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Full paper Submission

Farm School Lab . Design method for sustainable space for children school learning. Case of form finding in laboratory aquaponic system inspire by cymatic movement of water.

Keyword: *School Farm / Cymatic / Vernacular Design / Sustainables Learning Strategies*

Abstract

The importance of water for life purpose in planet Earth is vital. As a result of questionable behaviour on natural resources consumption, overproduction of meet, Co2 gas emissions, among others negative factors for our subsistence, have increased rapidly greenhouse effects in the last recent decades. This drawbacks makes us reflect on the delicate balance in which are we living today and how to rise the questions about to encourage future generations to make changes related with the importance of water resources and food production. According to World Food Organization and Agronomy (2016), agricultural sector will be facing enormous challenges to feed the 9.6 million people in nearly future. Also FAO predictions point outs that food productions should increase by 70 % by 2050 (Duran & Alves, 2017). In the complex scenario, future generations are crucial to change actions and also make others reflect about the fragility of our existence, they could make a real change and contribute with a delicate balance between a fragile ecosystems and human behavior. In this concern, smart farming represents a more suitable way to approach this challenges, this not just compared with a conventional rural farms activities , but also growing new trends in farms scenarios , emphasizing in social system organizations , such as school activities, neighborhood communities, among others collaborative way to produce healthy food. Aquaponic system for instance (Hydroponics and Fish Farming) corresponds a more symbiotic relationship between different species, at the same time it represents new trends worldwide for design social innovation in term of use of land and water resources. In this regards, farming activities for kids could represents an engaging way to transforms conventional spaces in a classroom. This show us a "real-life" meaning to children's meanwhile they learn. It can also provide great benefits in terms of environmental issues for learning and play strategies, like another empirical way to used core curriculum content standards. Biological life cycle can still be learned in this context, but is also possible to increase the curious of how can water have so much importance in life, firstly learning strategies by using 5 senses stimulating, providing

geometry, music and arts, increasing consciousness about ecosystem balance in a more playful and natural way.This case study addresses some topics related into new challenges about sustainability and future generations, emphasizing on water resources optimization. Through the design process for a laboratory farms shelter project, by using sound parameters obtained from the observation of geometric sound (cymatics), throughout the form finding design process, this article will illustrates some features considered for an experimental educational sustainable and holistic espace.

Figure 1.: Initial Conceptual Design, Virtual model Farm School Lab. Created by Elvert Durán Vivanco, rendered by Alice Ribeiro

Introduction
Methodology approach into learning design strategies

Research through design (RTD), is the scientific research version where the project design process is the epicenter or focus of study and its way of generating knowledge is through experience to cause an impact by way of results in one or more disciplines (Findelly, 2009). In this regard, Keyson (2009) agrees and points out that this type of research focuses on a more empirical approach, where the design process and its subsequent prototyping are valid stages for the demonstration of a hypothesis or theory. This methodology is strongly tied to the inherent activities or design practices. More specifically, in terms of creative design processes and the conception of complex geometric shapes in architecture and design, which over the course of time, has been a crucial question in exploratory research processes, mainly in relation to the tools, methods, language and also skills used, which inevitably affects the quality and originality of the results and their possible variables.

LILD, Laboratory for Free Design,Brazil, Empirical and natural learning methods on sustainables materials.

During the the last 30 years, there has been remarkable progress thanks to the constant work developed by the research center, which has provided a strong emphasis on tropical vernacular design and architecture. This traditional techniques and local materials knowledge laboratory, have innovated in its methodology, including new technologies for visualization in the design process. This LAB has being teaching to different year students, including school and university pupils, testing several types of bamboo construction techniques, where traditional knowledge and computer visualization skills are mixed on the same environment. (Correia do Melo J. 2016).This learning strategy proposal has recently shown the possibility of a co-existence this hybrid method, which combine virtual technological advances parallel to the construction of analogous models with vernacular techniques. The importance of know-how is defined by this laboratory as the ability to "think with your hands while working hands on" (Retting 1994). It is in this research context, where one of the fundamental pillars is the use of the trial and error method, through physical models on a

smaller scale, for its subsequent analysis, feedback and ensuing real-scale construction. Since this laboratory acts as a benchmark in Latin America, today, new technologies of virtual visualization and similarly constructed physical models are gradually being integrated, giving a new hybrid approach to its line of research through Design. (RTD).

Figure 2,3,4: Reciprocal structures model and bamboo section, phyllostachys aurea . Source author. Laboratório de livre design, Rio de Janeiro.Brazil,LILD, Emeritus Professor and founder José Luis Mendes Ripper.

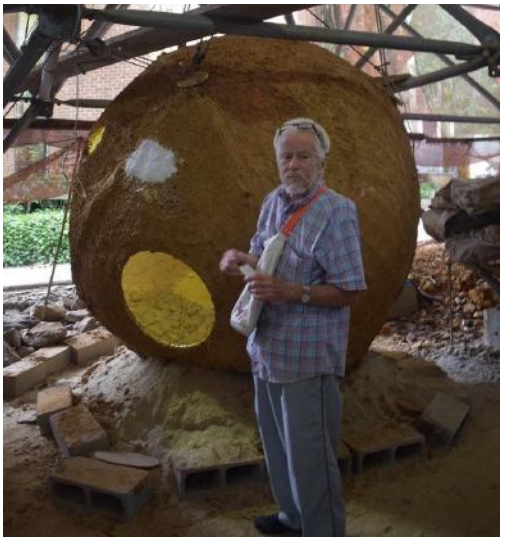
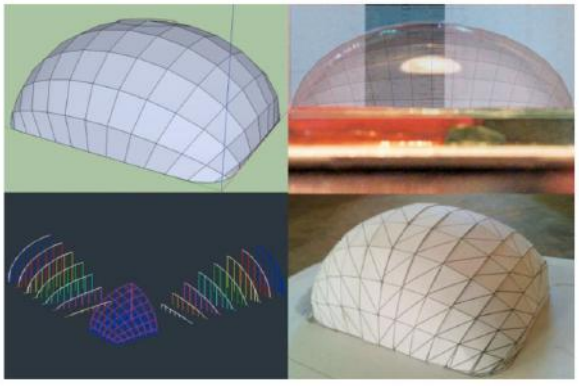


Figure 5 : Buble hall project based on the study and analysis of the minimum surface area of soap bubbles.
Figure 6: Geometric-digital parametrization and its subsequent real-scale construction, mainly in bamboo (*bambusa vulgaris*)

Figure 7: This exemple show us the concept space of ephemeral use in context of classrooms in socially vulnerable children in the city of Rio de Janeiro. Brazil.Design process. Source: João Vitor Azevedo.



In this sense, this text aims to articulate a discussion concerning impact of visualization technologies on applied research work of an academic nature, specifically considering the relationship in geometric spherical construction with vernacular techniques and materials with low environmental impact, among other matters related to temporary or ephemeral architecture, in a specific Latin American tropical context. In terms of children method strategies, we point out the fact that being working with tangible natural materials, is crucial to develop a consciousness about the values of natural world and its vital importance to avoid ecological drawbacks for the future and those problems that we are facing nowadays. (Correia de Melo, Ripper and Moreira, 2013)

Learning from nature.

In the evolutionary process of our planet, organisms and their natural ecosystems have gone through a long evolutionary process, enabling the optimization of their functions and structures, due to survive need on the environment that they inhabit (Correia de Melo, Ripper and Moreira, 2013). There are several examples of survival strategies, adaptation and transformation of different species. It is no an accident that their typologies, morphologies, their growth patterns, behavioral systems and resilience, among others factors are a fertile source of information and inspiration for different areas of knowledge.

From observation of golden proportion, Fibonacci sequences, fractals, proportional subdivision of Voronoi to geometric sound patterns (cymatic), are some examples that have contributed to demonstrate this ancestral wisdom from nature, being a kind of genetic code of knowledge inherited by the nature. However, it is worth to asking, is it possible to rewrite your structures, edit your relationships and generative systems?, Is the language of nature and its syntax what guides the new challenges to be applied into the artificial world? . In that concern , we can affirm that this type of coded information is increasingly recurring in areas of knowledge that are nourished directly from the source of the so-called Biomimetics. The term coined above, comes from the Greek mimetés , referring to the ability to imitate. This capacity is used by nature in its resilient will through, has been evolving for millions of years (Brajovic, 2016).

On the other hand, not just for in design issues, but also for any kind of he creative processes of the conception of complex shapes and geometries focus on natural patterns, have been during the course of time a constant focus on **learning** processes. Several approach methods, domain skills tools, and technique language are demanded, contributing a much more innovative final results research. Terms such as form finding, form shaping or free form making, are increasingly recurring in the processes of design and optimization of generative surfaces and form.

Virtual tools for understanding geometry. Design strategies for future new generations scenarios

With the advent of virtual graphic projection technologies, new paradigms have arisen facilitating role offered by the different virtual media in the ideation, evolution during the creative processes, in regards to more traditional practices in architecture, design and related disciplines. (Brown, T. 2008). Both, virtual and tangible versions could be running in parallel and complementary paths, the differences attend to the aspects of objectivity and subjectivity in the communication process. In other words, thanks to computer technology, virtuality can be rapidly observed and shared by potential users of the future object or projected space with special features (Correia do Melo,J., 2016). In this aspect, the parametric design, to a large extent, has changed the perspective of perceiving and projecting, mainly in computing coding, architecture,art and design, among other creative disciplines. It is necessary to mention that the parametric term derives from the noun parameter, synonym of variable of an equation or system. In other words, the parametric model refers to a digital model based on the set of variables, where the resulting three-dimensional shapes or digital patterns can modify the end result (Chiarella & Pastor, 2015). Likewise, the parametric design reflects some of the most recent trends in computer-aided design (CAD), both in academic research and in the market innovation of increasingly bold and differentiating forms, allowing control in generation and representation of objects from an algorithm programming. (DAVIS, 2011). However, we can see that under this complex scenario, both digital and analogous methods will bring with them a series of variables that directly affect qualitative and quantitative aspects in the research processes. In other words, the parameters defined by the computer, do not always represent the space or the materials used in them, it is only a simulation that allows the user to simply see shapes and relationships, this

does not necessarily imply that the configuration of space and materials will replicate exactly as a palpable and tangible physical space.
These characteristics imply an exhaustive care in the electronic modeling process. Work is done based on an multidimensional space abstractions around us, which is encoded by a classical mathematical representation, to then, make possible its visualization by means of a two-dimensional interface; the computer screen as an observation platform. This representation works in two different universes, the human-real and the universe of the apparatus. To understand and parameterize its operating rules, we work in an attempt to control a virtual space-time.. This could it be a crucial point for learning strategies, specially for future generations that are facing new paradigms in terms of computational skills for understanding geometry and math for instance. Traditional and new knowledge taxonomies frames should take into consideration those new learning scenarios, manly acknowledging this new computational skills demanded for the future school curricula . According to Teaching Children Coding and the Challenges Faced report (2016), coding is the newest addition to the modern day curriculum and is probably the most important skill to learn in the 21st Century.(Keijo Sipilä, 2016).

Figure 8.: kid-friendly programming example. **source** https://www.lifewire.com/kids-programming-languages-4125938 .

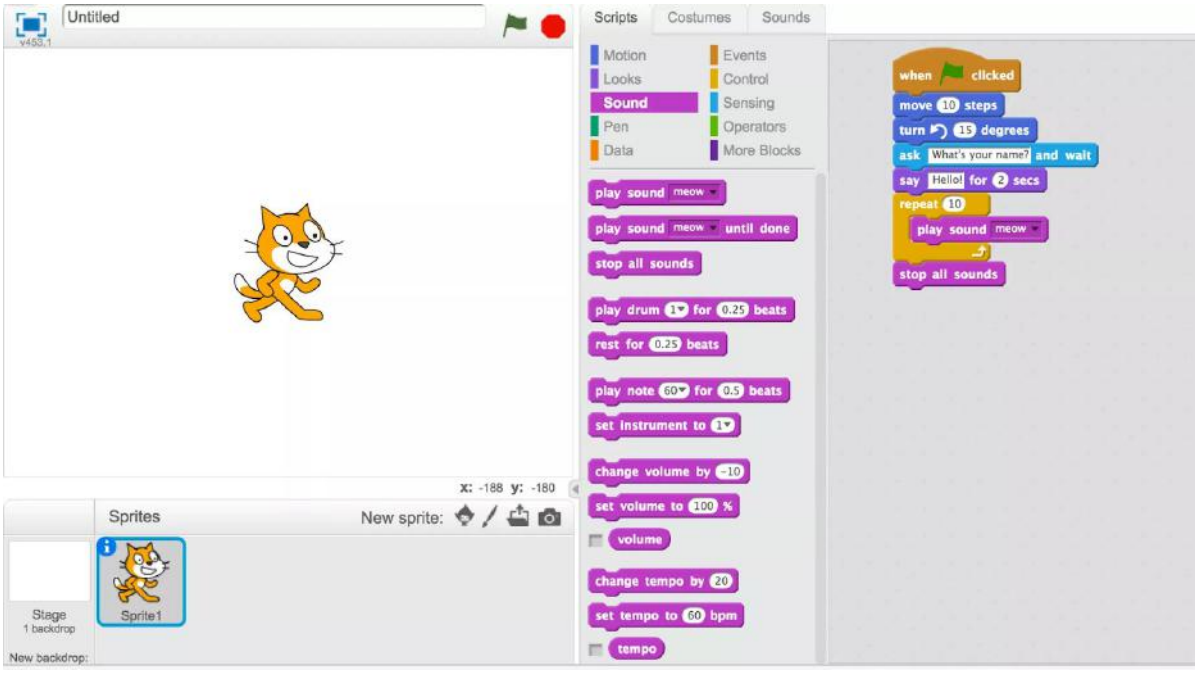


Figure 9.: Virtual models using parametric design : Rhinoceros 6, Grasshopper plugging Elvert Durán Vivanco.

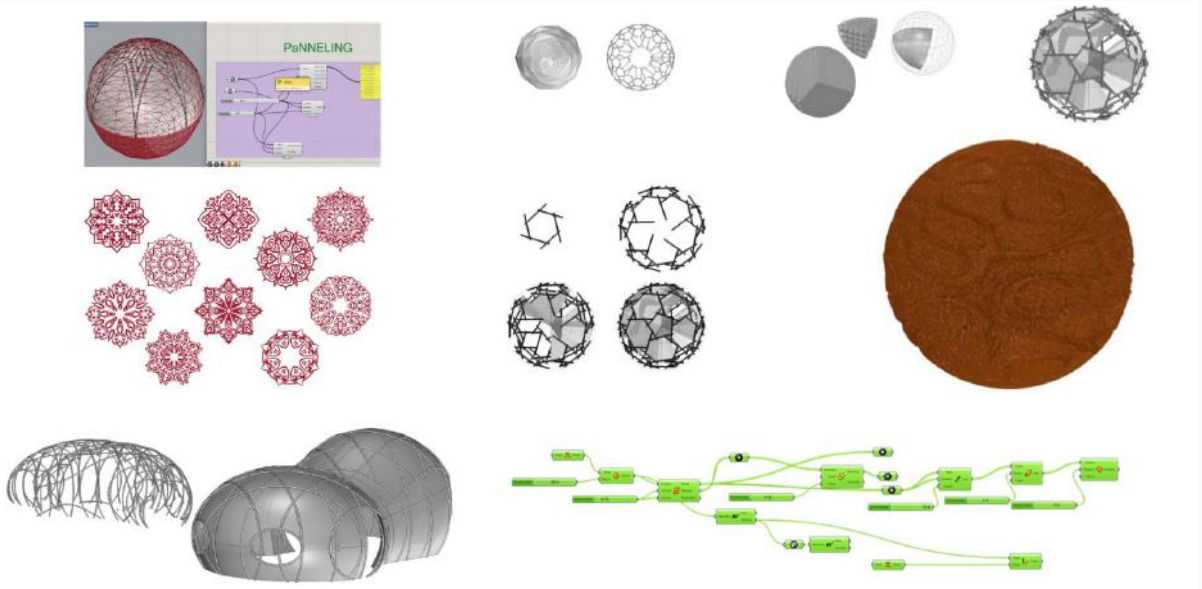
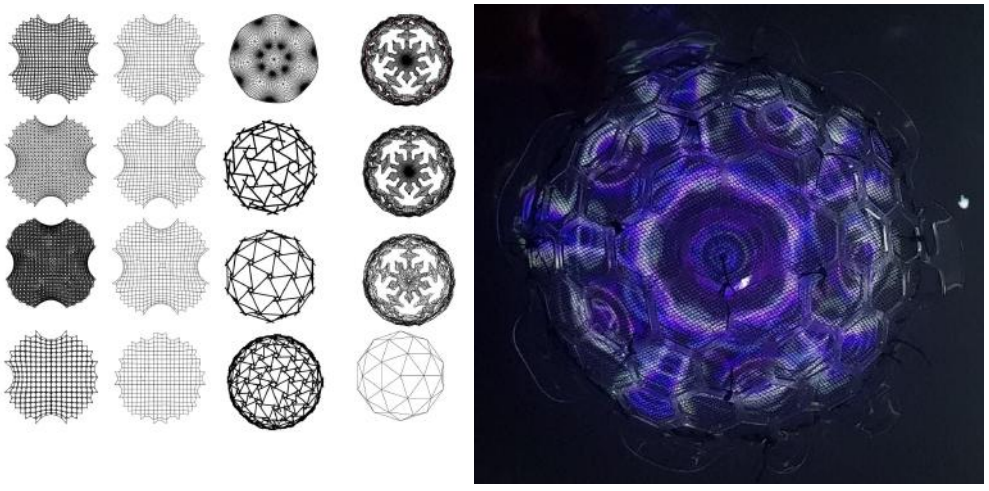


Figure 10,11.: form finding surface design throughout parametric design (virtual) and mapping light techniques (analogic) . **Source author.**



Designing process based on cymatic phenomenon.

First of all, it is necessary to define a meaning of a cymatic pattern and how this reference in physics can be an input for the creation of spaces, considering water is a fundamental element and origin of life. The term cymatics is coined from the field of physics phenomenon, and it analyzes the nodal phenomena in the movement of fluids and solids particles. Baptized by Hans Jenny, a swiss doctor and pioneer in this field, to refer to the effects of periodic movements that sound and vibration have on this state of matter, creating a variable wave, which is possible to be observed for the human eye and replicated its organization in the manner of a cyclic geometric pattern.
Subsequently, Chladni, in his book “Discoveries in sound theory” (1787), describes a series of geometric patterns, illustrating the vibration of a surface with sand granules with the help of a violin bow. Over time, an important numbers of experts, from differents fields of knowledge, from the mathematicians, artistic to therapeutic world, have been able to demonstrate the advances in the registration of these patterns and their application in different contexts, making possible the invisible to be visible.

Figure 12: Cymatic Patterns obtained from moviment water on cylindrical bamboo section (philloskatis aurea) . Frequencies from 16 to 158 hertz. Analog register, Camara Nikon D5500 Iso 2000. Vel. 40.,**Source :**https://www.academia.edu/41441108/Grapohica_2019_-_Procesos_de_dise%C3%B1o_generativo?auto_accept_coauthor=true

It is important to mention that the cross-sectional objective of this case study considers the causal relationship between the geometric concepts and the movement of water (measured through hertz frequencies) and its influence on potential uses , not just for form finding surface in design issues, but also in teaching methodologies for school curricular content, by using sound and matter (water or sands) to explain geometry or math, physic mistured with fluid art for instance , and at the same time, reinforcing the idea of importance of water in life.

Figure 13,14,15 : Cymatic record session, Tomorrow's Activities Laboratory (Brazil). Set of Cymatic Projection. Speaker made by bamboo internal structure , covered by mud and natural resin (Source: Author).

Figure 16,. Scheme of cymatic experiment , source; Figure Cymaticskin .Published on Aug 27, 2014.

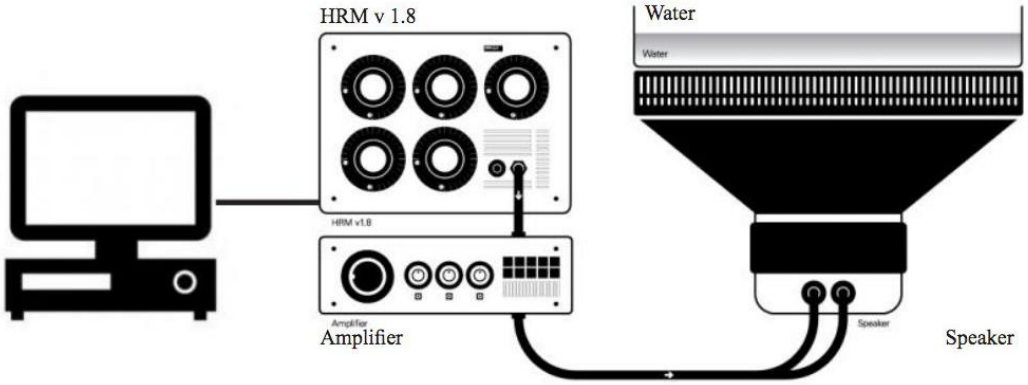


Figure 17: Different Cymatic frequency 55, 77, 97.5 hertz, printed models (Polylactic Acid (PLA)), Source: author.

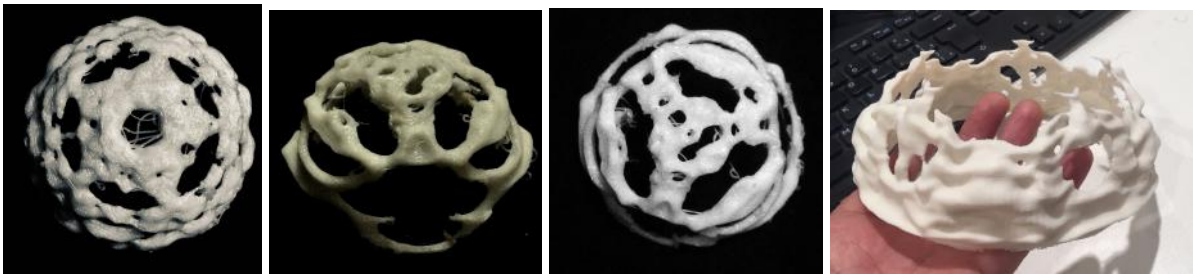
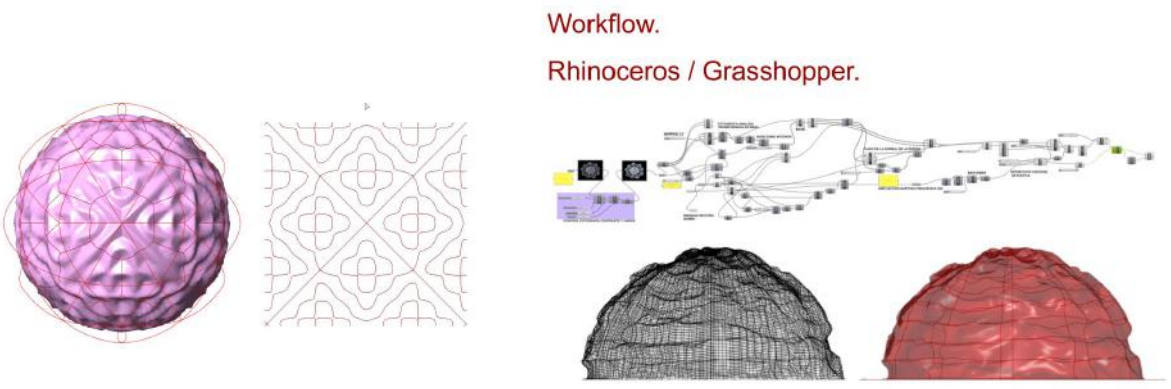


Figure 18, 19.: Programmation Rhinoceros and Grasshopper results according with sound frequencies .32 hertz , 77 hertz (sand and water). Source: author.



Farm School Lab; Aquaponic system design process based on cymatic phenomenon

This second case study addresses topics related to the new challenges in sustainability and digital design, using cymatic based on cymatic, also emphasizing on water optimization for future critical scenarios, such as water scarcity and the self-cultivation of food in community spaces.
Under the hypotheses that the design process is leading by a harmonic balance between the geometry of water and the well-being of human beings (with 75% water), plants and fish that inhabit the area.
Harnessing the power of the ecosystem with a careful mix of component part makes it so that by taking out only a specified percentage of the plant, insect or fish biomass, it will continue functioning by itself with only minimal adjustments. This project proposes to work with low-income communities from the neighborhoods and favelas neighboring the Museum of Tomorrow (Rio de janeiro , Brazil),so that with them we can develop the most low-cost method with the cheapest materials that can be scaled in the most challenging conditions. This ongoing study will enable us to optimize the methodology and the structure so that we can then launch this project in an open-source way across the globe.
The aquaponic system project was focus on differents criterias, such us identification and testing of species of non-traditional food plants from the savannahs and the Amazon, as well as insects that are the most high-protein, and most efficient and eco friendly system: prototyping modular structures (made by bamboo tensegrity structures) for food production that are optimal for adapting to specials conditions , such us small spaces indoors or outdoors ; optimizing the aquaponics system: adaptation of the system to urban challenges as well as automating the system.
Through the design process to **Farm School Lab** project , it will illustrate applied RTD method, using parameters obtained from the observation of geometric sound patterns (cymatics), its subsequent geometric interpretation using computational design tools, for its later development design process, considering spherical geometry and vernacular construction techniques (Duran & Verghese), manly in bamboo and others sustainable materials. From the registries of geometric harmonic movements, the measuring instruments procedure, methods of transference of geometric information in two dimensions to a spherical projection, criteria of structural upheaval and their respective materials and layouts of usability, modular and associativity in each proposed module, even the ability to replicate and adapt geometry to other contexts of use of extreme conditions. The cymatic phenomenon is used in this case, making emphasis on membrane form finding process and also its structural support form shaping.(Duran , E. , Correia do Melo. J, 2019).
Figure 20: Shelter diagram design . Aquaponic & other proteins (insect and spirulina).

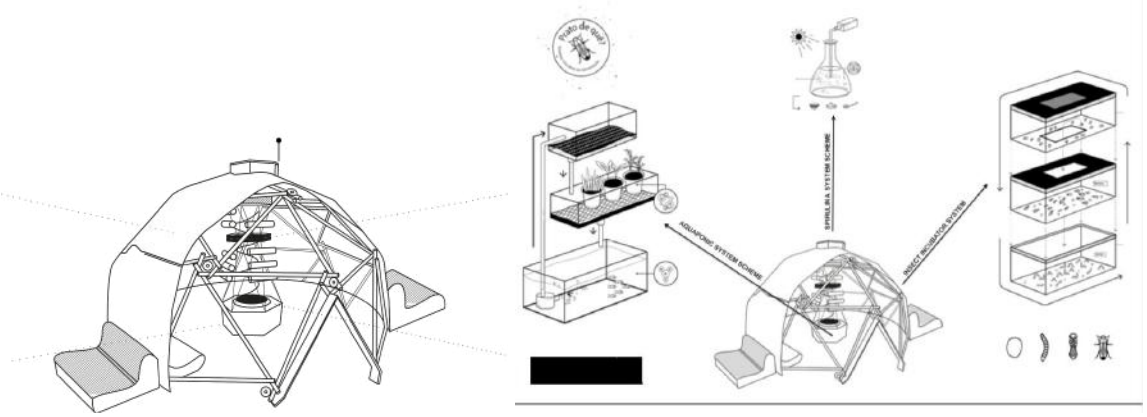
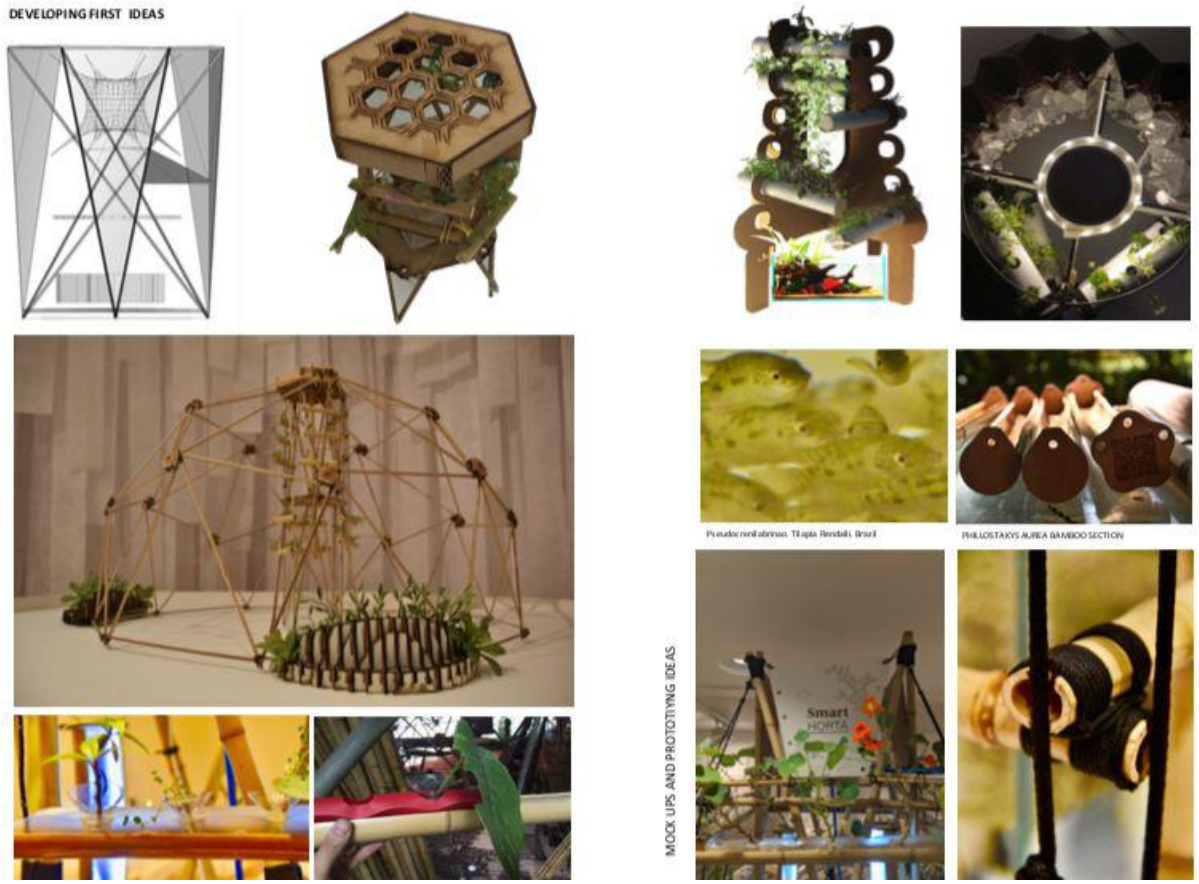


Figure 21 . Mechanical and virtual models. Dome reciprocal structure V2. Source . Author



The project focused on 4 main areas:

• Vernacular techniques and materials: use of bamboo, ex, Bamboo (Bambusa Vulgaris), Cane Bamboo (Phyllostachys Aurea); and others low environmental impact materials available in geographic space.muds, natural fibers (cords).

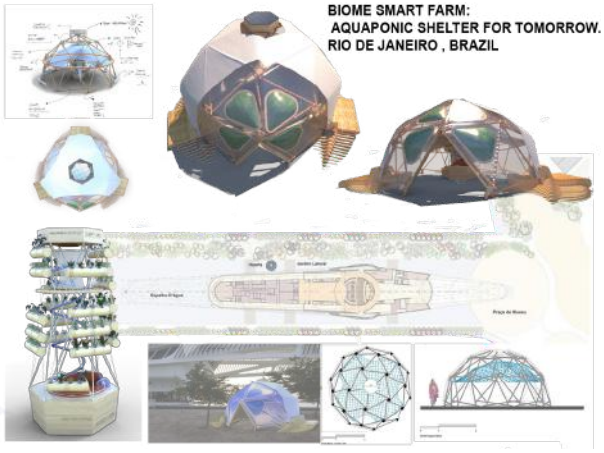
• Modularity and adaptability: prototyping of modular structures toIdeal food production for small places.

• Optimization of water resources through the reuse of water in small-scale micro-cultivation of fish and plants (edible, ornamental and / or medicinal).

• Raise community awareness of the importance of self-production of food.

Figure 22 : Design development process, Farm LAB shelter design and aquaponic tower .source : author .

Figure 23 . Aquaponic lesson for school kids on Museum of Tomorrow , Rio de Janeiro. Brazil September 10 th , 2019. source : author .https://www.youtube.com/watch?v=7i_w1b5f7RI



Conclusions

We can notice in this freedom to choose or free will of digital or similar methods, it will bring with it a series of variables that directly affect qualitative and quantitative aspects of the research processes.It has the condition to maintain the balance between the two world, the virtual and the tangible.

We can include other factors or variables that contribute not only to the design process, but also on physical materials, geometric, structural, spatial, constructive possibilities, among other relevant factors of the design results. Whether analogous or digital, in alignment with two, three or even four dimensions (cymatics), all tools have been an successes and failures procedure , as a valid methods to reach the solution or response to the challenge purpose of research. One collaborates with the other, and between the two they offer results with differentiating characteristics in much more playful and creative way. The important thing is to match right parameters that stimulate those freedoms that bring the virtual and make them dialogue with the concrete and tangible world. In term of “play and lean strategies”, this new knowledge strategy approach makes us think on a fruitful conversation between teaching design methodologies and learning strategies for new generations, especially considering upcoming challenges , not just in terms o sustainabilities issues, technological virtual tools , programmation skills, 3d printing knowhow , but also and terms of creativity applied into problem solving concerns, this among other futures curriculum school challenges.

FIGURES

Figures 1: Virtual models using parametric design : Rhinoceros 6, Grasshopper plugging Elvert Durán Vivanco, rendered by Alice Ribeiro.

Figure 2,3,4,.: LILD, Laboratory for free design, Brazil, Emeritus Professor and founder , José Luis Mendes Ripper . Models of collaborative structures and Bamboo section . Source author**.**

Figure 5,6,7. Buble hall project based on the study and analysis of the minimum surface area of soap bubbles, geometric-digital parametrization and its subsequent real-scale construction, mainly in bamboo (*bambusa vulgaris*) This exemple show us the concept space of ephemeral use in context of classrooms in socially vulnerable children in the city of Rio de Janeiro. Brazil.Design process. Source : João Vitor Azevedo.

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Figure 22 . Opening session on design proposal, Museum of Tomorrow , Rio de Janeiro. Brazil September 10th , 2019.
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