“Sensing Ecology”: Electronic Circuits and Programming from Designers to Citizens
从设计师到市民，制作和编程电子电路

Learn the basics of electronic circuits design, fabrication and programming to create your own smart device.

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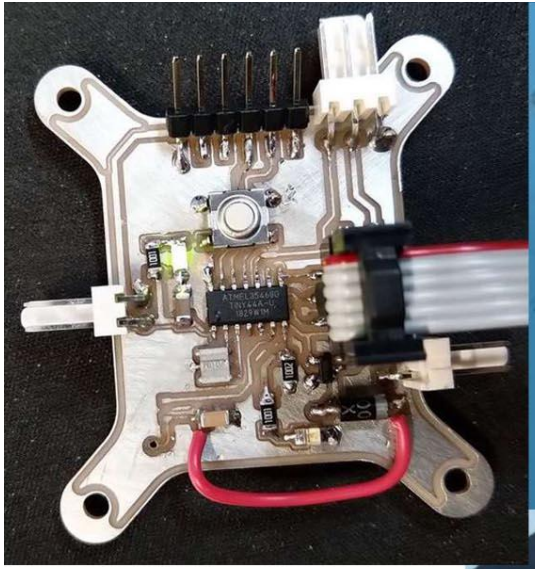
TA: Zhu Ziyi

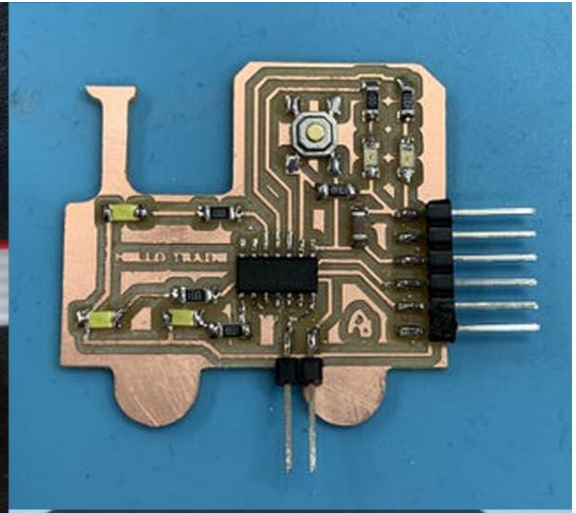
国家自然科学基金委员会
National Natural Science Foundation of China

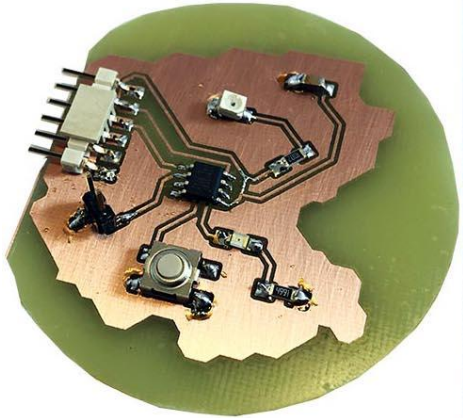
ECOLOGY AND CULTURES INNOVATION LAB
生态与文化创新实验室

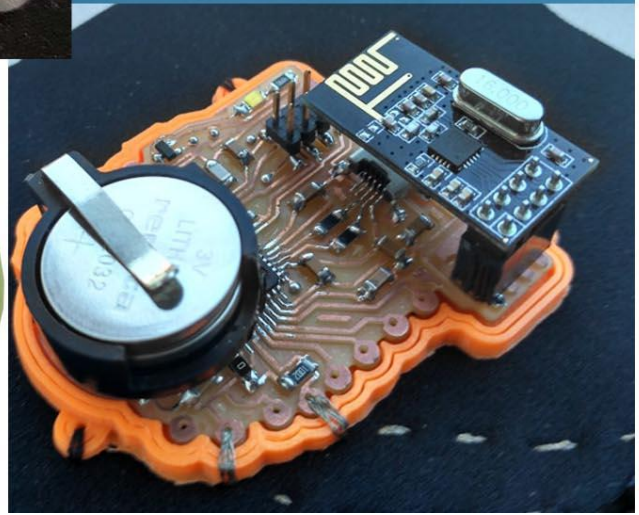
Fablab O | Shanghai
中国第一个“全制”开放创新实验室

DESIS tongji Design for Social Innovation and Sustainability
同济大学 社会创新与可持续设计实验室

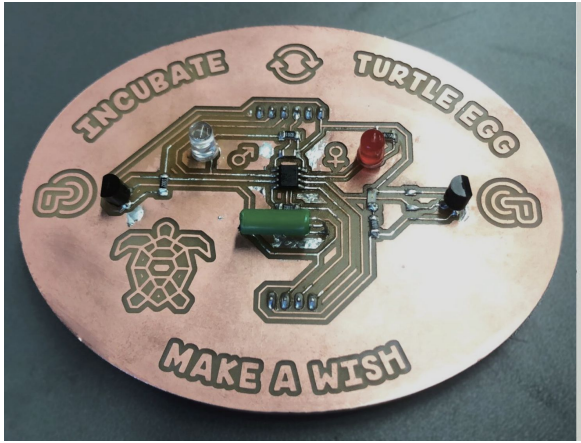


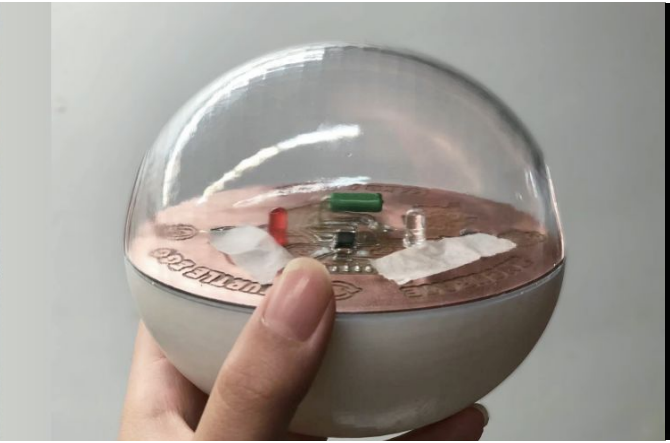


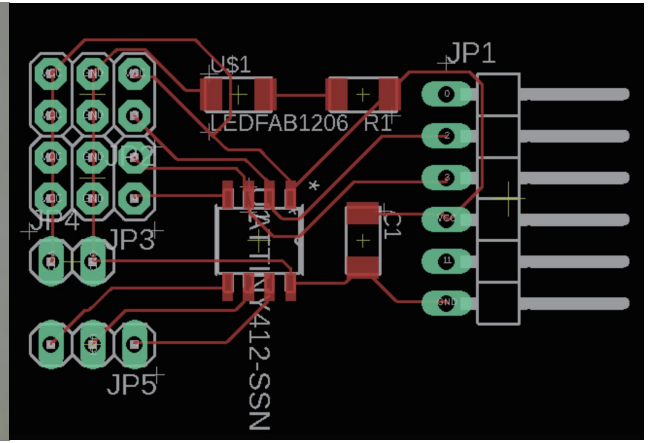


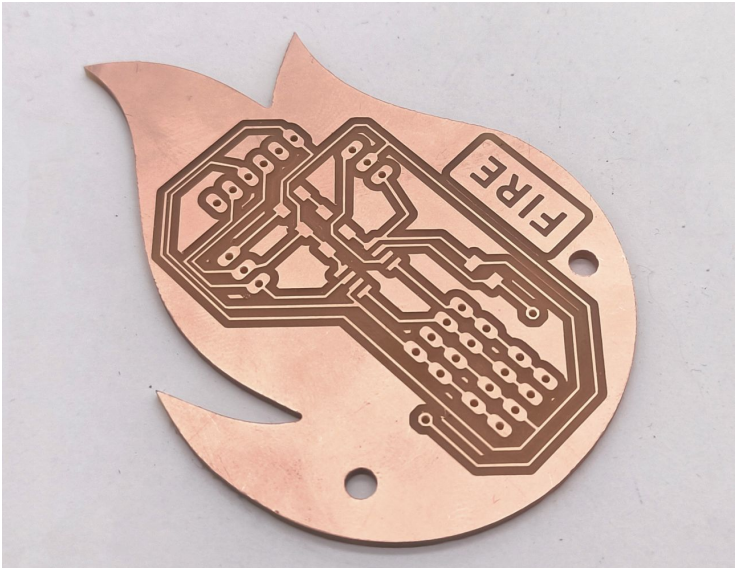


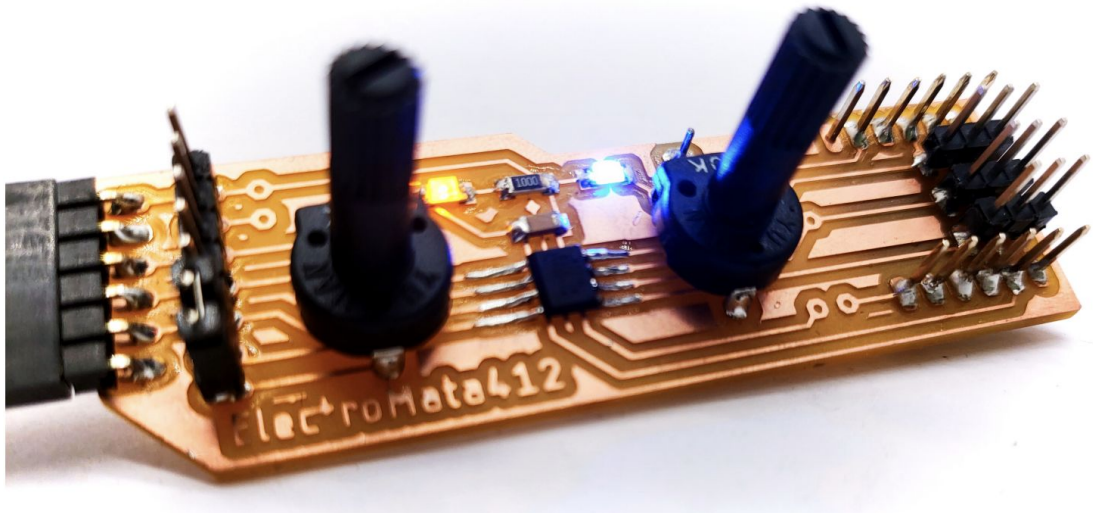

Raphael 10/14
ELECTRONICS
DESIGN
HOW TO
ALMOST
MAKE
ANYTHING
THE SQUARE HOLES HERE IS TO THE CRAZY
ROUND PEGS IN
THE TROUBLEMAKERS, THE
OMES, THE MISFITS,
HOLES HERE IS T
TROUBLEMAKERS, THE

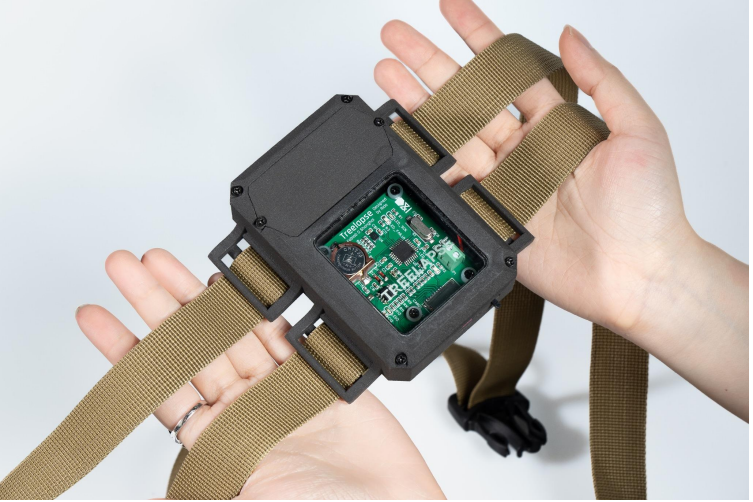

INCUBATE
TURTLE EGG
MAKE A WISH

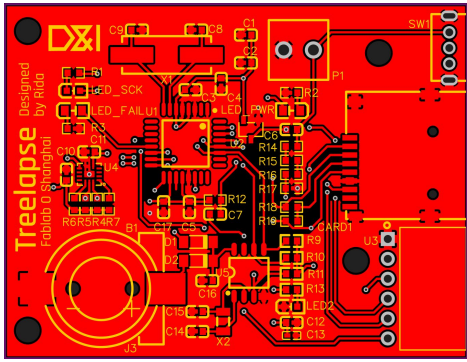


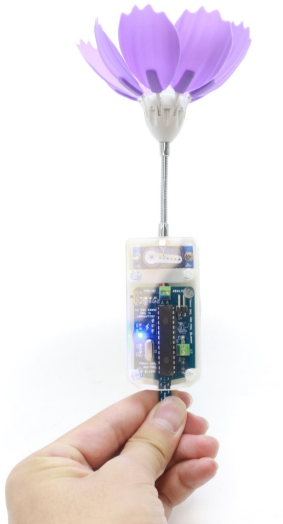

U$1
LEDFAB1206
R1
JP1
JP4
JP3
JP5
C1
ATTINY412-SSN

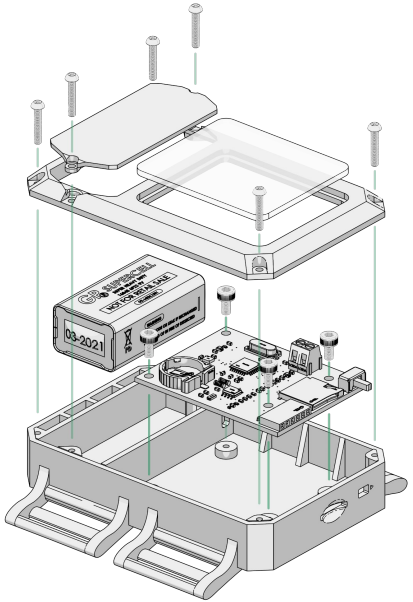

FIRE


fabtroMata412


Treelapse
TREELAPSE

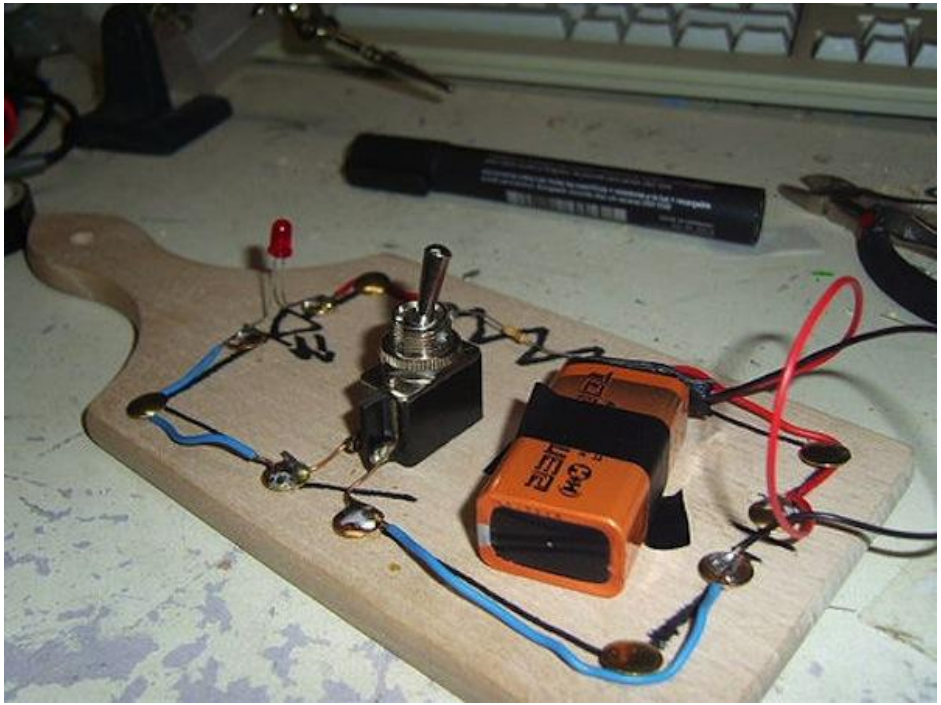

Treelapse
Designed by Rida
Fabilab D Shanghai
LED_SCK
LED_FAILUR
LED_PWR
SW1
P1
J3
X2
B1
CARD1
LED2




03-2021

Why designers want to learn circuits?

"To design smart products, the designer cannot be dumb."



The design of a product is not limited to the exterior shell, but it extends to the **integration** of form, structure, functions and interactions. The electronic system is an integral part of the whole system and must be understood.

Ultimately a designer that understands electronics can asks better questions *to* and better understands answers *from* experts.

Why making your own PCB?

"Can't I just go on Taobao and order it?"

Like 3D printing, before making it, you need to design it

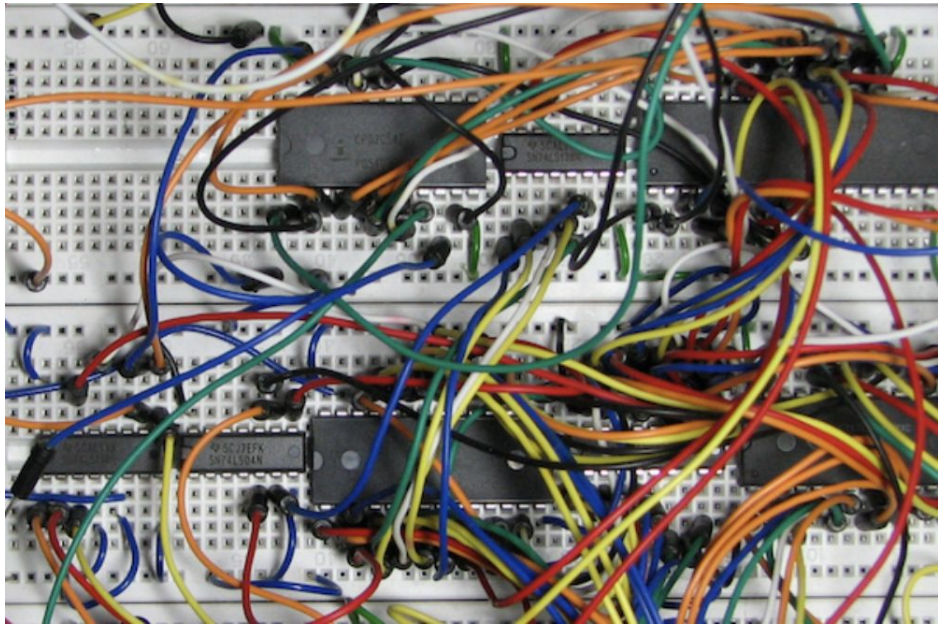
Unlike 3D printing making only one PCB is not economically feasible (must have minimum quantities)

PCB are screen printed, so an expensive screen setup is required

A circuit can be prototyped on a breadboard, but it leads to unwanted problems: loose connections and tangle of wires

Why making your own PCB?

“Can’t I just go on Taobao and order it?”



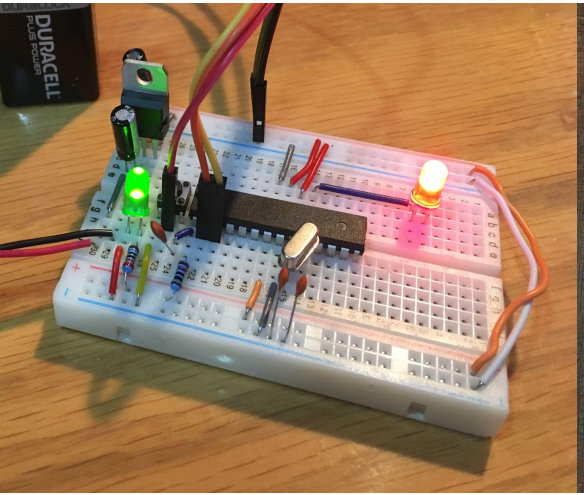
A circuit can be prototyped on a breadboard, but it leads to unwanted problems: loose connections and tangle of wires

Designing a PCB on a laptop and manufacturing it with a desktop CNC machine is easy and makes a reliable and usable circuit.

Later, when the prototype is tested and approved, the production will be sent to a factory

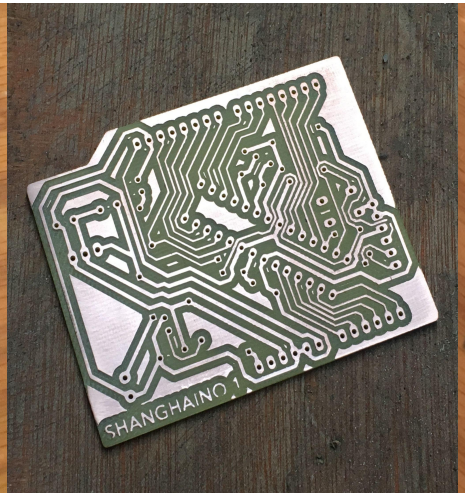
Why making your own PCB?

"Can't I just go on Taobao and order it?"



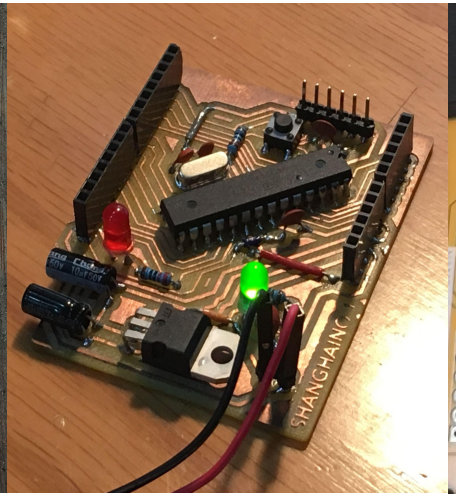
Breadboard prototype

1 Hour



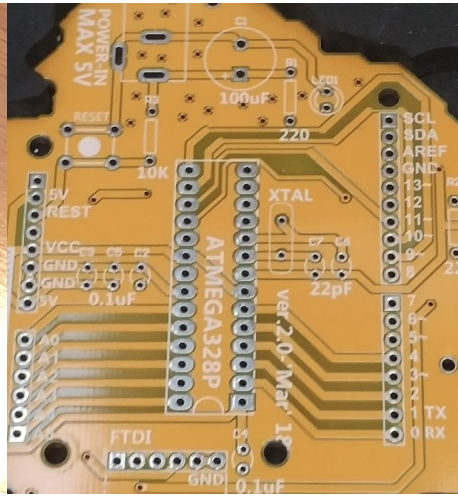
CNC manufacturing

1 day +



Working prototype

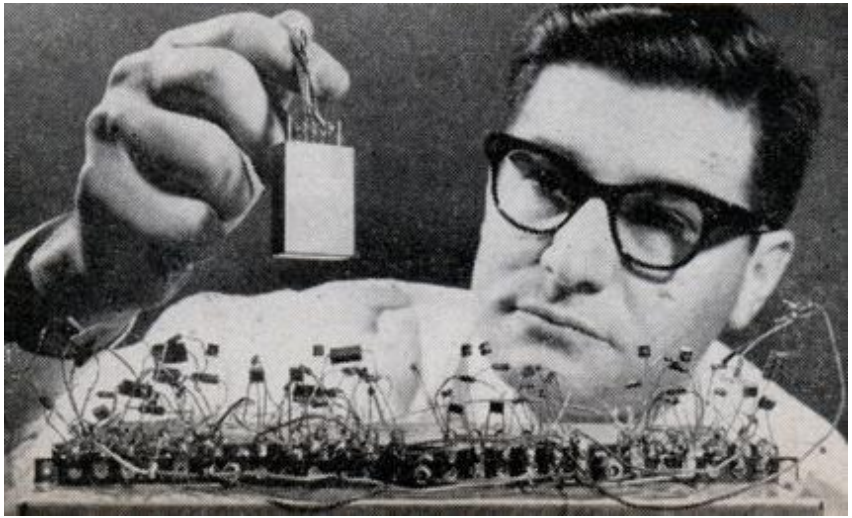
2 days +



Factory made

1 week +

How to learn circuits without ***a 5 years Master in Engineerings?***



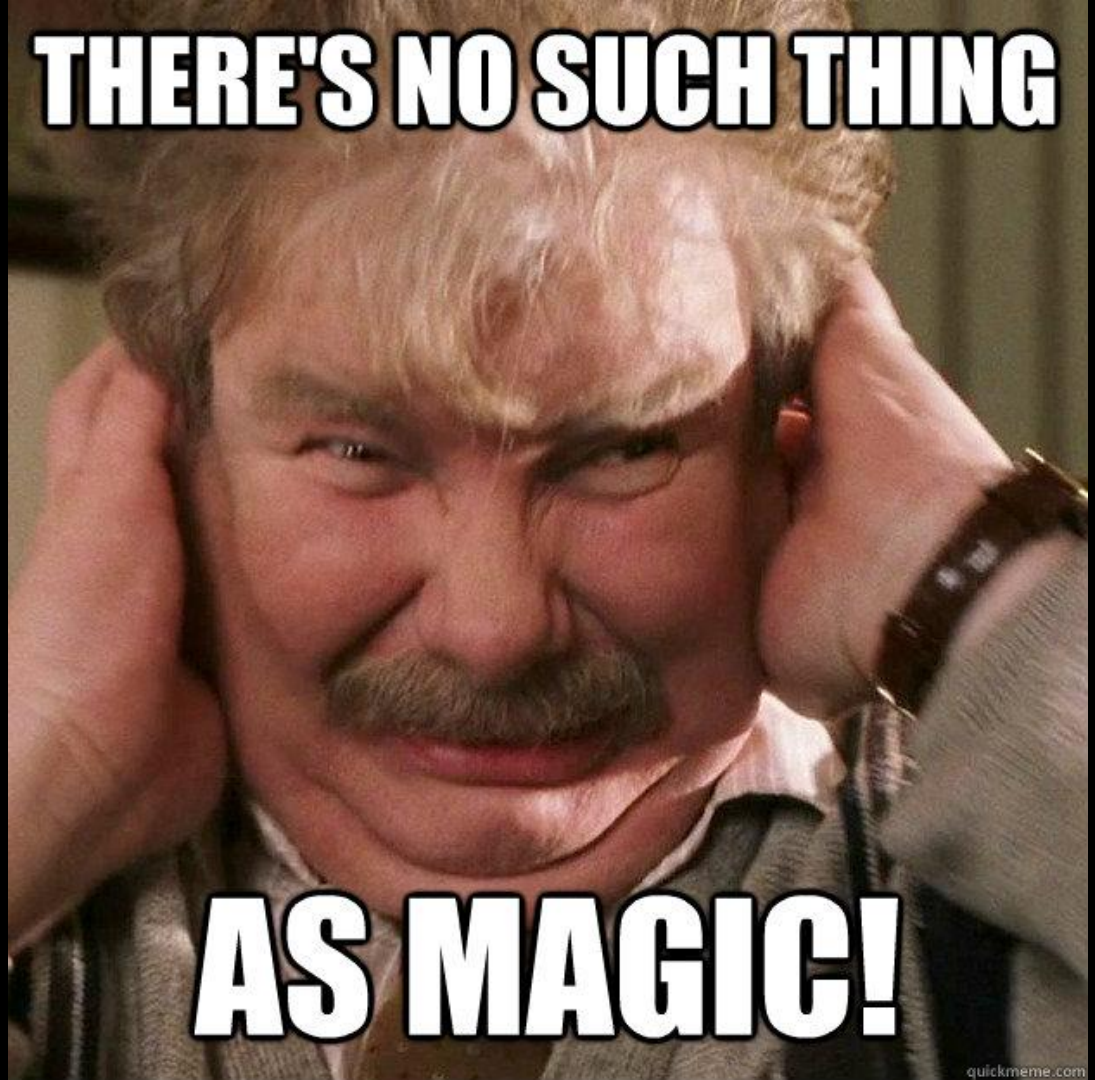
Use a mix of “**top-down**” and “**bottom-up**” learning approach.

Learn a few basic components of the subject and apply them in practical situations to build knowledge step by step.

How to learn circuits without ***a 5 years Master in Engineerings?***

Accept a certain level of **uncertainty**: be comfortable with *ignoring* most of the subject while making use of only the small portions needed to progress.

It can be frustrating when you can't explain certain things...


THERE'S NO SUCH THING
AS MAGIC!
quickmeme.com

Open-source material

The material used in the course is based on “How To Make (Almost) Anything” course from MIT and Fab Academy curriculum. All the material is freely available online at:

www.fabacademy.org

Topics

- Citizen science, urban nature, deep ecology.
- Basic electronic circuits and components theory.
- Electronic circuit design software (Autodesk Eagle).
- Circuit board fabrication (high precision CNC milling) and SMD soldering.
- Input and Output devices and breadboard prototyping.
- Embedded programming (Arduino Software).
- System integration (electronics packaging and user interaction).

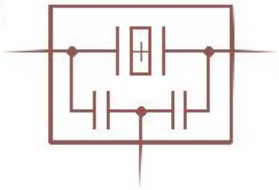
ELECTRONIC COMPONENTS & SYMBOLS

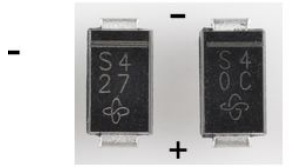
TRANSISTOR

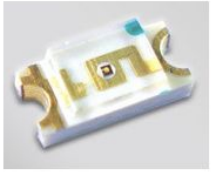
Transistors is the most important component of modern electronics. They are used as a digital switch in a variety of function.

CRYSTAL/RESONATOR

These components are also called clocks and they are like the Orchestra Director of the circuit: they emit a frequency that is used by the other components to align to the same timing.



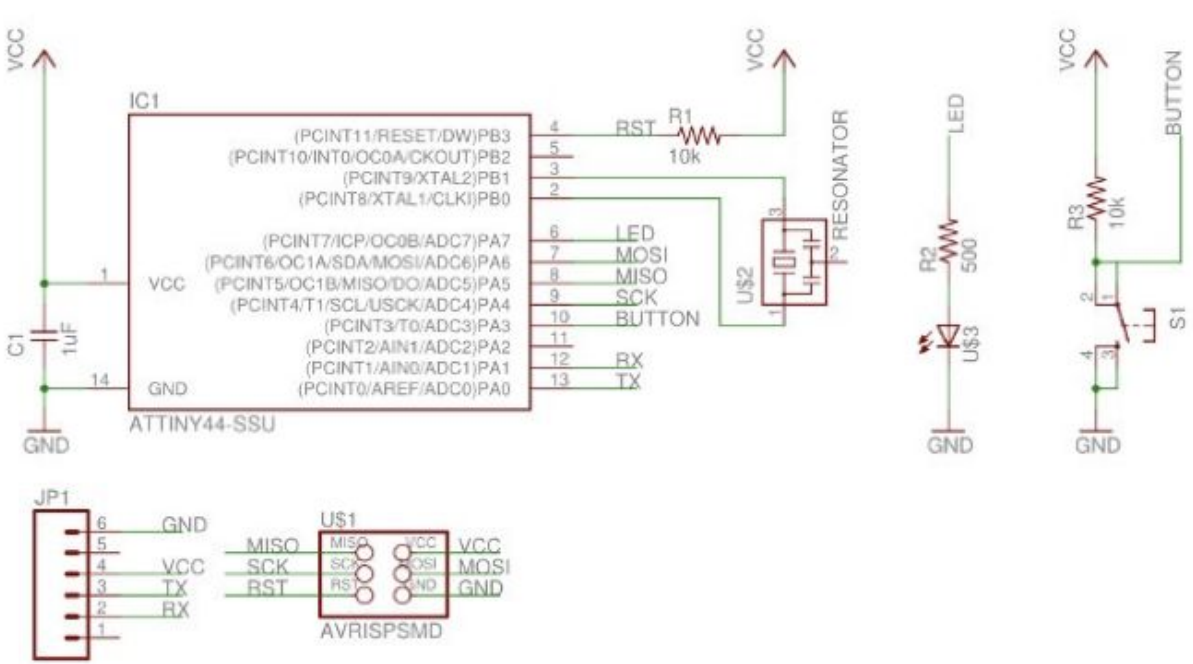




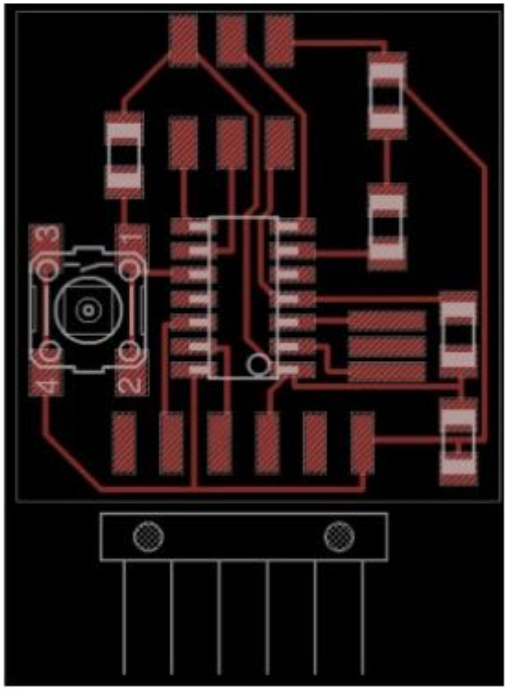
MICROCONTROLLER

The brain of the circuit. It can be programmed to make something using its input and output pins.

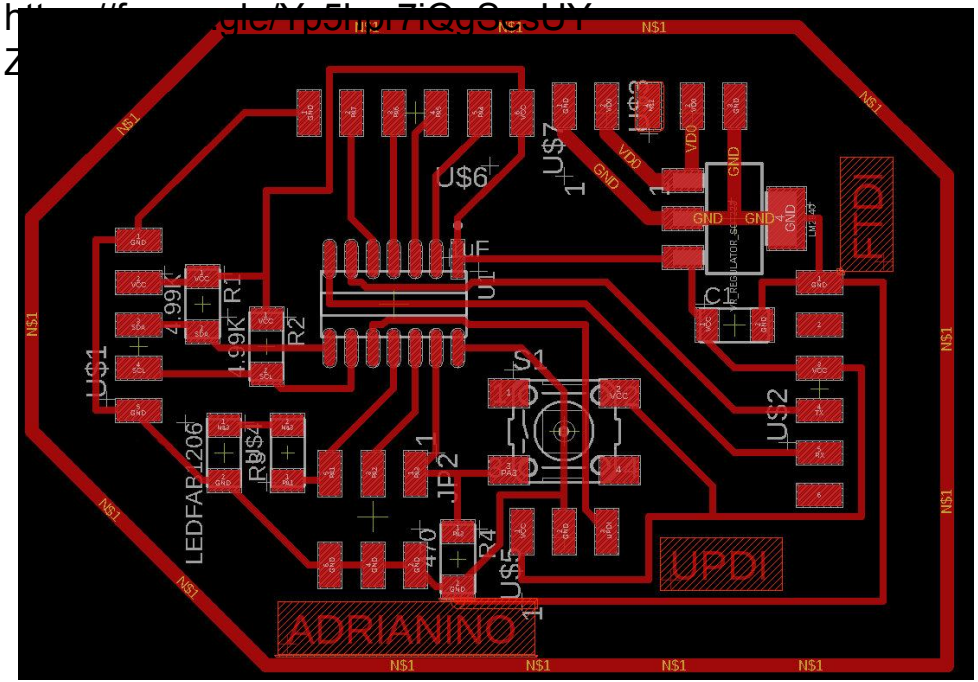
PCB CAD SOFTWARE

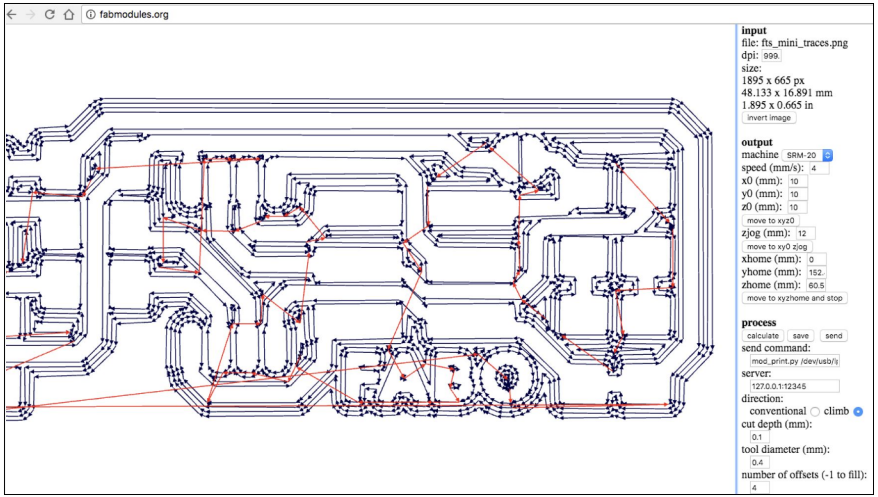


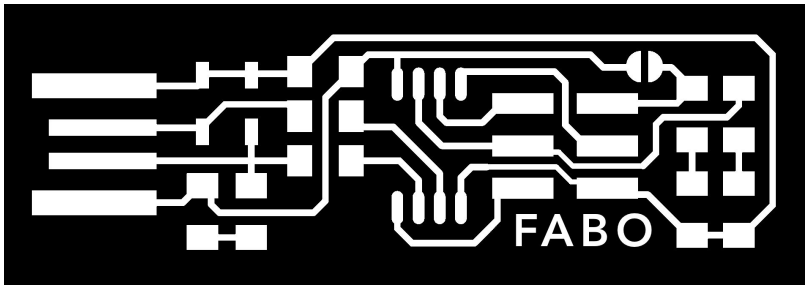
Schematic

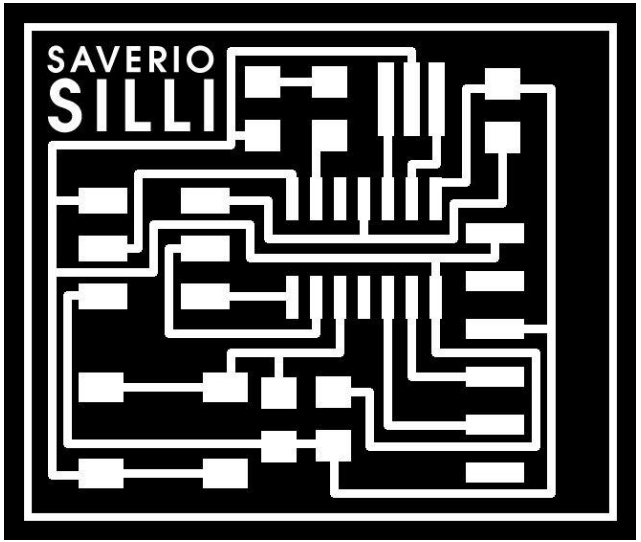


Board


N$1
U$6
U$7
U$3
U$1
U$2
U$5
R1
4.99K
R2
1.99K
R3
470
R4
S1
C1
LEDFAB1206
FTDI
UPDI
ADRIANINO

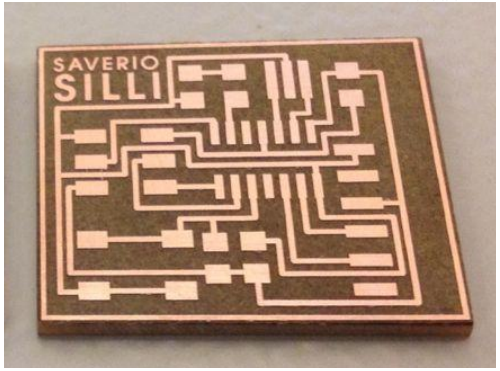

fabmodules.org
input
file: fts_mini_traces.png
dpi: 999
size:
1895 x 665 px
48.133 x 16.891 mm
1.895 x 0.665 in
invert image
output
machine SRM-20
speed (mm/s): 4
x0 (mm): 10
y0 (mm): 10
z0 (mm): 10
move to xyz0
zjog (mm): 12
move to xy0 zjog
xhome (mm): 0
yhome (mm): 152.
zhome (mm): 60.5
move to xyzhome and stop
process
calculate save send
send command:
mod_print.py /dev/usb/ls
server:
127.0.0.1:12345
direction:
conventional climb
cut depth (mm):
-0.1
tool diameter (mm):
0.4
number of offsets (-1 to fill):
4


FABO


SAVERIO
SILLI


Roland
monoFab
SRM-20


1/32 inch bit
for cutting out
the board
1/64 inch bit
for milling traces


SAVERIO
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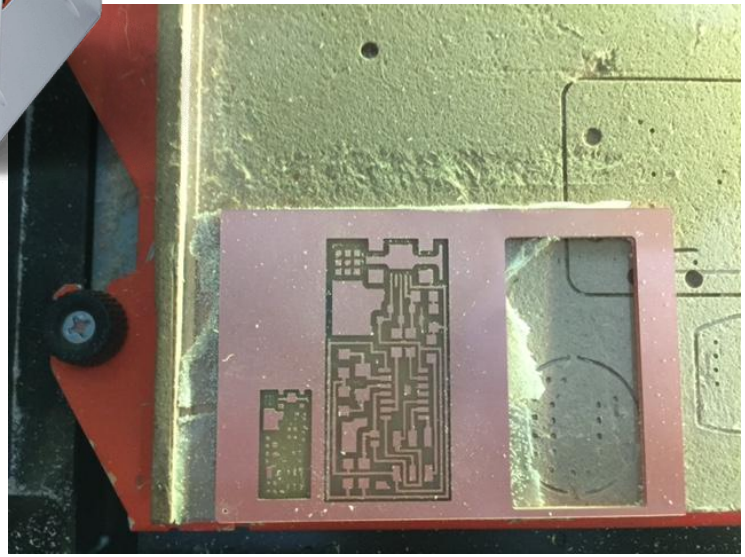
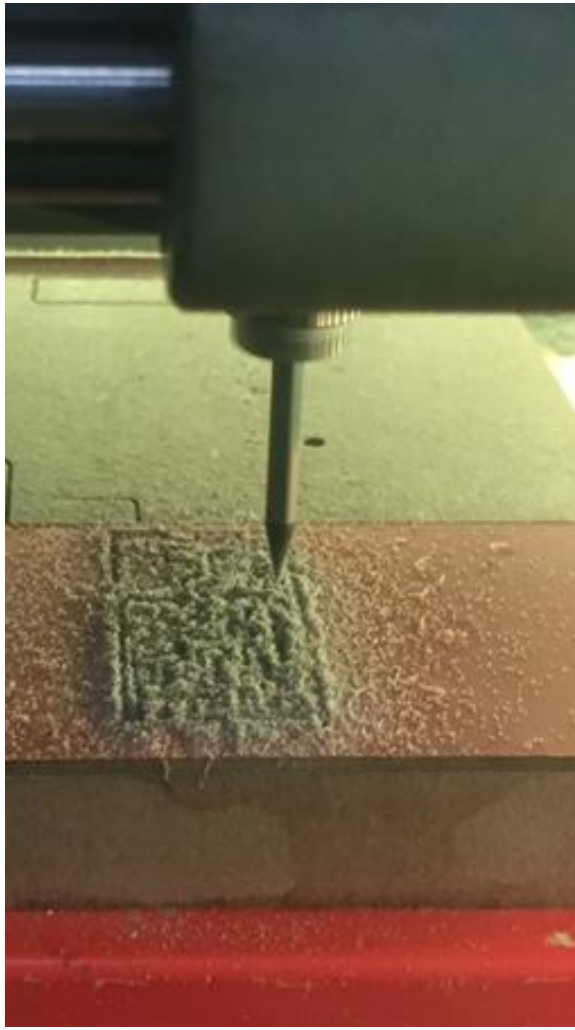




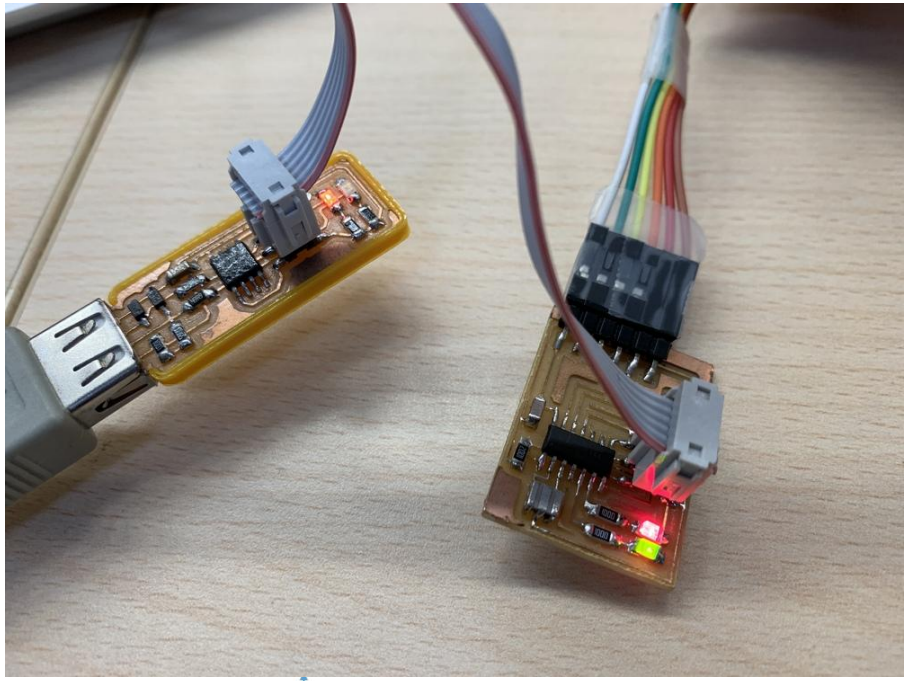
MAPPING ANALOG INPUTS TO ANALOG OUTPUTS

Now that we can **read** values from an analog sensor (0 to 1023) and **write** values to an analog output (0 to 255), we can use the Map function to make them equivalent

```
outputValue = map(inputValue, 0, 1023, 0, 255);
```

- name of the variable
- name of the function
- extremes of the first range of values
- extremes of the second range of values

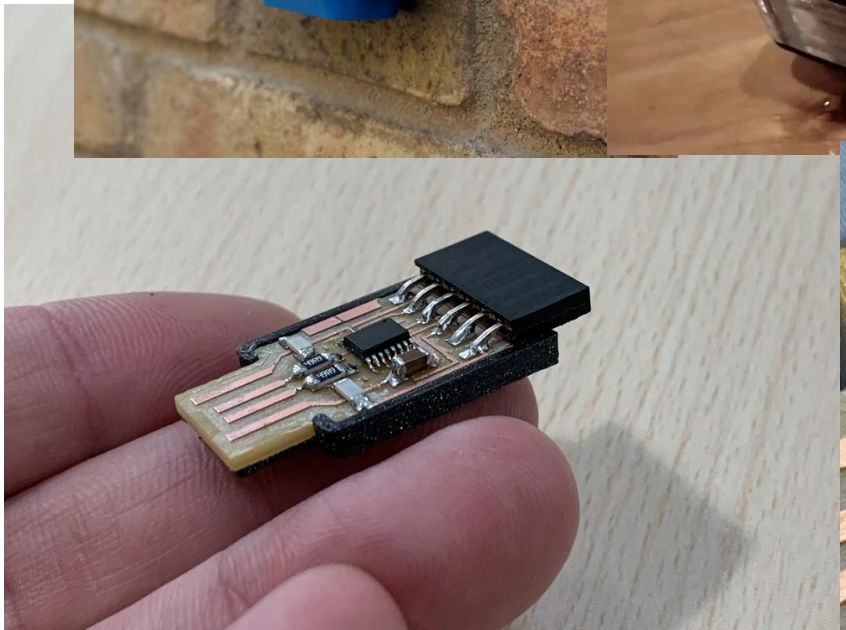
```
avrdude: verifying ...
avrdude: 1 bytes of hfuse verified
avrdude: reading input file "0xFF"
avrdude: writing lfuse (1 bytes):

Writing | ################################################## | 100% 0.00s

avrdude: 1 bytes of lfuse written
avrdude: verifying lfuse memory against 0xFF:
avrdude: load data lfuse data from input file 0xFF:
avrdude: input file 0xFF contains 1 bytes
avrdude: reading on-chip lfuse data:

Reading | ################################################## | 100% 0.00s

avrdude: verifying ...
avrdude: 1 bytes of lfuse verified

avrdude: safemode: Fuses OK (H:FF, E:DF, L:FF)

avrdude done.  Thank you.

MacBook-Pro-de-nicolas-viollier-2:fabISP_mac.0.8.2_firmware nviollier$
```

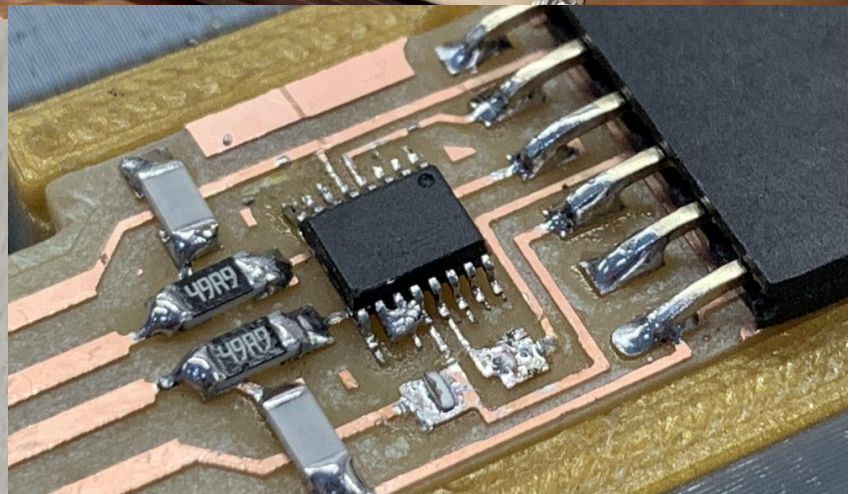


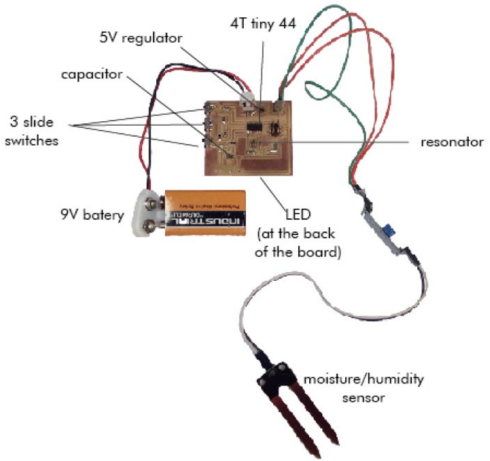
```
int i=0;
while(i<10) {

  digitalWrite(led, HIGH);
  delay(100);
  digitalWrite(led, LOW);
  delay(100);
  i = i + 1;
  }
```

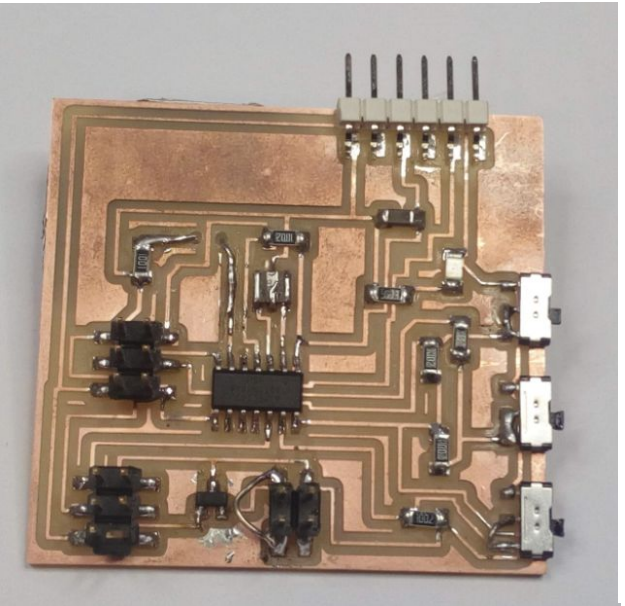
- name of the function
- things that will happen at every loop, until the condition is satisfied.
- increase the value at every loop


Citizen Science Faire
NO2 Sensor
(Nitrogen Dioxide)
CAN









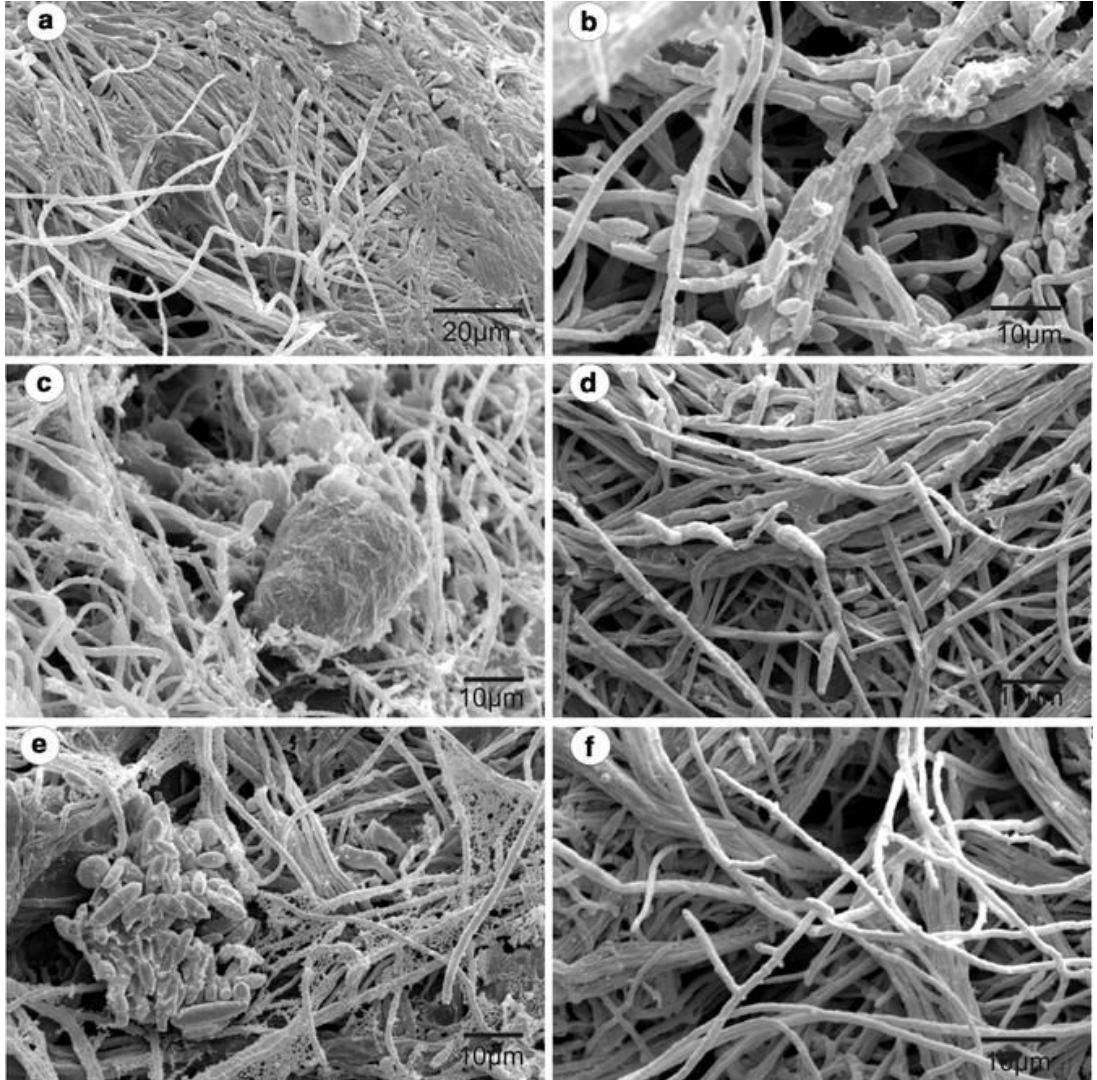
COMPONENT	PRICE
PINE TREE WOOD (6 cm x 8 cm x 5 cm)	$3
BLUE ACRYLIC (6 cm x 8 cm x 3mm)	$2.5
BLACK STICKER (6 cm x 8 cm)	$0.03
COPER PLATE (5cm x 5 cm)	$2
9v BATTERY	$4.5
SLIDE SWITCHES (x 3 units)	$0.06
CAPACITOR	$0.03
RESISTOR (x 3 units)	$0.50
5v REGULATOR	$0.03
AtTiny 44	$0.92
RESONATOR	$0.03
WHITE LED	$0.06
MOISTURE/HUMIDITY SENSOR	$1.65
total	**$15.31**

Introducing the design scope and brief

* ecological awareness as the next frontier of sustainability *

What is the biggest living organism on the planet?

https://en.wikipedia.org/wiki/Largest_organisms
https://www.britannica.com/video/185607/living-organisms-survey-representatives-plant-Earth-kingdoms


a
20μm
b
10μm
c
10μm
d
e
10μm
f
10μm

A design context for ecological awareness

A design context for ecological awareness

Urban-nature Synergies
have great importance in the development of cities
for three main reasons

- cities have been contributing to the consumption of the environment

- they are considered as a uniquely humanistic and artificial element,
even in the more recent ideas of “green city“ they are still uniquely anthropocentric

- cities are currently built with no ecological affordances.

Alternatively and critically to such dimensions,
we want to reflect upon some questions:

- Can cities become a laboratory of ecological practices?

- How can we empower citizens to embrace ecological knowledge?
How can we engage citizens in the care and nurturing for the environment?

- How can we transform the cities into a playground where every generation can learn
by practising meaningful relationships with Nature
which will also benefit the development of the cities themselves?

* from the idea of “human centred design” to the idea of "designing within a ecosystem”

* this is how our classroom may look like

-- immersion, instruments, sampling

Studio Brief

The studio's design challenge will revolve around the main idea of reconnecting or strengthening the bonds between humans and nature.

You will design devices that amplify humans' senses
or introduce new ones to enhance our connections with nature and natural phenomena. Such connection will enable way of knowing and appreciation towards the ecosystem.

Within the design challenge, you will learn the basic skills required to
design > fabricate > program
an electronic circuit.

Technical instructions will be 75% of the class time

With this project

We will challenge the way we look at the “design context”,
by including the “more-than-human”

Discover nature agency

Create collaboratively with and for the ecosystem

Prototype new way of knowing and interacting within urban nature

Spending more time outdoor and in observation

Studio Outcome

The studio is part of NFSC research project, the outcome will help the research of Urban Nature and Ecological Cities,
with the **design of a device that can collect data and interact** with the urban/natural environment,
natural phenomena, citizens interactions, environmental data, etc.

The final result is an **input and output system with a programmed micro-controller**,
integrated in a product, an interactive device
or the design of an intelligent environment.

Ideally, projects will be prototyped with a urban community

“Sensing Ecology”
From Designers to Citizens

public space / ecological space

“projects about the tree where you put the sensor”

citizen science
A participatory process in which the technological devices are turned into instrument of analysis, data collection, monitoring and dissemination of scientific knowledge

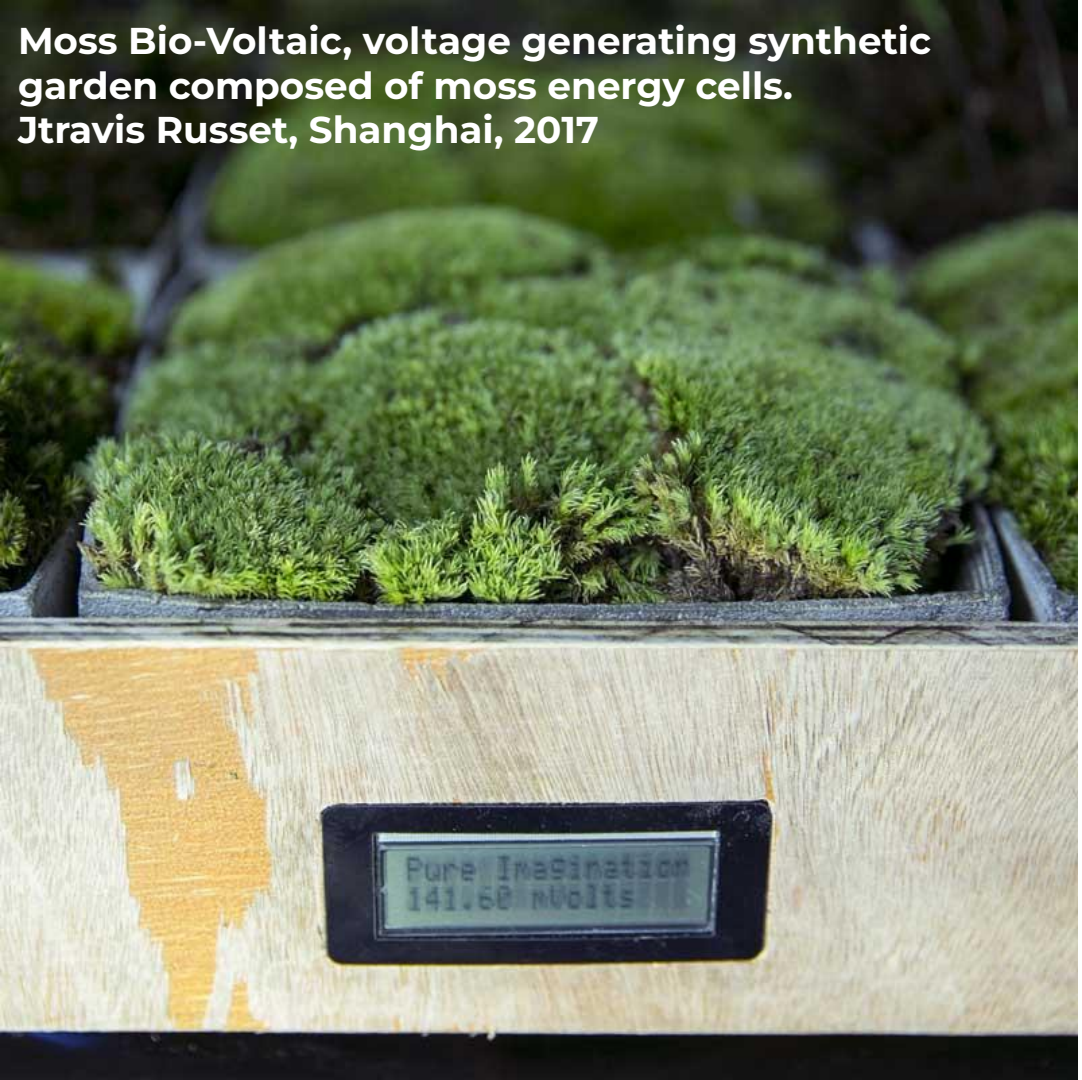
Contributory projects of data collection / collaborative projects (collection + defining and analysing) / co-created projects (designed with scientist)

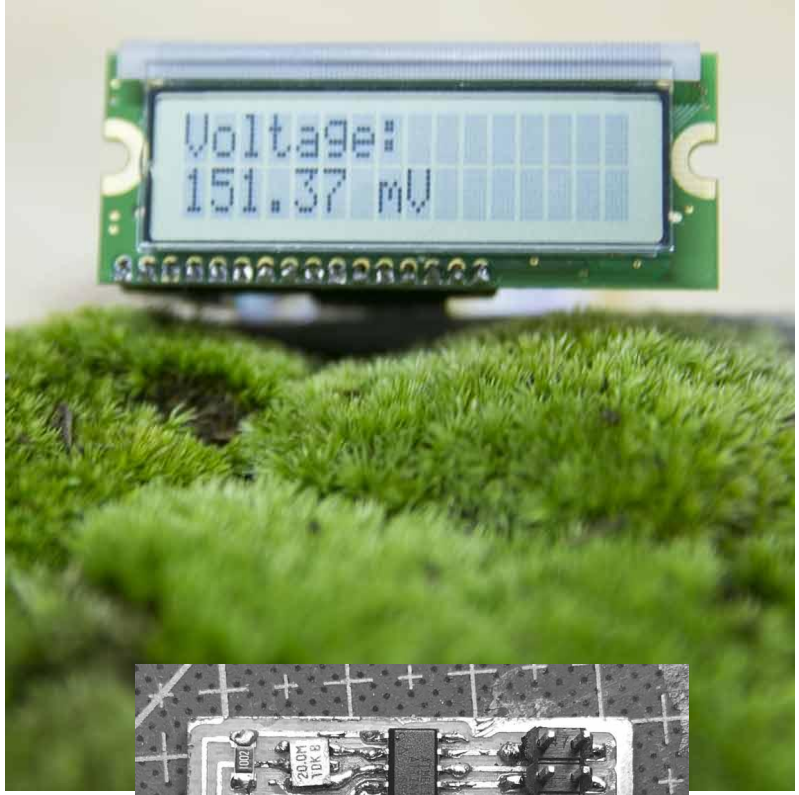
“Sensing ecology” in order to: know, care, engage

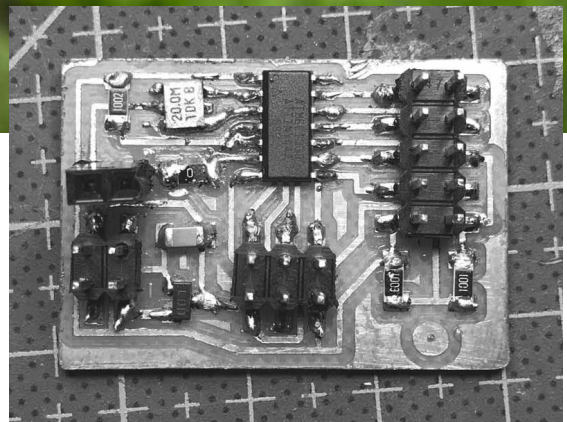
Input -- output

Augmenting the sensing opportunities for (smart) citizens

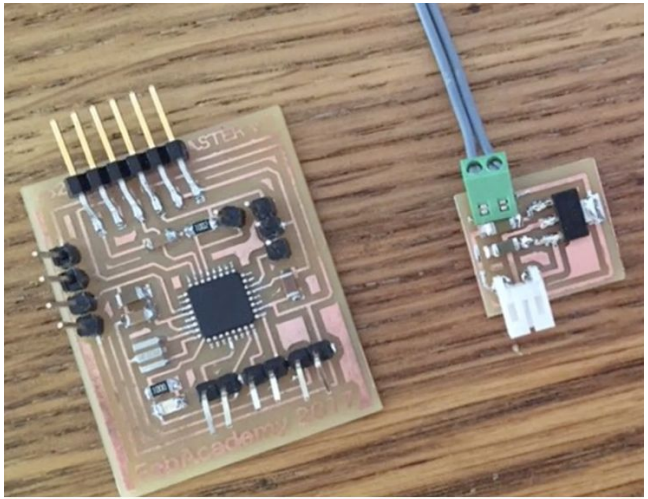
Moss Bio-Voltaic, voltage generating synthetic garden composed of moss energy cells.
Jtravis Russet, Shanghai, 2017

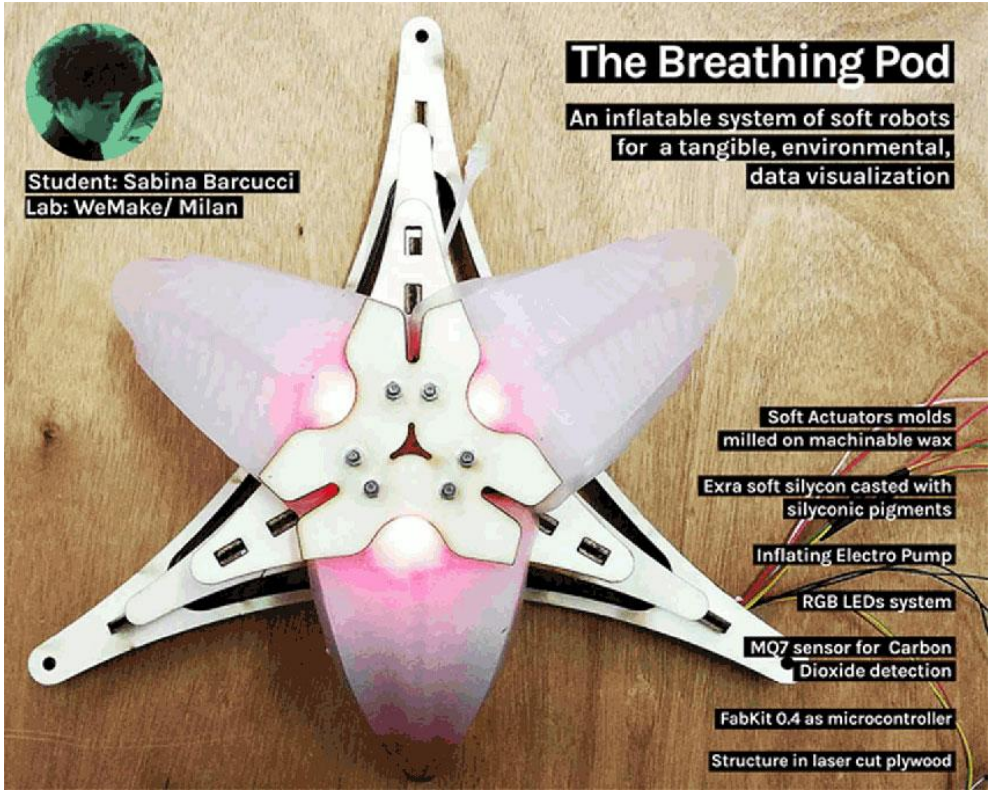


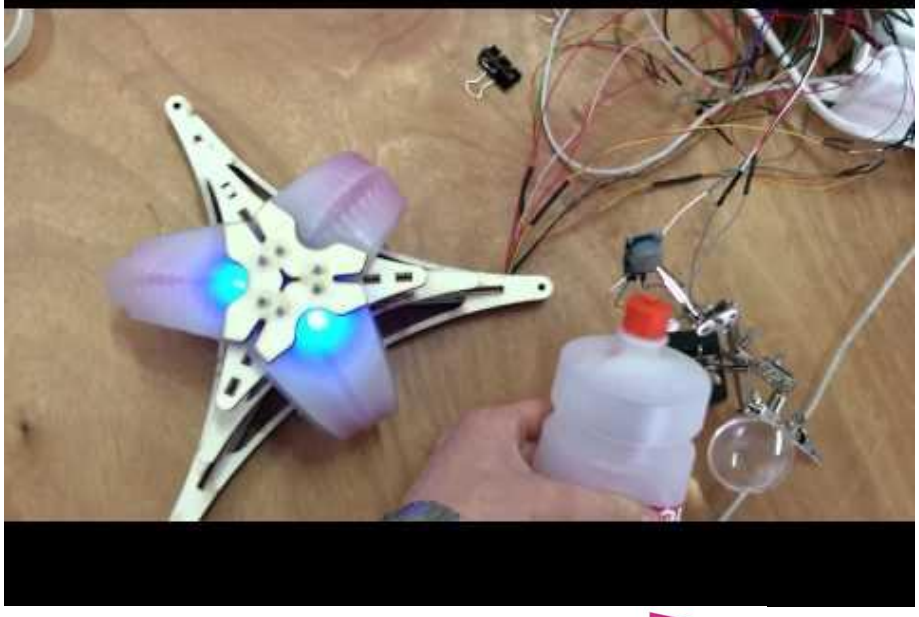


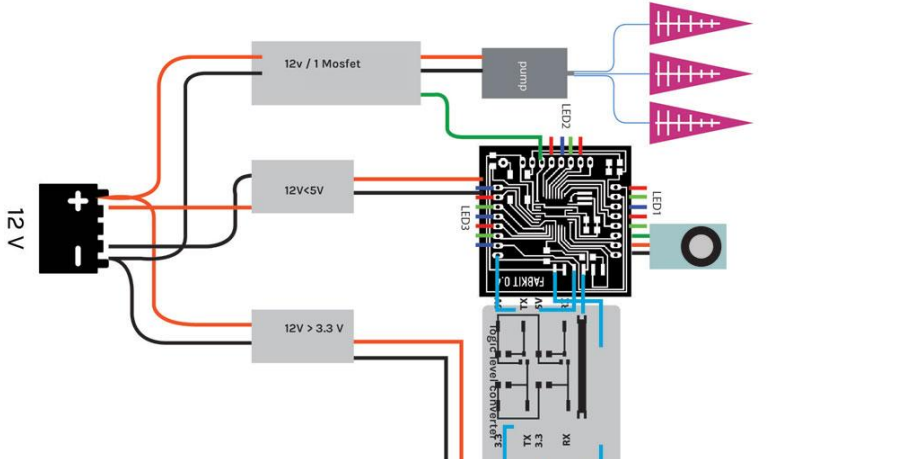


Faito, kite that collects pollution data while flying
Pilar Caballero, Madrid, 2018









Breathing Pod, bio-inspired robot that changes its shape in response to the changes in the environment
Sabina Barcucci, Milan, 2015.

Is this the right Studio for You?

You chose it because:

You want to learn technical skills that can be helpful for your future practice

You want to work on a smaller design challenge with more focus on learning and applying practical skills.

You are comfortable in a teaching environment where you are left free to make mistakes and you have to fix problems by yourself

You are comfortable with a “hands-on”, “bottom-up” learning approach
(only learn the little bits you need to move to the next step, ignore the other 90% of the topic)

You want to join a small group of digital fabricators and makers that will surely work over time while having a lot of fun

Code of conduct

1. Try to exercise an ecological mindset inside and outside the classroom
2. Acknowledge and be responsible for the impact that your creations might have on other people and the environment
3. Do not practice or condone harassment in any form, towards any manifestation of nature
4. Value the diversity of all the participants, their views and opinions
5. Exercise the right to express complaints or concerns
6. Keep an attitude and practice of sharing: document and share the material you create
7. Be well rested and Have fun

Evaluation Criteria

This class is a workshop class, not a lecture class, and it relies heavily on class-time participation, hands-on activities, group discussions.

The best thing you can do to get a high score in the class is to participate actively, help each other, discuss about the problems you encounter and document your work on a weekly basis.

30% In-class participation

30% Assignments and final Project

40% On-line documentation

Note that the criteria to evaluate the final projects will be defined case-by-case

Assignment for next Wednesday

Hand-sketching components: Make hand-drawn sketches of the basic electronic components used on the Arduino on a Breadboard. Drawing(s) must fit on **ONE A4 sized paper**.

1. Resistor
3. Electrolytic capacitor big black one)
5. Voltage Regulator (Transistor)
7. Microcontroller (ATMega328p)
2. Ceramic capacitor (tiny one)
3. LED diode
4. Crystal Oscillator
5. Pin Headers and Jumper Wires

Referring to the style of naturalistic illustrations, draw the sketch with sections, exploded and magnified views, including short descriptive text. Describe how components are made and what they are used for. Prepare a short lecture (3 minutes) explaining your findings to the rest of the class.

No PPT required.

This class is a PPT Free Zone

Assignment for next Wednesday

Document all the work you did so far (Arduino-on-a-bradboard + hand-sketches) on Github.

Clone the template page and modify the Readme in the folder corresponding to the assignment. Add pictures to the image folder and link them in the readme.

Describe what you did using a “tutorial style”.
Write as if you are going to teach your grandmother to do the same things you did.

How / where to find us

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