open their lab to artists and universities to conduct research on sound.

SNOWSOUND

Snowsound is their patented polyester sound absorbing material. Made by combining different density polyester in order to absorb different frequencies of sound, this material allows for the human voice to travel perfectly in a space, as the high frequency of consonants and the low frequencies of vowels are absorbed equally. Their design thus create balanced acoustic environments for people to listen, communicate, and concentrate in. This material is cut into different shapes and sizes and covered by their woven polyester fabric, also developed with sound absorbing qualities.

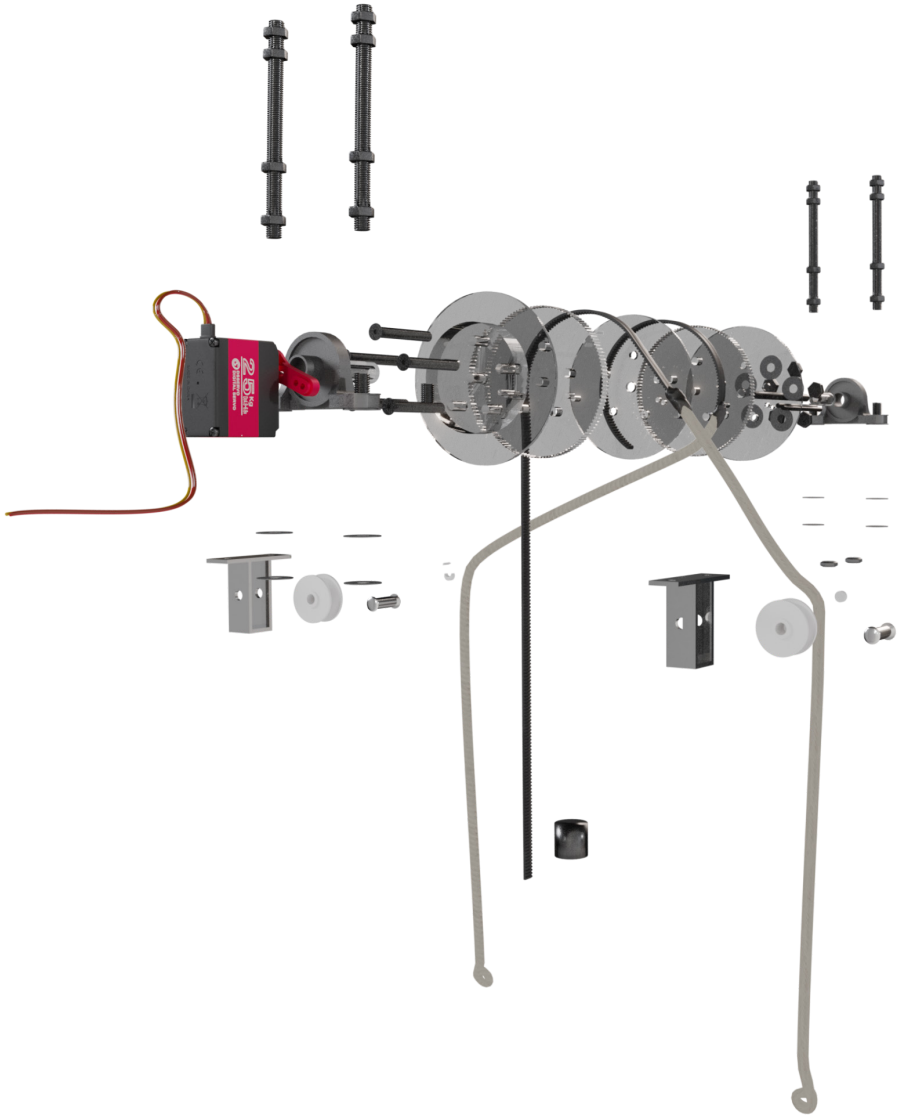
Anechoic chamber

Reverberation Chamber

Mechanism

SENSOR TO THE MOTOR

There are several parts that construct the mechanic system: there is a microphone, an Arduino Mega, a breadboard, a resistor, a capacitor, a servo motor, and a DC adaptor. The microphone is connected to the Arduino and senses amplitude, however, to get a loudness the circuit on the breadboard has been modified. A program monitors the microphone input and then calculates an average over 1000 milliseconds. If the average value is higher than the designated value, the program fires a signal to rotate the servo motor 180 degrees which is connected to the gear that pulls up the leaf panels. This is an iterative sequence and at the end of each sequences it evaluates if the environment is too loud or not and if it's not it will close.



PULLEY

The pulley is connected directly to the servomotor. Since the servomotor can only rotate 180 degrees, we calculated that the diameter of the pulley needs to be 82mm to pull the needed length of the belt that is needed to rotate the panel 90 degrees (double the length - the length that was needed to pull in order to rotate the panel 90 degrees (see the equation) divide by π and the diameter will be 82mm. However, there does not exist a timing pulley with 82mm diameter in the market, so we had to design a custom pulley which was made by laser cutting acrylic panel. We also made some holes to strengthen the cylinder and make it stable, and prepare the bearing to hold the whole structure.

EQUATION

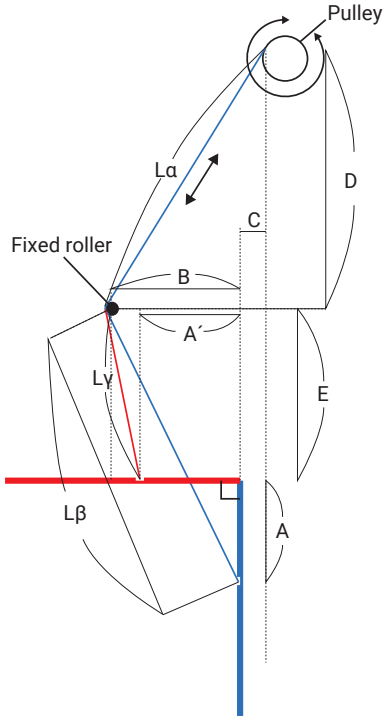
How much length of the belt that has to be pulled in order to rotate the panel 90 degrees
= Lα+Lβ-(Lα+L γ).

Blue line represents a belt when a panel is closed.
Red line represents a belt when it' s open.

$L\alpha = \sqrt{((B+C)^2+D^2)}$

$L\gamma = \sqrt{((B-A)^2+E^2)}$

$L\beta = \sqrt{(B^2+(E+A)^2}$



MODIFIABLE PROGRAM

```
//Parameters
#include <Servo.h>

Servo name_servo;

int servo_position = 0;

#define OFFSET 350
const int micPin = A0
#define PERIOD 50
int n = 0;
int maximum = 0;
int sumVol = 0;
int border = 50;
short flag = 0;
//Variables

int micVal = 0;
int volume = 0;

void setup() {
  // put your setup code here, to run once:

  name_servo.attach (10);

  Serial.begin(9600);
  Serial.println(F(!Initialize System"));
  //Init Microphone
  pinMode(micPin, INPUT);
}

void loop()
{

  ++n;
  if (n==PERIOD)}
  //set servo according to maximum
  if (sumVol / n > border){
    if(servo_position < 180){
      flag = 1;
      }

    for (; servo_position >=180; servo_position +=1){

    name_servo-write(servo_position);

}
      if/flag==1){
       d...
```

Discussion

Through our research, we understood how technical and complicated the study and mastery of sound is. This was further validated by meeting and talking with Franco Caimi who explained that there are precise parameters to respect in order to create a balanced sound with a space. This made us realize once again the value of the involvement of an expert and for further development of the product we recommend a collaboration with Caimi.

Our design changed throughout our process as we confronted our ideas to sound experts and became aware of the complexity of sound. We first wanted to create a system which could both absorb sound and reverberate it. The difficulty with this was due to the physical properties of how sound travels. As it expands through space at 360 degrees the control of sound reverberation is extremely technical and requires for a precise point from which sound is emitted. This is why we focused on the sound absorbing qualities of our product, looking at how we could create a balanced and adaptable acoustic environment.

Our prototype contains some limitations, and should not be seen as the exact representation of our final design as it can be optimised for the purpose we are seeking to achieve. The prototype is there to provide a general idea of the looks and function of our product. For acoustic panels to work optimally in a space they should be entirely covered by sound absorbing material. However, due to the weight of the material provided to us combined with the wood, we only covered one side so that our motor would be strong enough to lift both sides of the leaf. For the final product it is essential both sides are covered as the flat wooden surface has neither optimal sound absorption nor reverberation properties.
Ultimately, the wood could be subtracted from our product to create lighter and more efficient panels.

FUTURE DEVELOPMENT

The potential future development of our project would be to test our product with test in different acoustic environments, following the process shown to us by Franco Caimi, in order to optimise our product. Once we've refined our panel, the next step would be to develop the mechanism and system in order for them to work within a classroom space, figuring out the layout of the panels as well as the sensors. The sound parameters our sensor react to would also have to be tested with users, in order to understand the decibel level, frequencies, and time lapse our program must account for. Advice for follow-up research is to perform user tests to test the usability of the system and to see where improvements are still needed to meet all the user needs.

As a team we can be very proud of what we have achieved. A project like this is never completely finished, but within our limited timeframe we have learned and achieved a lot. We all come from different educational backgrounds, which had its challenges but ultimately resulted in a rich result. All our different expertises came together in this project where we could all contribute something different, and complement each other.

“Thank you”