

# BIONIKONLab FABNAT 14: A Workshop between Nature, Art and Technology



*“Nulla Ars imitari sollertiam Naturae potest” (Cicero)*

*“Philosophy is written in this very great book that continually stands open before our eyes (I say the universe), but it cannot be understood unless one first learns to understand the language, and know the characters, in which it is written. It is written in a mathematical language, and the characters are triangles, circles, and other geometrical figures, without which it is impossible to humanely understand a word of it; without these it is a vain wandering through a dark labyrinth.” (Galileo Galilei, The Assayer, 5-10, 1623)*

*“Make your student attentive to the phenomena of nature, you will soon make him curious; but, to feed his curiosity, never hasten to satisfy it. Put matters within his grasp, and let him solve them. Let him know nothing because you have told him, but because he has understood it himself; let him not learn science, but invent it.” (J.J. Rousseau, The Emile, Book III, 2, 1762)*

## The Project

---

I am Massimo Lumini (1957) an architect, designer, Art and Design teacher and free researcher in biomimicry and I started this educational project around 1996. The BIONIKONLab & FABNAT14 laboratory is currently a maker-space located in Iglesias, a small town in Southwest Sardinia in Italy, inside the Liceo Scientifico of an Institute of Higher Education (IIS “G.Asproni” currently directed by Professor Daria Pisu) and its peculiarity consists in the fact that here we experiment, together with young students aged 14 to 16, a teaching model based on the design approach inspired by bionics and biomimicry.

From its earliest beginnings, BIONIKONLab has been defined as “An educational workshop between Nature, Art and Technology,” a learning environment with a strong constructivist pedagogical vocation, inspired by the places of artistic and artisanal production of “Renaissance quality,” in which teacher and student are continuously involved in an experiential feedback between theory and practice, processes of ideation, experimentation, design and construction, in which doing in order to understand replaces the passive and prepackaged knowledge of the frontal lecture.(1)

### **BIONIKONLab & FABNAT14**

Presso IIS “G.Asproni”  
Loc.tà Su Pardu  
09016 – Iglesias -SU / Italia  
cais01300v@istruzione.it

**Direction and  
Educational Coordination**  
Silvia Musa

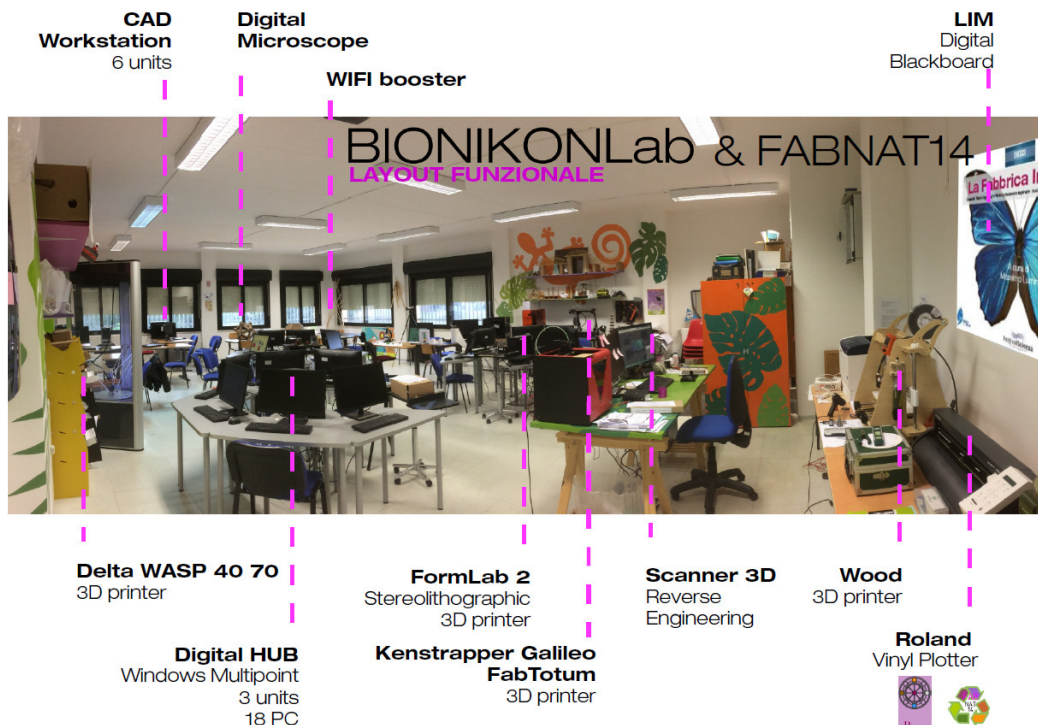
**Scientific Coordination**  
Massimo Lumini  
m.lumini57@gmail.com

The basic idea that guided this original didactic experimentation, unique in the scholastic educational context of the Italian panorama, was to graft onto the typical didactic curriculum of “Drawing and History of Art” of a Scientific High School Institution a very valuable wealth of knowledge and operational methodologies of bionic cut, experimented through collaboration in IED-Cagliari at the Department of “Design for Crafts” founded and directed by Prof. Carmelo Di Bartolo.(2)

Thanks to several visits conducted between 1987 and 1992 in the IED-Milan office, I was able to get to know and metabolize in my teaching and professional work, his unprecedented approach to problem-solving for industrial design and environmental sustainability.

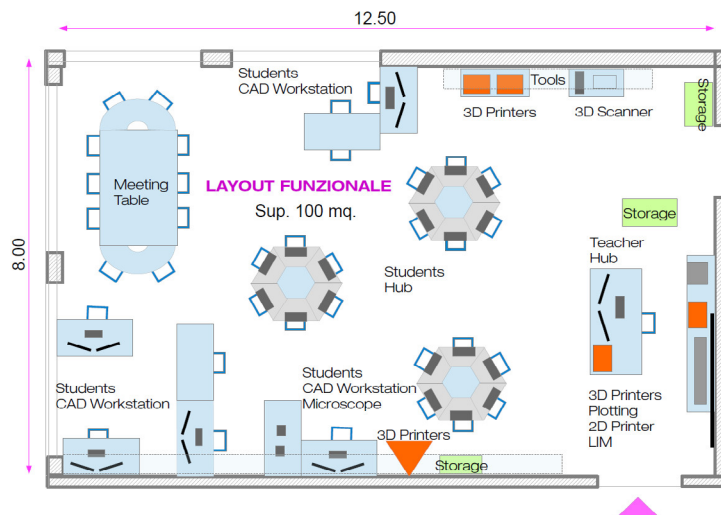
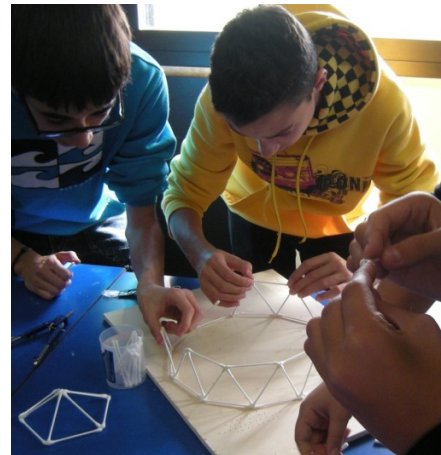
The space of the BIONIKONLab & FABNAT14 is organized to accommodate CAD-CAM design and digital manufacturing and 3D printing activities, allowing about 20 students to organize freely in team-work.

The educational process that Di Bartolo in his CRSN-CRIED was pioneering since the late 1970s with groups of students from all over the world, was characterized by a mix of original study and work methodologies marked by basic design inspired by natural morphological analysis of cellular tissue samples, both plant and animal: seeds, plants, leaves, animal constructions, burrows, nests and formal and functional structures found in living organisms in toto, combined with theories and applications of advanced solutions from the bionic discipline and the emerging bioarchitecture and theories of so-called light architecture.





Over time, this transversal vision between Nature, Art and Technology has proven to be a winning pedagogical and educational proposal, capable of promoting creativity and new knowledge and skills in the educational processes of the young students involved. Especially thanks to the last ten years of intense research and promotion activities, the laboratory has achieved a discrete thematic indexing in the biomimetic field and achieved an important institutional vision on the web and initiated interesting collaborations, including at the international level, positioning itself in the educational sector landscape as an educational experiment with innovative characteristics.(3)



The functional layout allows for work: on individual or paired CAD-CAM workstations, on three “hub” islands for six students assembled in coworking, gathered around a meeting table for 10-12 students in plenary meetings, and at various stations with printers, digital microscopes, and work tables for modeling and other manual and construction activities.

BIONIKONLab & FABNAT14 collaborate with external entities such as the School of Education of OIC-Ordine Ingegneri di Cagliari, Ass. APS-ETS Academia Terra or CRS4-Center for Research, Development and Advanced Studies in Sardinia, creating events and formats of technical-scientific popularization or biomimetic design workshops and are very active in participating in initiatives such as regional technological Makeathons, educational workshops for various Science Festivals, Cultural and Literary Festivals and other proposals with a social promotion character

## Biomimicry Workshop, 2017-2018

“Water and environmental management inspired by desert plants and marine aquatic animals” with architects and engineers at the OIC-Ordine Ingegneri di Cagliari Training School. The design theme was about water management in succulent and succulent plants, and designers had to create ideas inspired by the solutions adopted by Cactaceae, *Fenestraria*, *Welwitschia mirabilis*, *Cotula fallax* and other interesting plants from arid climates. Young students from the lab, trained for years in biomimetic problem-solving, assisted the teams of engineers and architects in the various design stages.

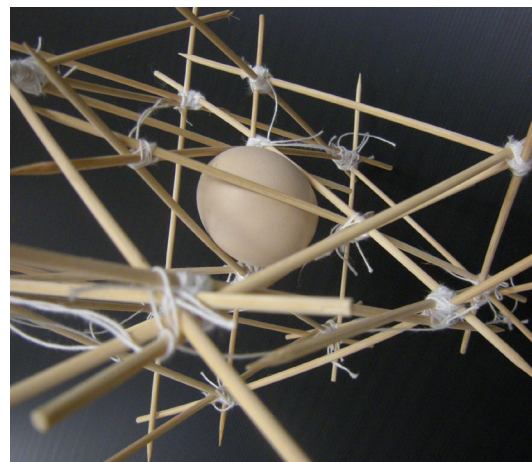
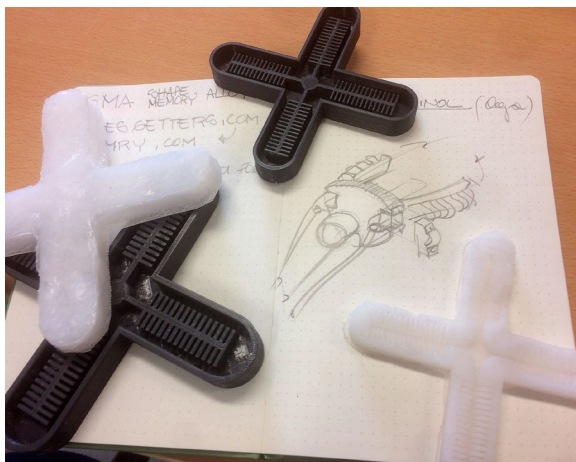
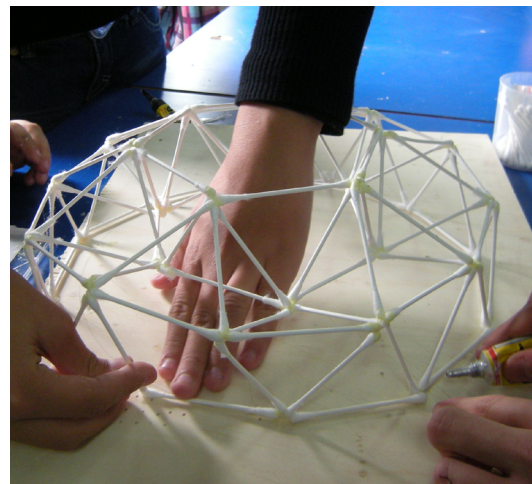
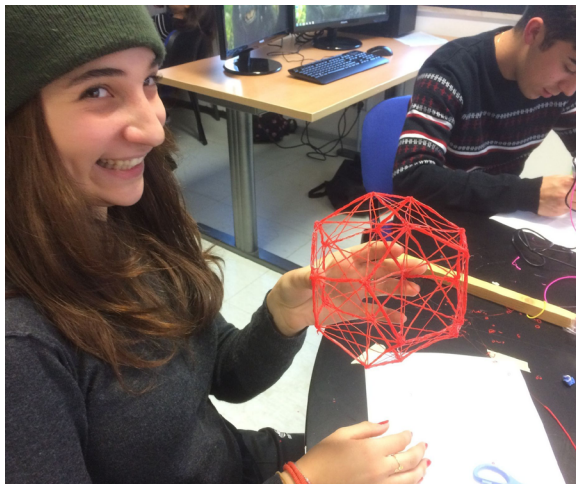




The cornerstones of the training process involve students' attainment of the following knowledge/competencies:

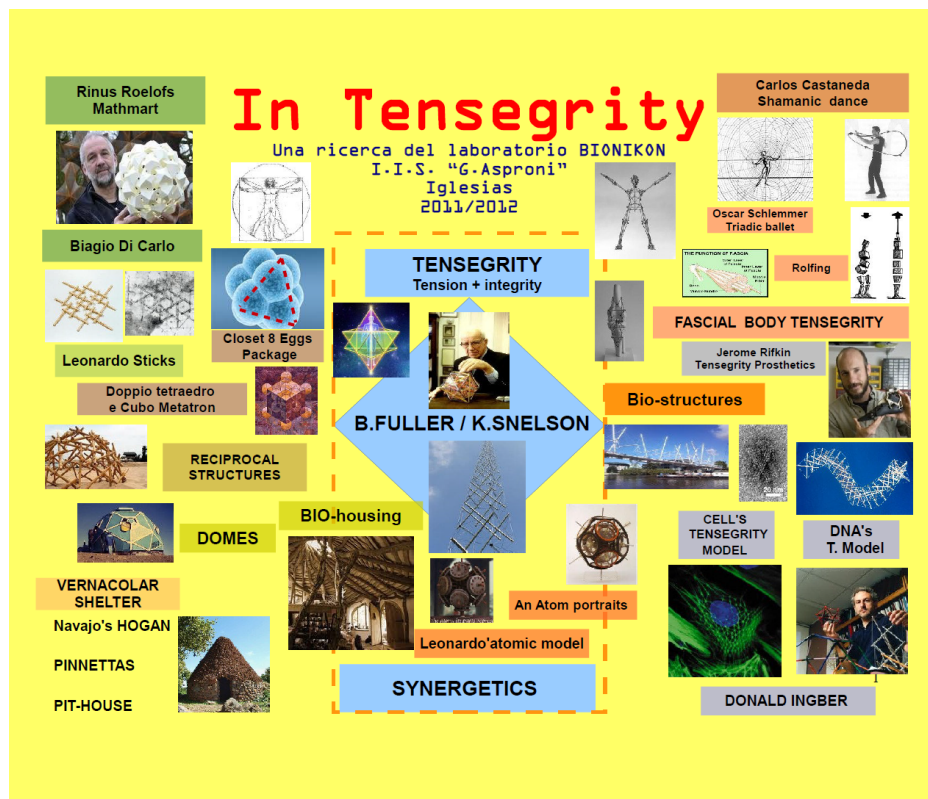
- **AUTONOMY OF THOUGHT AND RESPONSIBILITY FOR RESEARCH**

The student is helped to perceive his or her personal learning as an active, open-ended and always in-progress (working progress) process. We work together to transform the traditional tendentially passive and unmotivated role of the «student,» who sits, still and stuck on his or her desk, uncritically replicating and «reprinting» the knowledge learned from the teacher without coloring it with the nuances of a particular personal reworking. Our approach tends to build a different, more active, conscious and responsible attitude, more typical of the «researchers» mindset. A new role of one who takes upon himself the responsibility, but also the fascination and satisfaction, of passionate study in the continuous discovery of original and creative solutions to the problems of human life and the planet.



## • TRANSVERSALITY

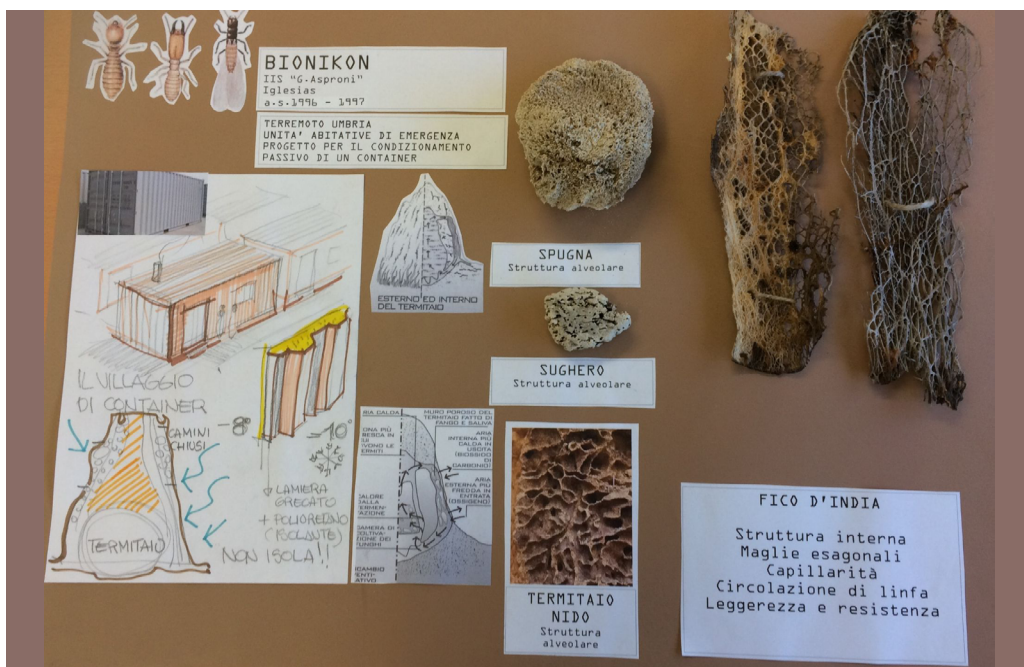
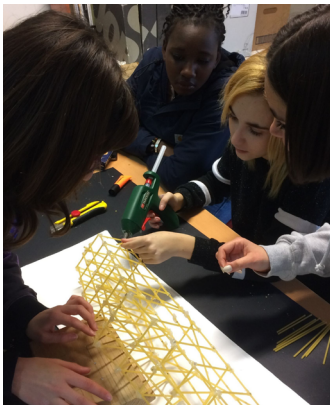
From the perspective of intellectual development, in the lecture-workshops that take place in BIONIKONLab & FABNAT14, an attempt is made to unite rather than divide knowledge. Problems are analyzed through conceptual map constructions, in which stimuli from all fields of knowledge converge, brought together to succeed in contaminating in an analogical and creative way the different school curricular areas, separated by timetable and programs: Science, Physics, Mathematics, Geometry, Chemistry but also Art and Philosophy are brought into play in order to succeed in drawing an organic and dynamically evolving conceptual map, which gives a possible sense to the enormous complexity of contemporary episteme and praxis. The ability to be able to traverse and navigate among so many fields of human knowledge should not be confused with a kind of Omniscience. It is about training oneself in uninhibited learning, able to explore the new without preconceptions and prejudicial occlusions in order to help build in students a “well-made head (E.Morin 2000),” helping them to consider things intimately joined together by invisible threads of meanings, cross-references and analogies, observing them at 360 degrees. It is necessary to learn how to ask the right questions to the various expertise, different and complementary disciplinary approaches, finally practicing the effective art of analogical and creative transfer. Common cipher that binds all these cognitive fields together is the pedagogical goal of developing in the student a systemic vision of human making and its socio-environmental impact that falls on the local and global ecosystem.





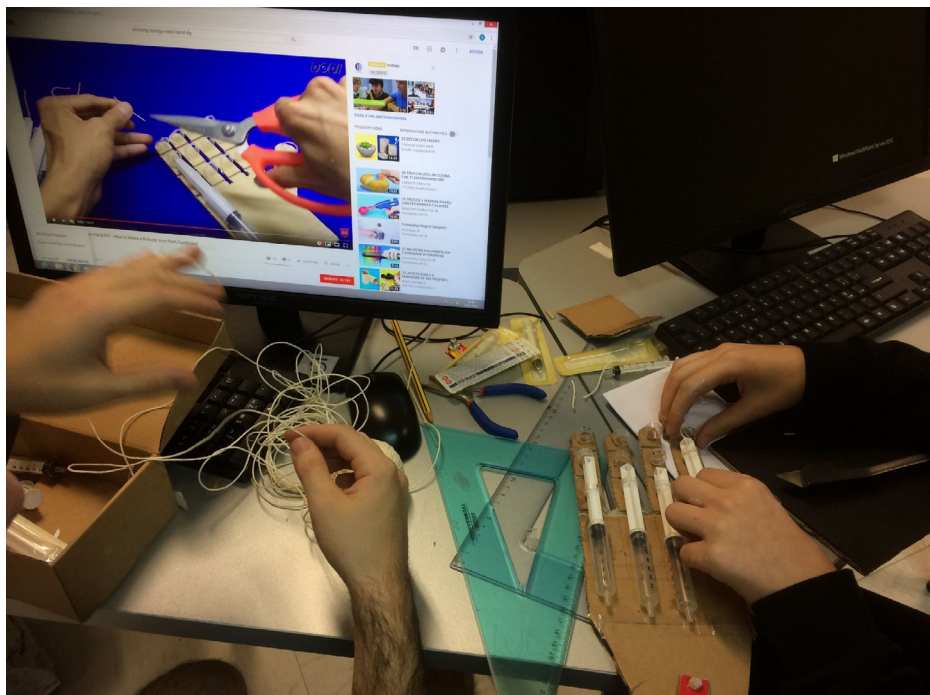
## • PROBLEM-SOLVING

The student, unceasingly, through creative incubation techniques such as brainstorming or synectics is immersed in a learning environment that tends to problematize reality and let students experiment with and make their own solution methods through the continuous exercise of creative thinking, which is naturally introduced in their own research school work. Training in these techniques of lateralization of creative thinking helps students to recognize the new, not to fight it in its emergence, and to develop original strategies, which are useful when dealing with solutions related to needs or the elaboration of design concepts, knowing how to decline them in the different contexts of Problem-setting and Problem-solving. Learning how to correctly pose problem-setting issues, how to put them on the table for analysis and discussion, is also not something that can be taken for granted and is of great help in building a creative and problem-solving attitude in young people.



- **TEAM-WORK**

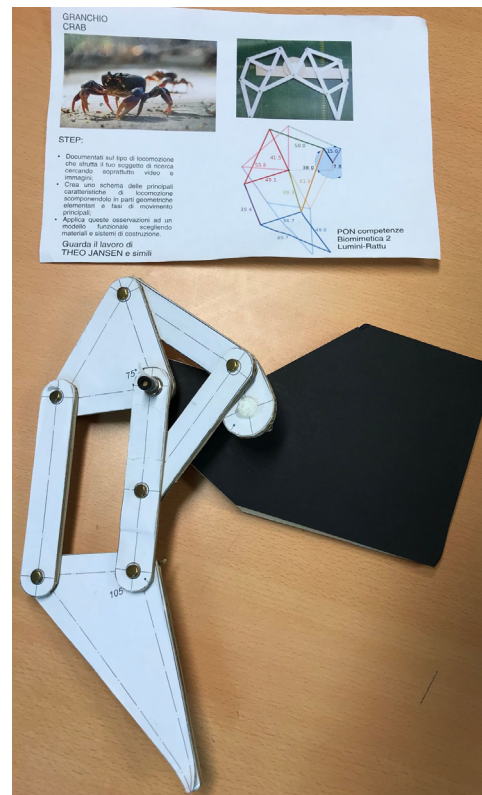
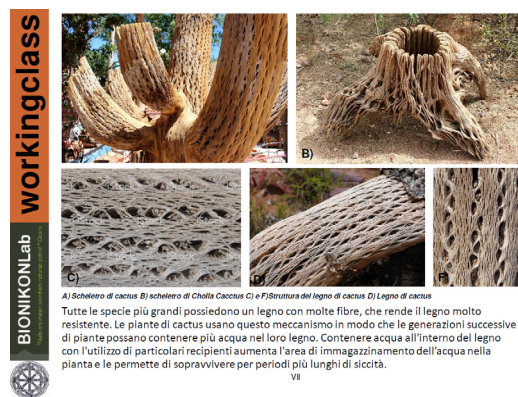
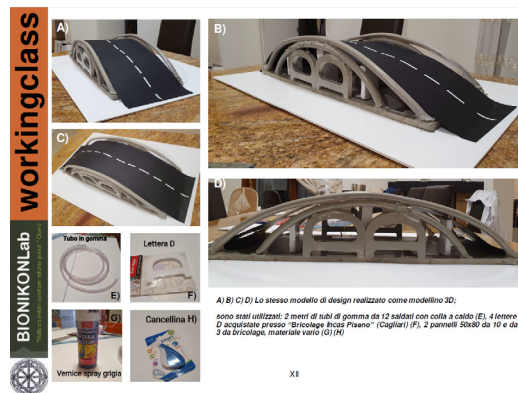
Students constantly work in groups to sharpen their sharing and mediation skills, to open the armor of student-monad, to help each other overcome the difficulties and tensions that arise in the dynamics of integration in a peer group (negative competition, envy, resentment, pessimism, negative thinking, lack of clarity of roles and skills and competencies), succeeding in overcoming their own communication difficulties and experiencing the positive energy typical of a well-motivated and coordinated professional team-work to achieve a goal (research target).



- **COMMUNICATION**

Everyone needs to learn the techniques of textual and image communication in order to be able to correctly and as clearly as possible convey their ideas, first to themselves and then to others. The basics of graphic design are learned, which is fundamental to learning techniques for effectively representing one's results, developing the correct creative skills and technical abilities to know how to handle different communication environments: analog, media and digital: text, images, video, audio, construction models, CAD models and 3D printing. Fundamental is the experimentation with basic design strategies that are necessary for the creation and management of pitches, PowerPoint, teaching handouts, work and research plans, functional layouts for educational exhibits, timelines for workshops and more.

Gaining the knowledge that the fruit of one's own thoughtful and reworked work can constitute a research database and documentary material for development for future research, instead of ending up with a stamped paper band inside a locker destined never to be read again after correction by anyone and to be burned after five years of storage in some dark, stale and dusty school warehouse, gives the young high school junior a feeling of usefulness and necessity. One's own thought, small as it may be, is a drop in the ocean of creative flow, and over the years the archives of senior work constitute invaluable materials for new elaborations by juniors. I have always believed that it was better for one of my students, to grow in the school having the clear conviction and awareness of being part of an organic process, a design ecosystem, of an ever-evolving database, where study and research do not turn out to be an end in themselves and a mere grade, but vice versa tools for the creation of a special place, to be shared and grown through one's own valuable contribution.

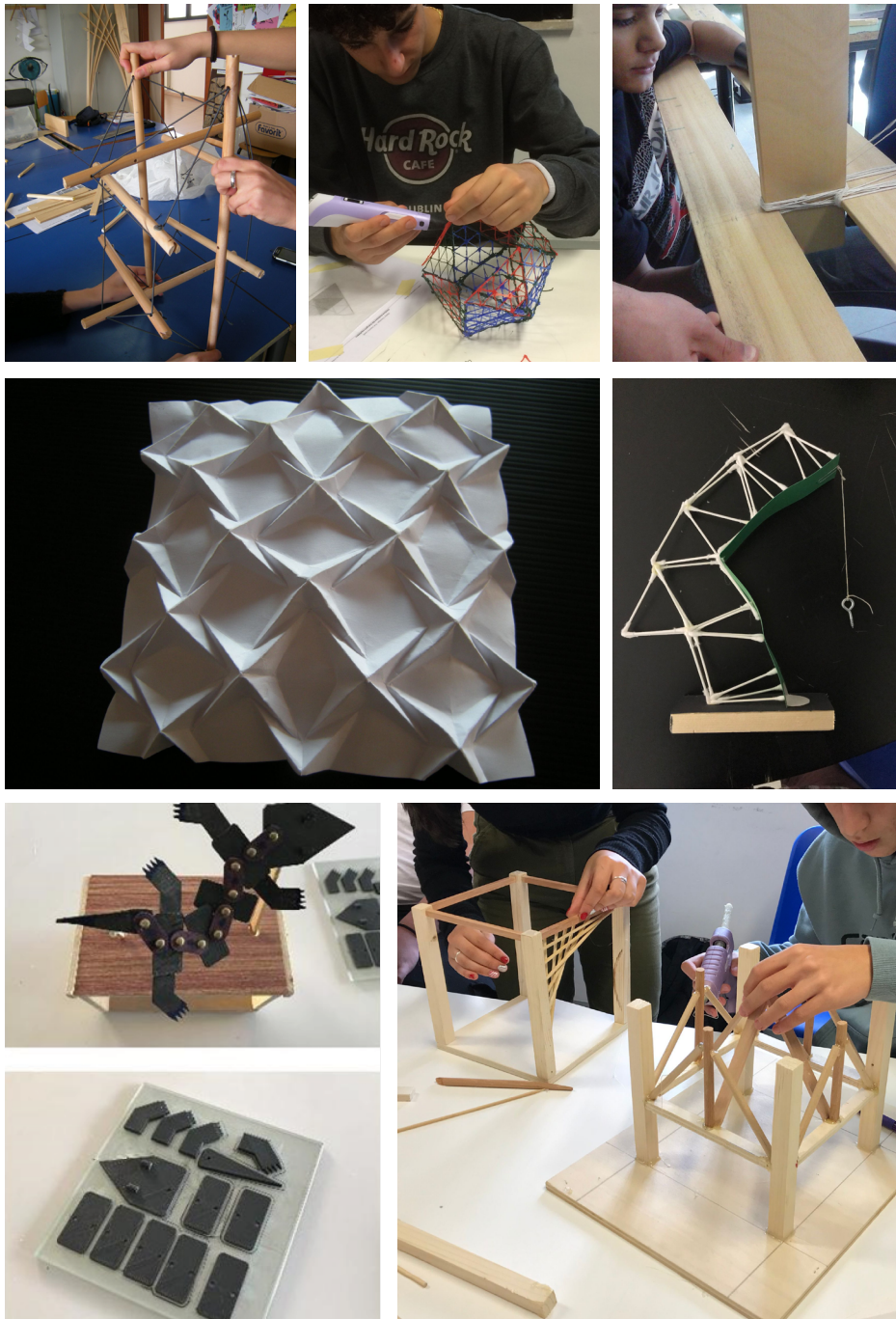


## • MANUAL CONSTRUCTION SKILLS

“Digital natives,” accustomed from a very young age to mashing keys and touching glass surfaces to execute digital commands, are undergoing a negative process of de-evolution by gradually losing the fundamental experience of tactility and fine motility of the body and especially of the hands and their brain coordination with vision and other cognitive areas. A great many students are increasingly suffering from learning disabilities and attention disorders in a worrisome way. Through Basic-Design experiments, they are initiated by the teacher to put their psychomotor skills to work in the difficulties of hand-building increasingly complex



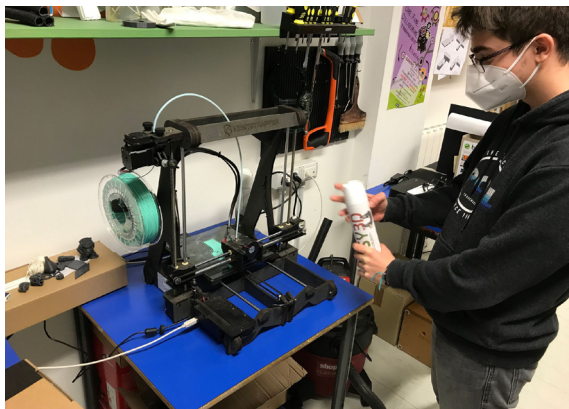
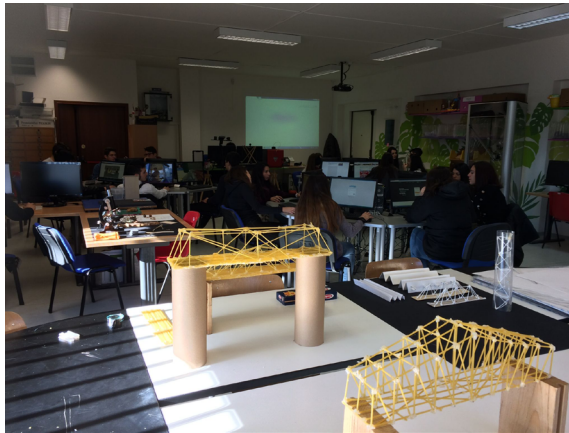
models, involving themselves in a process of manual and intellectual learning of the foundational design methods for understanding the products of natural technology and human artificial technology, considering them both as “light structures” (Frei Otto). Learning and experiencing skills in manual drawing, manipulation of lightweight materials such as paper, cardboard, wood, and metals to learn techniques for constructing lightweight models useful for structural, form and function verifications is a true medicine of body and mind

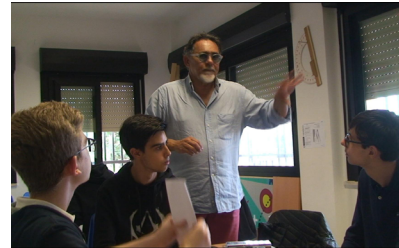




- **CREATIVE DIGITAL TECHNOLOGY**

Over time, starting in 2014, BIONIKONLab has been equipped with a makers pace - the FABNAT14 - and students have begun training in CAD-CAM design and the use of 3D printers and other digital manufacturing technologies, to make their backgrounds and knowledge increasingly adherent to contemporary developments; manual skills continue to be practiced through basic design, but are “ enhanced “ by the digital and rapid prototyping component.





B Lab

**IIS “G. Asproni”**  
**Liceo Scientifico**  
**Loc.tà Su Pardu**

**IGLESIAS**

**25 Ottobre**

Ore 9.00 – 13.30  
 Aula Magna - Succursale

**TÓPICOS EM DESIGN:**  
**BIOMIMÉTICA,**  
**SUSTENTABILIDADE**  
**E NOVOS MATERIAIS**

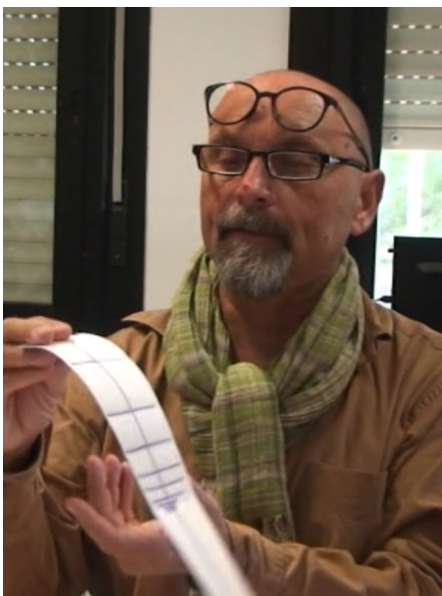
**Presentazione del Libro**  
**A cura dell'autore**

**Prof. Ph.D Amilton Arruda**

**Universit  Federal**  
**Pernambuco (UFPE)**  
**Recife - Brasile**

[illegible][illegible]

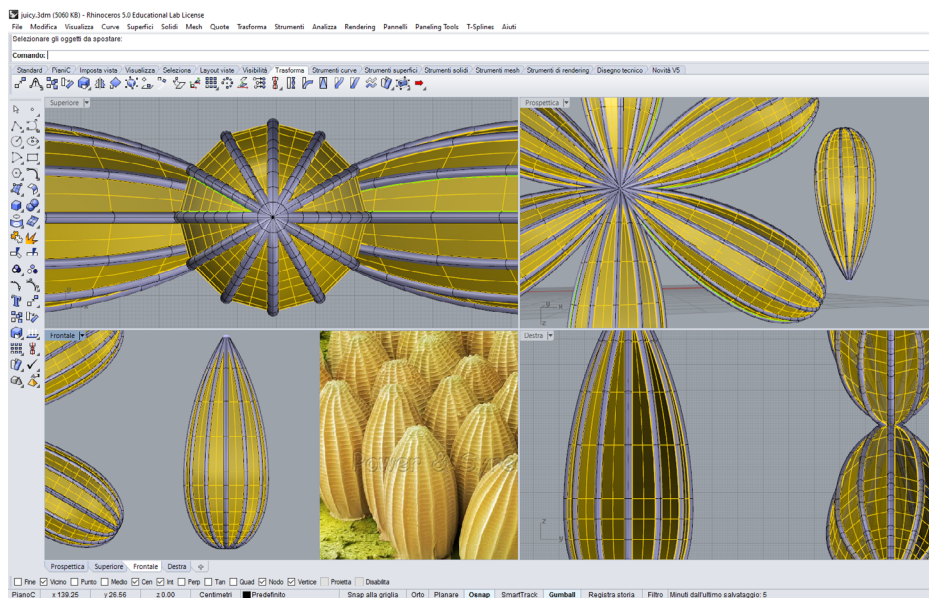




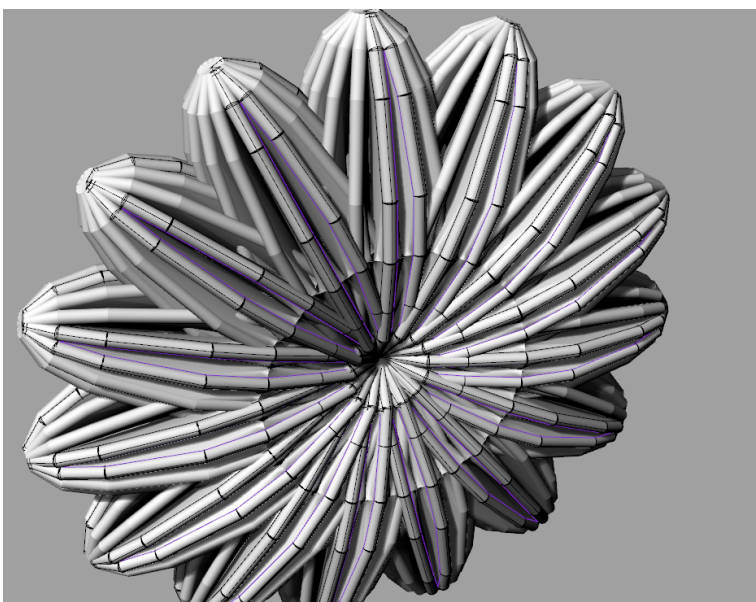
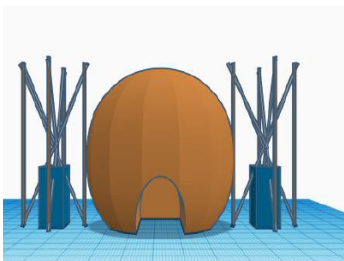
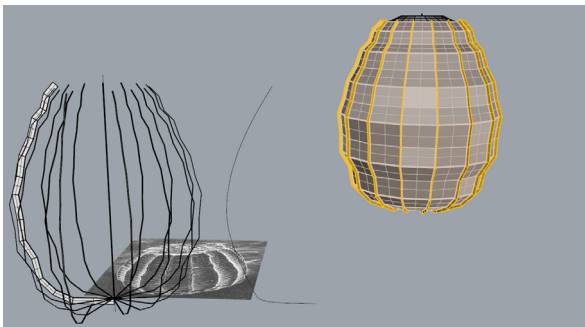
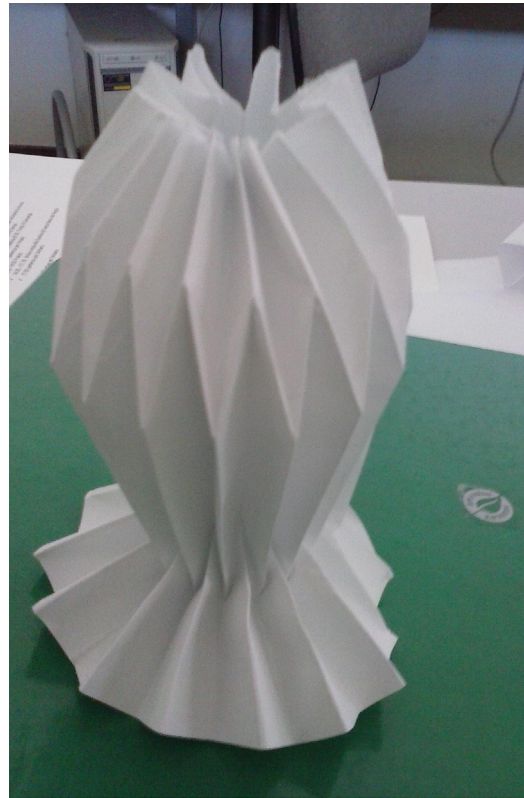
“Poor” and recycled materials such as packing cardboard and others are widely used in the construction of our working models

## METHODOLOGY

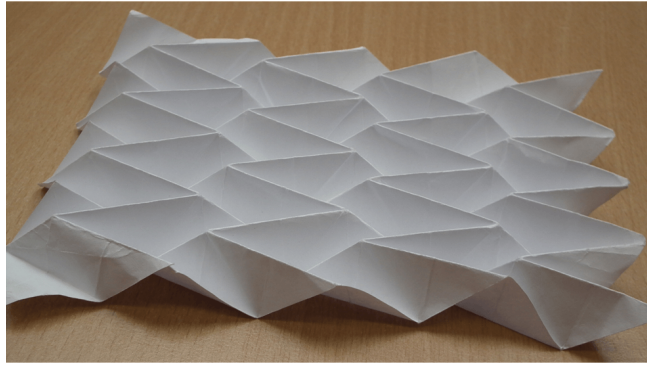
- Use of problem-setting and problem-solving phase, of brainstorming sessions and symplectic techniques to exercise students in developing collaborative and shared creative processes and defining original approaches to design;
- Observation of organic specimens from life, also using digital tools such as optical and digital microscopes, additional lenses to make the optics of cell phone and tablet cameras more powerful, so as to make them effective tools for forging visual data on their study sample;
- Bionic and biomimetic drawing from life, building on Leonardo da Vinci's style of careful biophilic observation, as found in the visual notes of his various Codices;
- Lightweight model building and since 2014, with the introduction of 3D printing, CAD-CAM design and rapid prototyping;
- Creation of biomimetic design concepts and their communication;
- Participation in science popularization projects, contests and training projects.(5)







CAD and Basic Design study models, inspired by the morphology of lepidopteran eggs.



## PROJECT 'EMERGENCY 2020

---

### NECESSITY, CREATIVITY AND BIOMIMICRY IN THE TIME OF COVID19

The very difficult condition that the tremendous COVID19 pandemic has imposed on global societies has had a severe fallout on the educational world. Millions of teachers and students in every nation found themselves, within a very short time, having to face and manage one of the worst social and cultural emergencies of the century, reinventing in a digital “distance” dimension (DAD) all social and community aspects of school life.

The laboratory activity of BIONIKONLab & FABNAT14 suffered a traumatic total interruption, just as extremely interesting projects were being developed such as, for example, “In@ble. Prosthetics and Open-Source Assisted Technologies.

On several occasions, starting in March 2020, our activities suffered continuous pauses and restarts creating a very frustrating discontinuity of work; but in spite of everything, thanks nonetheless to the positive opportunities offered by DAD (Distance Learning) we reacted by trying to make the most of its best functional aspects such as the ease of sharing meetings by groups and subgroups, producing digital materials and easily sharing them among users through the network, being able to easily organize video-meetings at every hour and quickly connecting users far apart with each other in interactive modes.

In addition, DAD has allowed the organization of in-depth thematic groups such as for example, basic literacy courses in the use of CAD software such as Rhinoceros, going on to create an atmosphere of community and positive professional complicity and intimacy, which sometimes, in the school in attendance, is not easy to implement. School work has been severely impaired by restrictions on attending lab spaces, and this has prevented us from applying ourselves to model building and the use of 3D printing machines but has been enhanced on the design processing front.

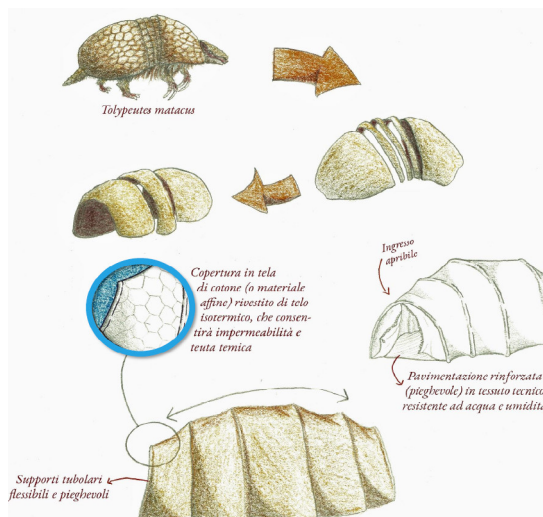


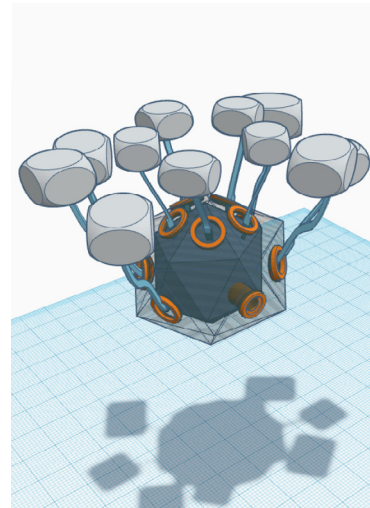
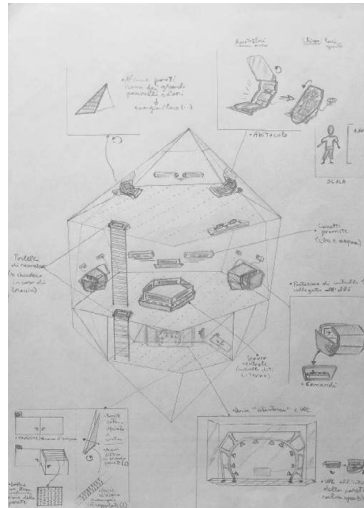
In particular, I found the results of an integrated design involving all of the two-year groups very interesting. The concept was called “EMERGENCY 2020.” The project was planned as a joint activity for the two second-year classes divided into several Design Units composed of a pair of students who partnered freely with each other.

I gave each Unit a problem-setting sheet, in which the characteristics of a serious environmental emergency scenario were simulated, inspired by the news reports concerning the effects of climate change on the planet and other disasters caused by human action strongly impacting human communities, such as floods, earthquakes, severe fires, radioactive fallout, etc. Students were proposed the highlighting of a main need to be confronted with by design, arriving at the conception of a design concept (creation of a technological human-environment interface) inspired by biomimetic solutions.

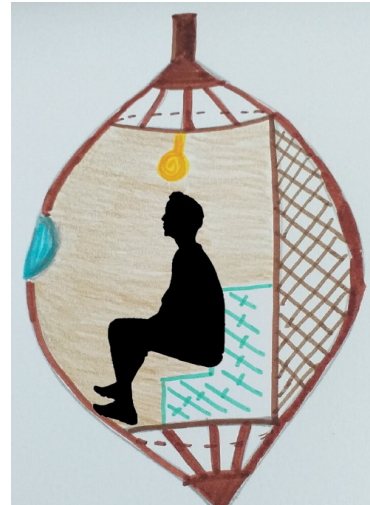
They were required to document the characteristics of their scenario (check-list) and, using the system of analogies in accordance with the operating methods of the biomimetic design approach methodology, they were to research one or more models of natural technology useful for inspiring sustainable solutions. The whole process of analysis, research, ideation and design was to be composed in a final Powerpoint-type presentation.

The first classes, on the other hand, focused on analyzing the human and social emergencies present in refugee camps around the world that gather millions of humans in the most insecure living conditions due to conflict, ethnic cleansing and environmental disasters. Through biomimetic analysis they were asked to propose environmentally sustainable solutions to problems related to shelter infrastructure (housing), water supply, waste disposal, lack of space for aggregative and social life, education, health, etc. Some of the most significant solutions proposed by students are presented in the photo documentation.

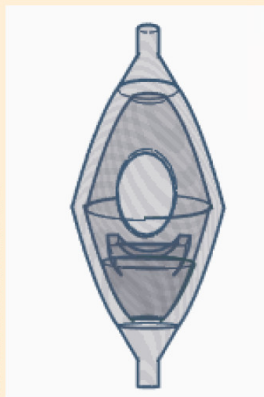
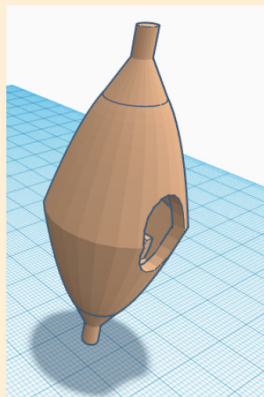
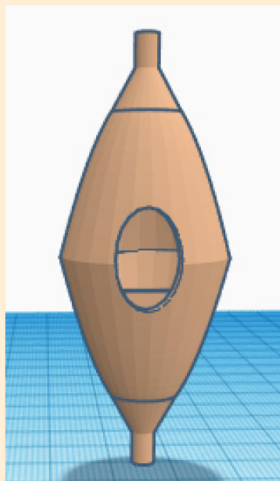




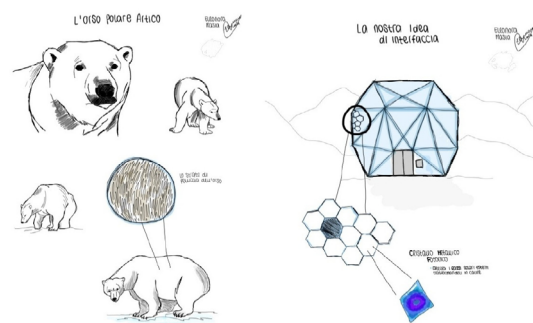
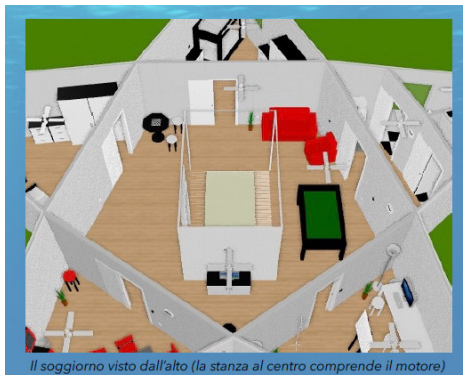
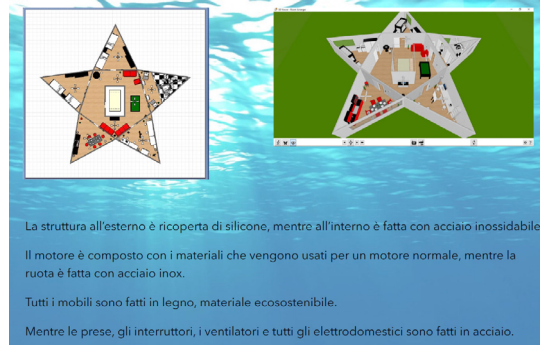
**PROBLEM SETTING:**  
PROGETTO PER  
UN ABITACOLO  
ARBOREO DA  
UTILIZZARE IN  
CASO DI  
GRAVISSIMA  
INONDAZIONE IN  
ZONE CON  
PRESENZA DI  
GRANDI ALBERI,  
BOSCHI, FORESTE



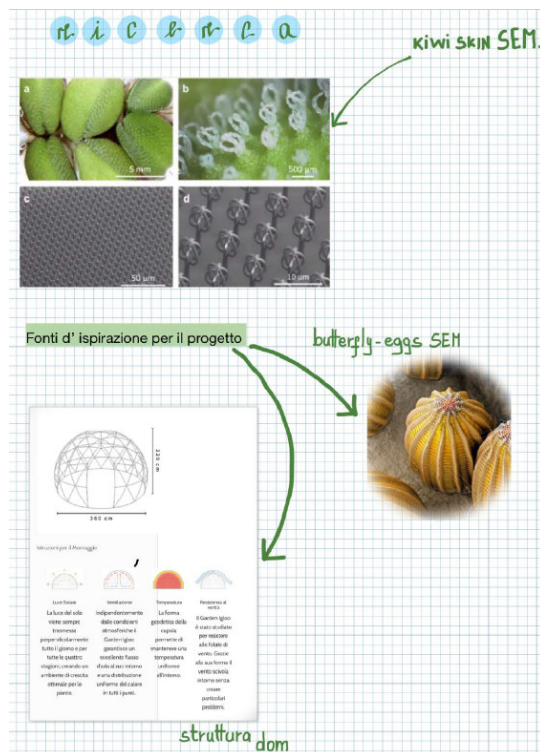
### MODELLO CAD







Alcuni esempi di concept studiati dagli studenti (14-15 anni).



## MAKEATHON 2020/2021

---

Sardinia is a beautiful island, located in the heart of the Mediterranean, an archaic and mysterious place with a thousand social, cultural and economic contradictions.

It has areas of serious economic and social underdevelopment and entire areas destined for problematic military servitudes that irreparably disfigure its ecosystems, but on the other hand it guards environmental, cultural, archaeological and anthropological heritages and resources of exceptional magnitude that are often not fully exploited, however.

Over time, then, it has given extraordinary examples of techno-scientific foresight and creativity in some strategic areas related to digital development.

For example, CRS4-Center for Research Development and Advanced Studies in Sardinia located in the Technology Park wanted by Nobel Rubbia in Pula in the course of its history has distinguished itself for some Internet-related precedents: it created in August 1993 the first Italian website([www.crs4.it](http://www.crs4.it)), helped create in 1994 the first European web-based newspaper (L'Unione sarda) and one of the first Internet Service Providers (Video On Line).

Currently, many investments are being directed for technological and scientific innovation, and BionikonLab&FABNAT14 are realities that have been able to create their own space of credibility in the regional technological context, due to the amount of projects dissemination, participation in industry events and more. For this reason, when the first Sardinian Makeathon was held in Sardinia in December 2020, we were invited to participate. (<https://www.lanuovasar-degna.it/region/2020/12/12/news/at-scientific-of-iglesias-the-makeathon-award-1.39654397>)

We were the only school present out of a number of participants belonging to professional realities, FABLAB also national, digital professionals, IT sector and innovation in general. We participated with two teams composed of the following teachers:

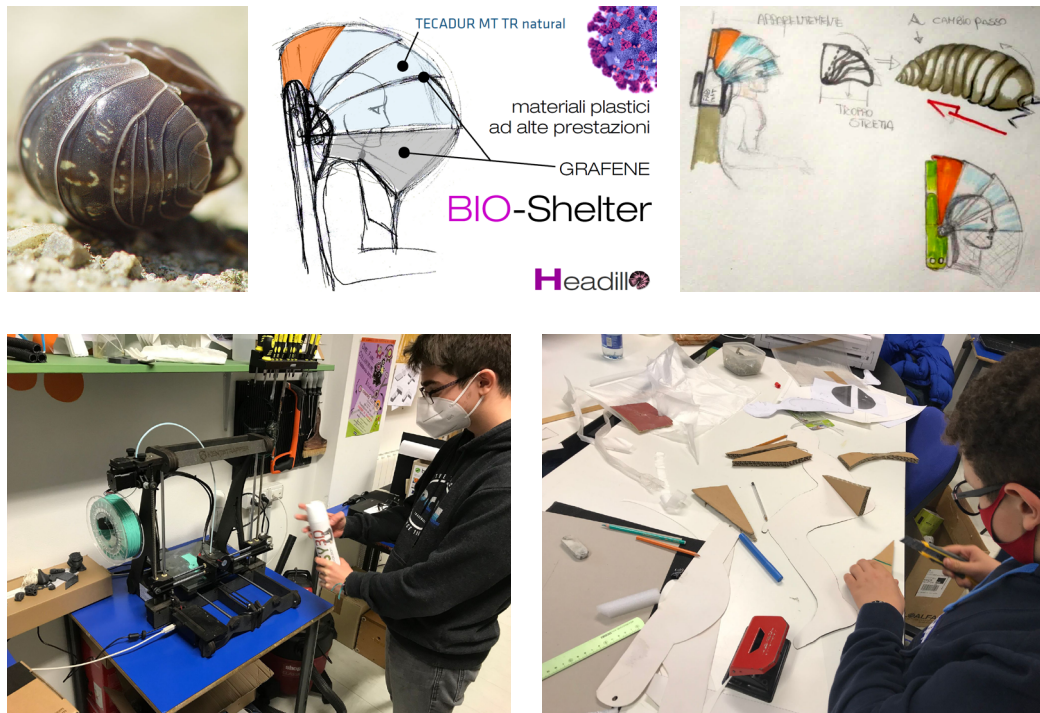
- **Massimo Lumini:** team leader and coordination of biomimetic research and development;
- **Silvia Musa:** design and light modeling manager;
- **Emanuela Manconi:** CAD-CAM expert and design methodology;
- And by the very young students/designers (15 - 16 years old) **Elisa Chighine, Aurora Contu, Leonardo Cuccu, Michele Di Romano, Paolo Granella, Francesco Matzei, Carlo Saiu e Francesco Soddu.**

The Makeathon contest called for teams to design and prototype, using 3D printing, an original concept thought to contribute to design solutions for post-Covid19 issues through a three-day technology marathon from December 3 to 5, 2020.

## **HEADillo**

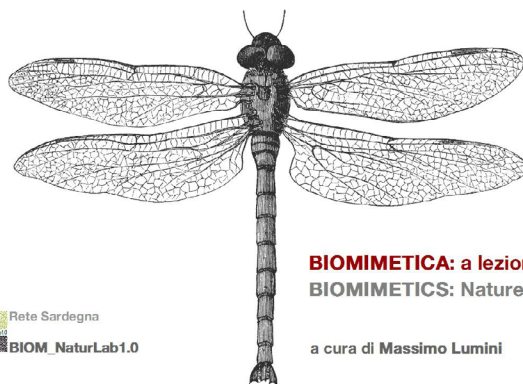
---

It is a design for a kind of helmet-bioshelter, designed to create an individual micro-environment protected from potentially COVID19-infected aerosols. This design is applicable in the seats of airliners and public transportation in general. The biomimetic inspiration comes from the observation and analysis of the very special exoskeleton of *Armadillidium vulgare*, a small terrestrial crustacean that can enclose itself in a kind of ball in case of danger, through chitinous plates hinged together. The discovery of this morphological and functional peculiarity generated a bioinspired idea to create a safety cap with seals and graphene air purification filters.





In our projects there is always a component of attention to the issues of environmental sustainability, renewable energy and resources of the economy and the planet, to educate the new generations in a systemic and solution-oriented eco-friendly vision.



**BIOMIMETICA: a lezione dalla Natura**  
**BIOMIMETICS: Nature's teaching**

a cura di Massimo Lumini



