UNIVERSITAS KRISTEN MARANATHA

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SEMINAR NASIONAL

PROSIDING

Budaya Dan Kearifan Lokal Untuk Masa Depan:
Antara Tantangan dan Peluang di Era Disrupsi

UNIVERSITAS
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ISBN 978-623-92354-1-3

Kamis, 17 Oktober 2019
Universitas Kristen Maranatha
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Cetakan pertama, Desember 2019

DAFTAR ISI

DISRUPTIVE TECHNOLOGY IN ANGKLUNG BIOMIMICRY EXPERIMENTATION

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ABSTRACT

As a young species of 200.000 years, human is part of earth ecosystem. For 3.8 billion years, other living beings have evolved, adapting and selected by nature, until we came and disrupt the balance. Population growth have driven more efficient technology against traditional agricultural that once was rich of local wisdoms. The usage of traditional artifacts in repelling pests is replaced by pesticides with hazardous chemicals that have harmful impacts on nature, including humans themselves. In result, global climate change and food security are critical issues in this disruptive era.

Nature-derived myths and traditional culture in some parts of Indonesia uses local wisdom for its agricultural activities. At Sindang Barang, ritual of Angklung playing was used during seeding, maintaining and harvesting of rice plant in order to receive spiritual blessing from Dewi Sri (goddess of fertility). There are patterns and strategies of traditional Angklung in repelling pest and fertilization of rice field. Hollow sections in bamboo tubes act as resonant chambers that produce frequencies which animals and plants respond.

This article explains of Angklung design experimentation with disruptive technology. With use of digital modeling and 3D printing, resonant chambers can quickly be developed with precision. Developed designs uses PLA (Polylactic Acid) and FDM (Fused Deposition Modeling) printing method. Altering the design of the diameter and length of the resonant chambers produces different frequencies. The result of this experiment are sources for further research as part of biomimicry analyzation of dissertation study in progress and use modular concept that helps combine different frequencies measured with spectrum analyzer. Frequencies of the prototypes can be compared to pest response in rice fields. Past, present and future of art and design is always evolving. Industrial revolution with 4.0 technology such as Additive Manufacturing / 3D printing is used not to change but to enhance the local wisdom tradition in explorative design of sustainable product.

Keywords: angklung; *biomomocry, experiment, local wisdom*

ABSTRAK

Sebagai spesies muda 200.000 tahun, manusia adalah bagian dari ekosistem bumi. Selama 3,8 miliar tahun, makhluk hidup lainnya telah berevolusi, beradaptasi, dan dipilih secara alami, sampai kita datang dan mengganggu keseimbangan. Pertumbuhan populasi telah mendorong teknologi yang lebih efisien terhadap pertanian tradisional yang dulunya kaya dengan kearifan lokal. Penggunaan artefak tradisional dalam mengusir hama digantikan oleh pestisida dengan bahan kimia berbahaya yang memiliki dampak berbahaya pada alam, termasuk manusia itu sendiri. Akibatnya, perubahan iklim global dan keamanan pangan adalah masalah penting di era yang mengganggu ini.

Mitos yang berasal dari alam dan budaya tradisional di beberapa bagian Indonesia menggunakan kearifan lokal untuk kegiatan pertaniannya. Di Sindang Barang, ritual bermain angklung digunakan selama penyemaian, pemeliharaan dan panen tanaman padi untuk menerima berkah spiritual dari Dewi Sri (dewi kesuburan). Ada pola dan strategi Angklung tradisional dalam memukul mundur hama dan pemupukan sawah. Bagian berongga dalam tabung bambu bertindak sebagai ruang resonansi yang menghasilkan frekuensi yang direspon oleh hewan dan tumbuhan.

Artikel ini menjelaskan tentang eksperimen desain Angklung dengan teknologi disruptive. Dengan menggunakan pemodelan digital dan pencetakan 3D, ruang resonansi dapat dengan cepat dikembangkan dengan presisi. Desain yang dikembangkan menggunakan metode pencetakan PLA (Polylactic Acid) dan FDM (Fused Deposition Modeling). Mengubah desain diameter dan panjang ruang resonansi menghasilkan frekuensi yang berbeda. Hasil percobaan ini adalah sumber untuk penelitian lebih lanjut sebagai bagian dari analisis biomimikri dari studi disertasi yang sedang berlangsung dan menggunakan konsep modular yang membantu menggabungkan frekuensi berbeda yang diukur dengan penganalisis spektrum. Frekuensi prototipe dapat dibandingkan dengan respons hama di sawah. Seni dan desain masa lalu, sekarang, dan masa depan selalu berkembang. Revolusi industri dengan teknologi 4.0 seperti Additive Manufacturing / 3D printing digunakan tidak untuk mengubah tetapi untuk meningkatkan tradisi kearifan lokal dalam desain eksploratif dari produk yang berkelanjutan.

Keywords: *angklung*; biomimikri; percobaan; kearifan lokal

INTRODUCTION

Global climate change and food security are one of the most critical issues we are facing today. For 3.8 billion years, living beings have harmoniously evolved and selected by nature. Balance is key, but ironically lost in the last 200.000 years since Human become a part of Earth's ecosystem. For example, just 64 years after the Republic of Indonesia's independence in 1945, the global temperature has risen 1° Celsius. Meanwhile, according to International Union for Conservation of Nature, biodiversity is declining (IUCN, 2019). Within 105,700 species currently on the Red List (list of endangered species), more than 28,000 species are threatened with extinction. Our policy, plan and action have to reverse the damage done, it is time to learn from nature, our grandest teacher in our planet.

As the population grows, finding balance of supply and demand is never easy. 264 million people of Indonesia (World Bank, 2017) need to have food, water and other living infrastructures. As the Republic of Indonesia shifts from agricultural to industrial nation, many farmers do not have any successor with the fact that there are only 4% of farmers aged 15-35 left (BPS, November 2019).

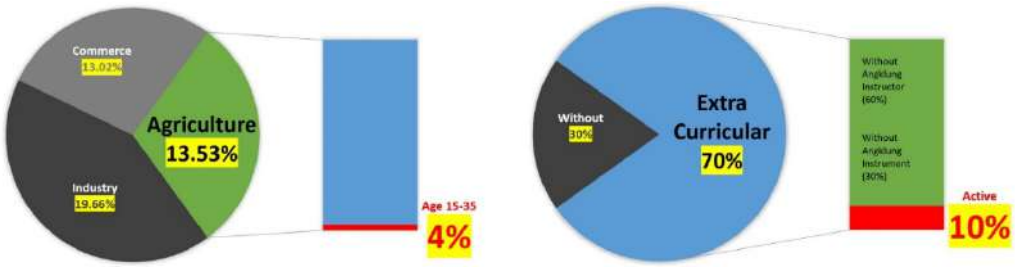

Figure 1. Top 3 Indonesian GDP 2018 (A); Angklung usage in West Java School (B)
Source: BPS, November 2019 (A); Dudi Darma Bakti, Saung Angklung Udjo Foundation, 2017 (B)

Local wisdoms are used widely as traditional culture in Indonesia. With approach to respect nature, specifically in agriculture routine, there are rituals of blessings and worship. Dewi Sri (Nyai Sri Pohaci) is mythically known as the fertility goddess. Her presence is appreciated by conducting ceremonies with sound of6 rattling bamboo tubes, currently known as Angklung. These artefacts have long agricultural history before transforming into an idiophone musical instrument. Ecologically, the animal respond to certain frequencies of vibrations. These sound spectrums produced by rattling resonant bamboo tubes can be measured scientifically.

The traditional method of Angklung playing has many advantages in repelling pests compared to the use of toxic pesticides. With toxic chemical such as DDT the effects are not just harmful for insect but also for us because it is non-water soluble and is considered a possible human carcinogen. With natural way of action and respond of Angklung, the biodiversity of species is preserved.

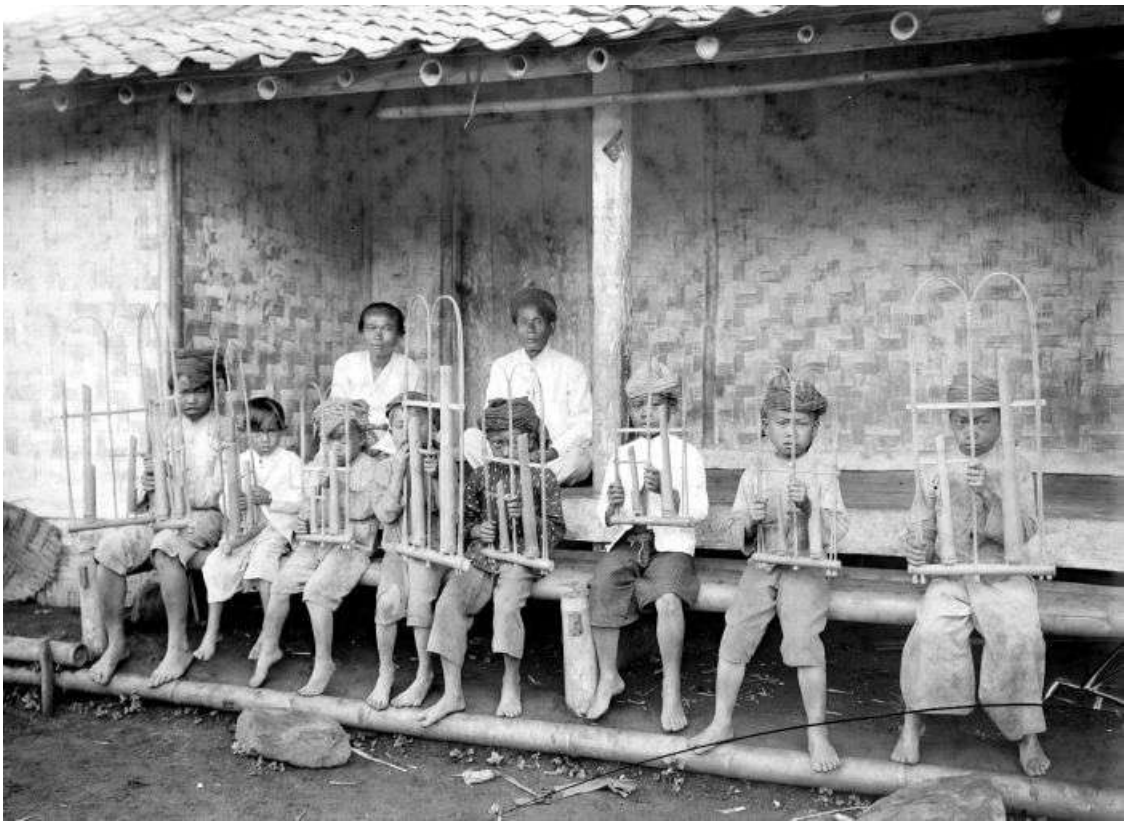

Figure 2. Young Angklung players, circa 1918
Source: wereldculturen, n.d

Countless stories and folklore about Angklung has existed since the 7th century. Angklung is originated and has existed before the first Hindu kingdom in West Java (Groneman in Cahyadi, 2018). One of the oldest Angkungs (believed to be more than 600 years old) can be found in Bungko village, Cirebon, West Java and was used as missionary endeavor of Islam religion. Later, Angklung was spread to other places in Indonesia, such South Sumatra, Kalimantan, Lampung, Central and East Java (Kunst Yaap in Cahyadi, 2018). In Bali, Angklung was also photographed and preserved in Walter Spies' book.

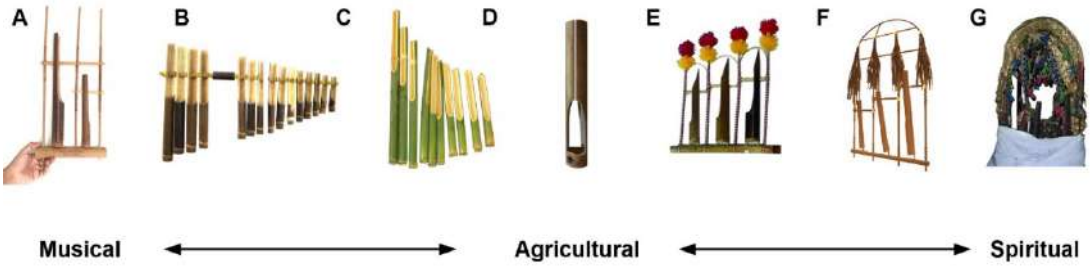

Figure 3. Angklungs, from modern Padaeng (A), Calung (B), Senggayung (C), Kepuakan (D), Reyog (E), Buhun (F), Bungko (G) and their function/meaning as traditional artefact.

There are three main functions of Angklung. Before it was known as a musical instrument, Angklung has agricultural and spiritual meanings (Figure 3).

SPIRITUAL

Even in spiritual context, Angklung is closely associated with rice planting ritual. The ritual is performed by playing Angklung in three steps. First step is to wake Dewi Sri the night before ceremonial planting of rice (ngaseuk). Second step, to announce her marriage to earth (ngereremokeun), performed in following morning. Lastly, to symbolize the earth receiving "medicine" in order to protect the rice from harmful diseases, performed a few weeks later to end the ritual (Wim van Zanten, 1995).

AGRICULTURAL

Nowadays, Angklung's agricultural function is still preserved in form of Angklung Gubrag at Cipining village, Bogor, West Java. The people believed in the folklore of Dewi Sri and the growth of rice plant. When a harvest failure occurred, it was associated with the anger of Dewi Sri. The people then made a ritual art show to invite the goddess to come back to earth and bless the fertility of the rice. However, the first attempt was not successful. To prevent famine treat,

Mukhtar, a local young man, and his friends meditated for 40 days at mount Cirangsad. When they returned to the village with some gambang surat bamboo, they created a set of Angklung. The village then held a ceremony accompanied by that Angklungs and effectively made the rice field fertile, ending the famine. The people believed that the Angklung Gubrag sound made Dewi Sri comes down to earth, as the word Gubrag means fall or go down. Gubrag is also the sound of the tune without musical notes and long before the Angklung becomes diatonic (Sundanese form of musical notes) or pentatonic (International form of musical notes). Six of the Angklung Gubrag was named Bibit, Anak Bibit, Engklok 1, Engklok 2, Gonjing and Panembal. Hypothetically, the usage of Angklung Gubrag is a form of biomimicry found by local wisdom and successfully repel pests and fertilize rice plant (Figure 4).

Figure 4. Angklung Gubrag traditionally used as ceremony during Nandur, planting of rice based on star dating and still conducted ritually in Sindang Barang.
Source: youtube, 2019

Since 2010, Angklung is recognized by UNESCO as Indonesia's Intangible Cultural Heritage of Humanity in form of a musical instrument. Designer and researcher have the responsibility to explore, enhance, expose and promote the Angklung (Sugiharto, 2018). The potential of Angklung's agricultural function has not yet explored. Therefore, this research is needed to be conducted with the main aim of sustainability.

CREATION METHODOLOGY

The basis of this project is experimentation with emphasis of traditional artefact derived from nature and agricultural use, inspired by local wisdom and sustainable approach. Physical properties of Angklung Gubrag, which is still preserved as a ceremonial tool to enhance

fertility of the rice plant, need to be confirmed by scientific measures. The spectrum waves of the sound produced can be compared to the spectrum that animal can respond, in this case ultrasound. It is very time consuming and not feasible to make prototypes of testing samples with traditional methods, as it requires special skills of Angklung maker. In addition, the most suitable materials used are also hard to find (black bamboo) and too precious to be used as disposable testing equipment. Disruptive methods need to be used, in this case rapid prototyping. It is important to use the most efficient method that can replicate the main characteristics of traditional Angklung Gubrag, and also the samples need to be accurate and repeatable for the measurements. With today's disruptive technologies, from the ground up it can be designed digitally and shared, produced, modified and tuned with the most efficient and sustainable methods.

Morphologically the modular Angklung prototype is based of form follows function. The struss section of the middle frame is conventional efficient design and similar to how nature creates form (Williams, 2013). Just like a grebe bird with long neck and short tail, the middle part is counterbalanced crane and tower. Additive manufacturing technologies have certain characteristics, mainly during embodiment process. Layers of melted material in coordinated X and Y axis are extruded by moving nozzle, however due to earth gravity force, the melted material will fall if there is void, so by design (or automatically, software) there is option of adding support material. These extra material for supporting the main material used for the actual product is further removed, hence it is considered waste, both in cost and environment impact (energy, waste, material). With clever design, we can build product without support material. Positioning the Z-axis, removing the bridge and use maximum of 45° angle of void, can be performed and also considered during the design stage.

BIOMIMICRY, ANIMAL RESPONSE.

Ultrasound frequency, mostly beyond human ear can detect but actively used in animal world. Sensitive responses of those sound by animal, connected to survival, reproduction and identification activities. Copiphora Gorgonensis (Figure 5) can track source's position accurately by using acoustic trachea chamber at sides of their chest, slowing down soundwave movement into the eardrum beneath their knees. By comparing the sound waves delay, crickets can identify the exact distance and position of the source.

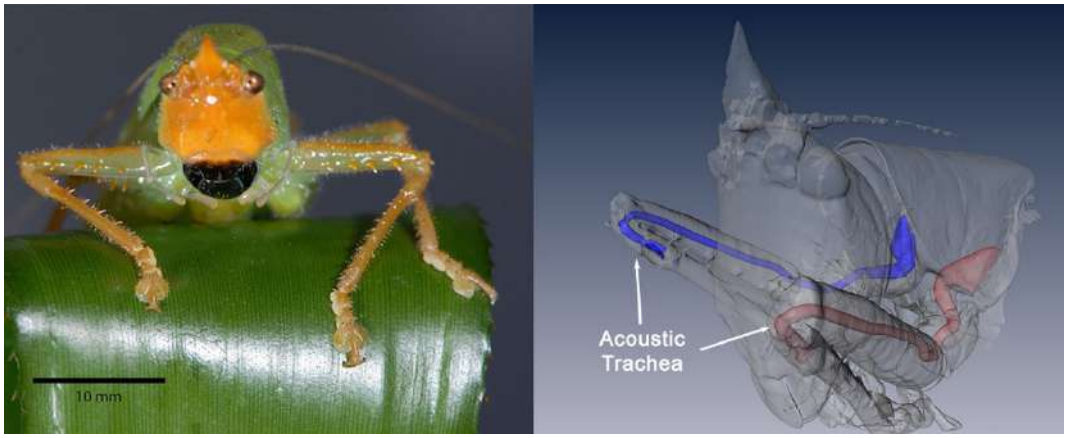

Figure 5. Acoustic chambers leaf cricket for position detection.
Source: Robert, D and Montealegre-Z, F; Jonsson, T

Table 1. Ultrasound frequencies in Animal

FREQUENCY	***ANIMAL***
3-5 kHz	*Birds, Butterflies*
22-25 kHz	*Cats, Dogs*
38-44 kHz	*Mosquitos, Fleas, Spiders, Cockroaches*
50-55 kHz	*Flies*
52-60 kHz	*Lizards*
60-72 kHz	*Mice*

Source: Author, 2019

The sound waves are not only responded by animals but also plants. Researches show that certain resonant frequency can enhance growth by 5.7% (rice plant) up to 37,1% (cucumber). The resonant vibration of stomata can improve nutrition absorption.

3D PRINTING

As one of disruptive technologies, the exact term describing this method have evolved from Rapid Prototyping to Additive Manufacturing. Terry Wohler mentioned 3D Printing in 1989 and by 2009 these method is standardized in an international standard (ISO/ASTM 52900) and revised in 2015:

> *2.3.1*
> *3D printing*
> *fabrication of objects through the deposition of a material using a print head, nozzle, or another printer technology.*
>
> *Note 1 to entry: Term often used in a non-technical context synonymously with additive manufacturing (2.1.2); until present times this term has in particular been associated with machines that are low end in price and/ or overall capability.*
>
> *ISO/ASTM 52900:2015(en)*

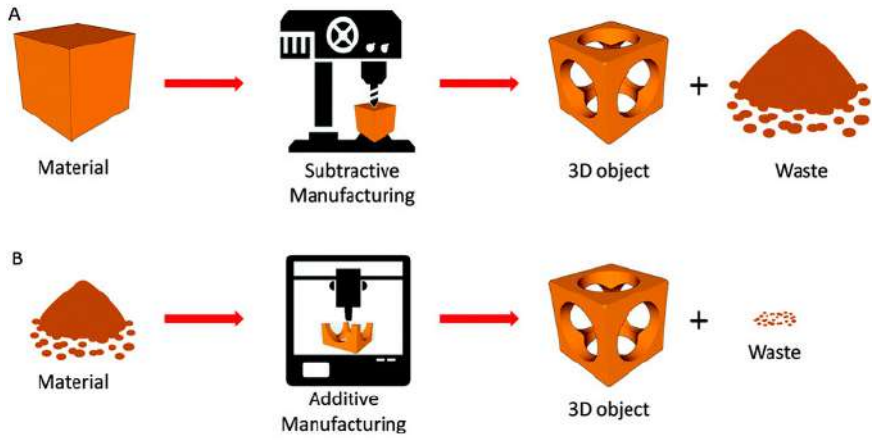

Figure 6. Additive manufacturing uses less material and produce less waste compared to subtractive method. Source: 3D Natives, from https://www.3dnatives.com/en/3d-printing-vs-cnc-160320184/

With the Additive manufacturing method, it is possible to produce prototypes with void chambers both in structure and body. Instead of making holes from solid parts with mechanical process that use a lot of energy, time and also produce waste material, the holes and hollow sections can be made precisely from the beginning of the production process.

Use of 3D design reduces the effort and time in making modular Angklung prototypes for experiment purposes compared to original bamboo tubes. Organic bamboo material for Angklung has to have specific water content, age and type, requires special skill for

production and tuning of the sound frequencies. In purpose of experimentation and testing of output sound spectrum, modularity is one of the key point, and the use of digital rapid prototyping is suitable. However, the skill and techniques of original bamboo Angklung production is a masterpiece and can be enhanced and explored by art and design.

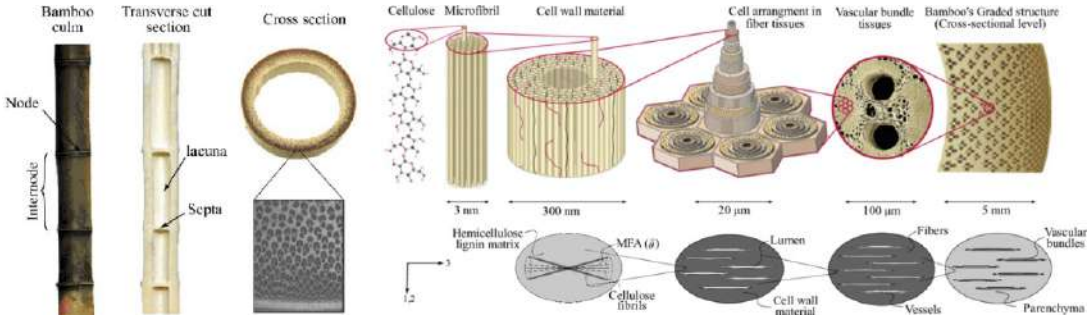

Figure 7 Micromechanic chambers in Bamboo.
Source: Tarun Gangwar, 2019

The culm in Bamboo material is made from various density hollow cells. The chambers are denser towards the skin and sparser in the middle of the plant. This genius of structural efficiency is mastered by Bamboo plant that make them grows with rapid rate, certain species of bamboo can grow 910 mm in a day or about 1mm every 90 seconds.

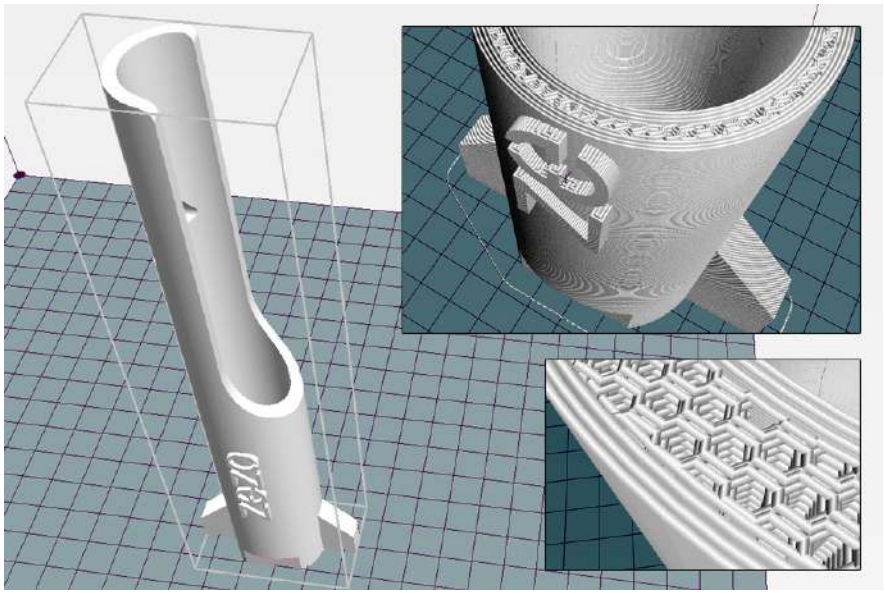

Figure 7. Honeycomb chambers in 3D printed prototype with Adjustable infill density and structure form.
Source: Author, 2019

With 3D printing slicer software, we can adjust the density and structural types of infill. In this project (figure 7) honeycomb is used as it has one of the most efficient volume versus strength ratio. It is possible to choose between 20% to 100% infill as needed and tuned by different materials used in the printing process.

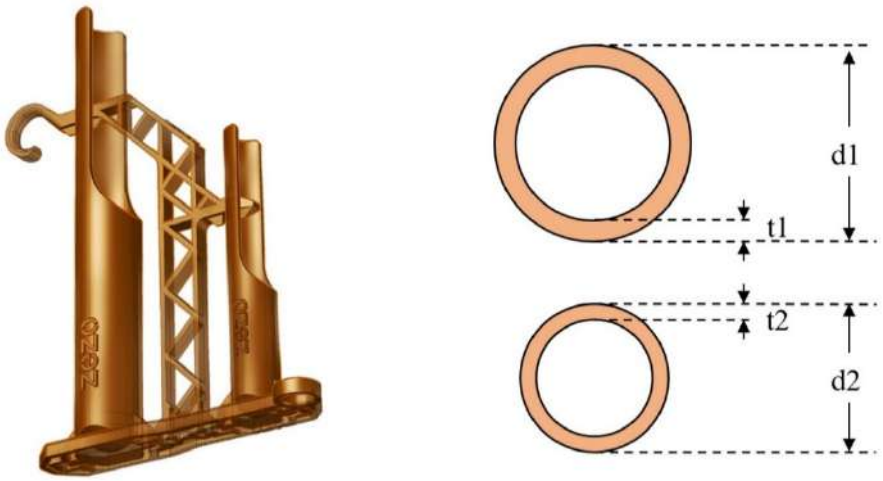

Figure 8. Modular resonant tubes thickness
Source: Author, 2019

The design of this modular Angklung uses zero support material. All the parts can be printed cleanly without any support and resulted in more efficient energy, material and time used to print. This concept is in harmony of the sustainability aspect of the biomimicry methodology.

Table 2. Specification of Product Samples

Sample	***A***	***B***	***C***	***D***
Material	*Bamboo*	*PLA wooden*	*PLA wooden*	*PLA wooden*
d1 (mm)	*40.2*	*40.0*	*40.0*	*40.0*
d2 (mm)	*28.1*	*28.0*	*28.0*	*28.0*
t1 (mm)	*4.0*	*3.0*	*2.5*	*2.0*
t2 (mm)	*3.7*	*2.5*	*2.0*	*1.7*

Source: Author, 2019

The resonant tubes are made with several variations of dimensions for experimentation purpose. Sound characteristics, are not discussed in this article but the modularity are one of the main design concepts. The biomimicry methodology of Angklung sound to repel pest and fertilize plant can be measured with spectrum analyzed in further experiments. Variations and tuning of the sound is needed later in the research process.

ERGONOMY

Ergonomically, the product has to conform to basic safety and usability during operation. As ambidextrous instrument, this Angklung has two physical handles. The upper handle is an open 24mm ring that can be used with just left thumb or both thumb and index finger, as a pivot point for Angklung movement. Lower handle is used to move the Angklung in

horizontal rocking direction to make the rattling sound, hence the location of the 18mm hole with smooth taper can be comfortably pinched with right hand. The locations of those two handles can be further optimized to make the most efficient rattling sound that caused by the impacts of the tubes into the base.

The leverage ratio of the handles versus the distance between the tubes to the base can be calculated and designed. Modular concept also resulted that the leverage ratio can be changed with just modifying the base or the frame, without need to change the tubes. This concept helps with efficient use of materials and also the variable requirements during experiments. Other ergonomic considerations are during assembly and maintenance. The product can be disassembled with just two M3 bolts, replace the tubes with very simple steps and physical upper mount that locks in place. There are triangular form of male and female joints that can be disengaged just by simply rotate the resonant tubes.

MODULARITY

Modularity is one of main constraints in this design. As one of experimentation tools in research dissertation, the resonant tubes have to be created, tuned, changed quickly and easily without changing other parameters. With 3D printing, the variations of the tubes can be precisely fabricated with different thickness, length, proportion and material. Modularity is built-in the design as a main feature. With just 2 bolts, the product can be disassembled, tubes can be changed, and put back together easily.

Figure 9. Replicable modular resonant tubes design.
Source: Author, 2019

These aspects of design development show that there are many parameters involved in functional product. The precision needed in making Angklung, both manually or digitally can be performed in details. Thorough design calculation can help the embodiment process for specific purpose of Angklung, as musical or ideophone instrument or as agricultural or ceremonial use.

CREATION PROCESS

From the ground up, the creation process of the modular Angklung is based from 3D design. With digital modeling and manufacturing, form dimensions can be produced with precision, repeatedly. With just one base and main frame, samples of different tubes thickness, length and material density can be mounted. With 3D printing software, the infill is set in 20% minimum to maximum of 100%. The void and cavities of natural bamboo is thicker at the outside, can be replicated (although not exactly the same) in the 3D printed sample.

The less infill, more efficient material used and quicker printing process time needed. The infill can be set in geometrical form, and for this sample, honeycomb is selected for efficiency. Biomimicry method in taxonomy is used for finding the most efficient form, and we can learn from nature, in this case, bees that use hexagonal pattern for strength ratio versus weight and material use.

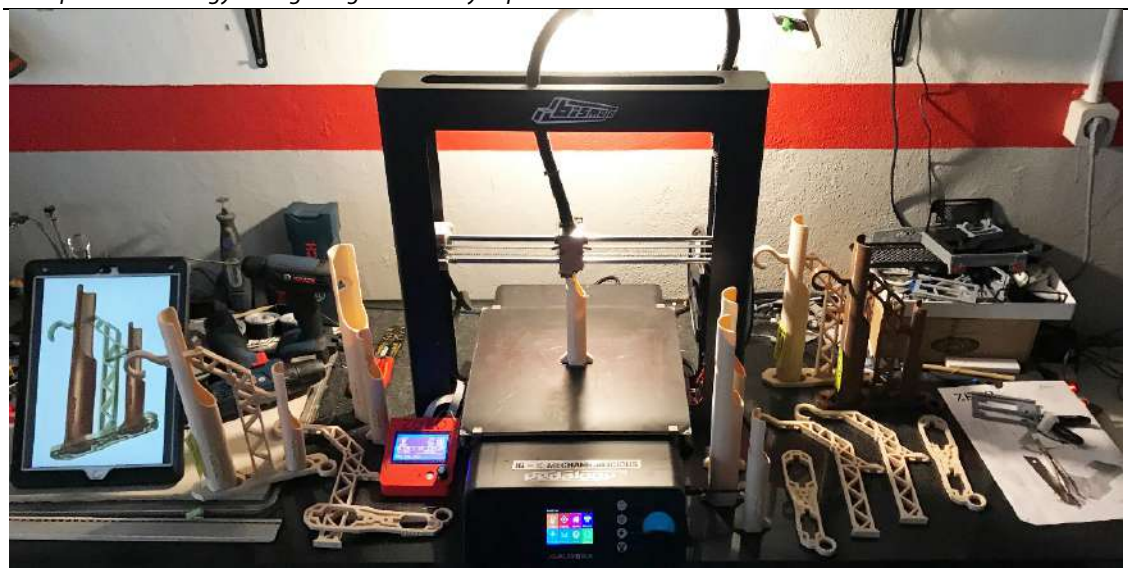

Figure 10. Prototyping process with additive manufacturing method at author's workshop
Source: Author, 2019

BIOMATERIAL

PLA (Polylactic Acid) is one of biopolymers used as filament material in FDM printing process. As bioplastic, PLA is biodegradable and more environmental friendly compared to ABS, Nylon etc. The lower melting point of 180^{O} Celsius also helps with energy usage during long printing process. PLA is available in many colors, and also so many producers, some even mixed real wood with PLA and some are recycled. Further development of additive materials for 3D printing is possible with other more biodegradable biopolymers produced by living organism with lower melting temperature.

FUSED DEPOSITION MODELLING STRATEGIES

As designed, the samples are able to be printed without support materials. This method helps reduce time, material and failure risks during printing process and the removal of the excess materials. Hot bed temperature is between 45-55 C and Hot end nozzle is between 190-210 C, and after cooling down the parts can be removed from the base and on to the next process: assembly. There is no post processing needed after printing the parts.

ASSEMBLY

The assembly of the modular Angklung can be performed with hand and 1 tool: 2 mm hex screwdriver. It is also possible to use Philips bolts and driver, but in this design the hex is selected due to stainless steel material which is more durable and rust-free. To prevent stripping of the treads at the main frame, the bolts should not be over-tightened during assembly. With correct torque, the 3D Angklung can be disassembled many times, and designed with long treads area to improve the durability.

Normal printing time for part A (Frame) and B (Base) is about 2 hours. The resonant tubes take longer, about 3 and 5 hours each. Compared to original bamboo, the manufacturing time is much quicker and suits the requirement for experimentation purposes. Rapid prototyping is applied form the beginning of the process to the end, with sustainability, usability, ergonomic, modularity and precision aspects for a functional product.

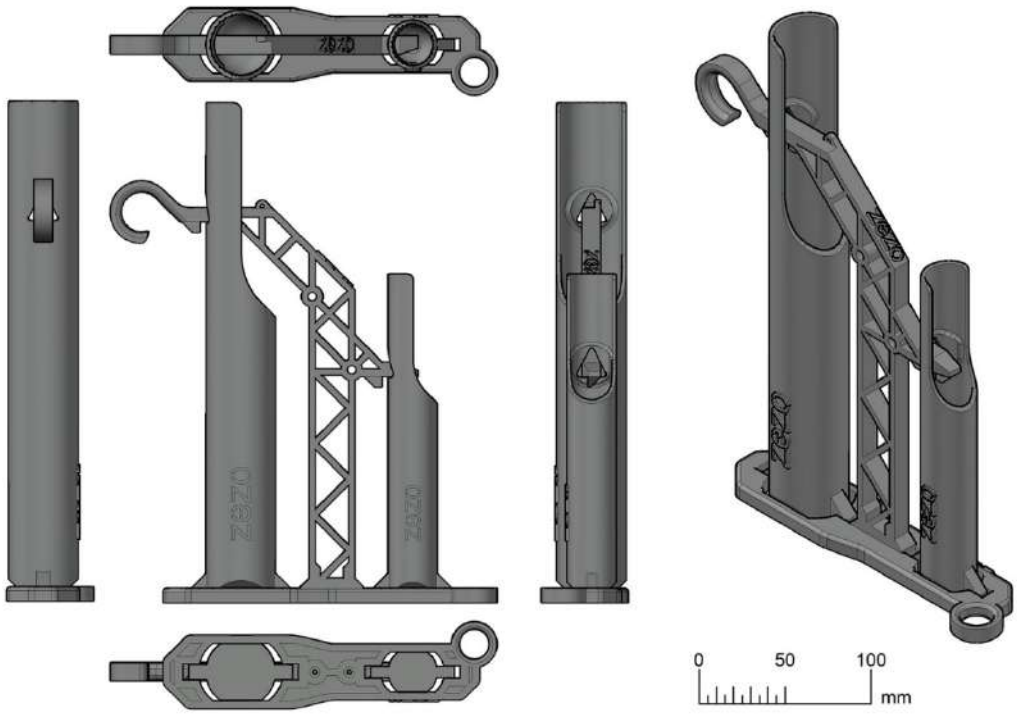

Figure 11. Angklung GubXYZ prototype with scale dimensions.
Source: Author, 2019

ISBN 978-623-92354-1-3

Figure 12. Angklung GubXYZ prototype in wooden brown.
Source: Author, 2019

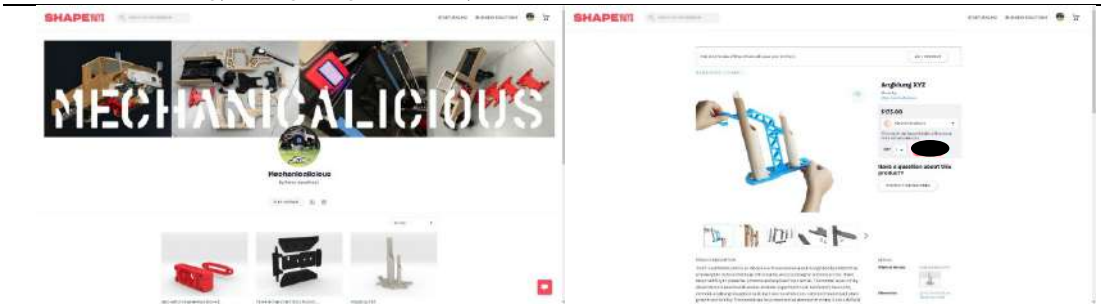

Figure 13. Digital model of Angklung GubXYZ can be shared, downloaded and printed anywhere in the World, one of disruptive method's advantages.
Source: Shapeways, 2019

CONCLUSION

Past, present and future of art and design is always evolving. Industrial revolution 4.0 technology such as Additive Manufacturing or 3D printing is used not to change but to enhance the local wisdom tradition in explorative design of traditional heritage Angklung idiophone.

Recognition of earth-friendly local wisdom and exploration of this heritage traditional product can hopefully make a positive impact in food security, nature preservation and climate change awareness. Indirect impact involved is the exploration of traditional Angklung, but not as musical instrument, but as functional product with biomimicry approach of agricultural pest repellent. This approach is based on local wisdom of Dewi Sri Pohaci as mythical origin of rice plant, symbol of fertility and prosperity.

With method of rapid prototyping, this project of design and art finds balance within aspects of modularity, ergonomic usability, repeatability, precision, ease of production and efficiency. Based on local wisdom in agricultural tradition, there are biomimicry function and pattern that can be emulated with respect of nature and sustainability. The results are a functional product that is modular for experimentation of animal response of sound in biomimicry of natural pest repellent in agricultural purpose.

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