Helmut Schmidt Universität

First Landing:

FabLab In The Nigerian Innovation Space

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A Report of GreenLab Microfactory's first workshop in cooperation with Benny Group of Schools, OpenLab Hamburg, and Helmut Schmidt University

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To the proprietress and staffs of Benny Group of Schools, we would like to say a very big thank you for availing your facility to hosting the GreenLab, thereby registering your print alongside the GreenLab's as the first FabLab in Nigeria's innovation space just like Neil Armstrong did on the moon.

I would also like to express my warmest gratitude to my day one supporter, my untiring mentor, and my inspiration right from the cradle till Messiah returns. Mum, I am writing this with massive love for you. Your prayers and support got me this far.

To my siblings, who are too great to be spoken about in only one paragraph, I would like to say your encouragements from the first opening of my eyes till date, the financial support, the jokes and laughter, oh how could I forget the beatings I got from some of you when I was young, and naïve. All those vital lessons I learnt from you made me stronger. If I thank you for all you have done, without doubt I will definitely run out of words.

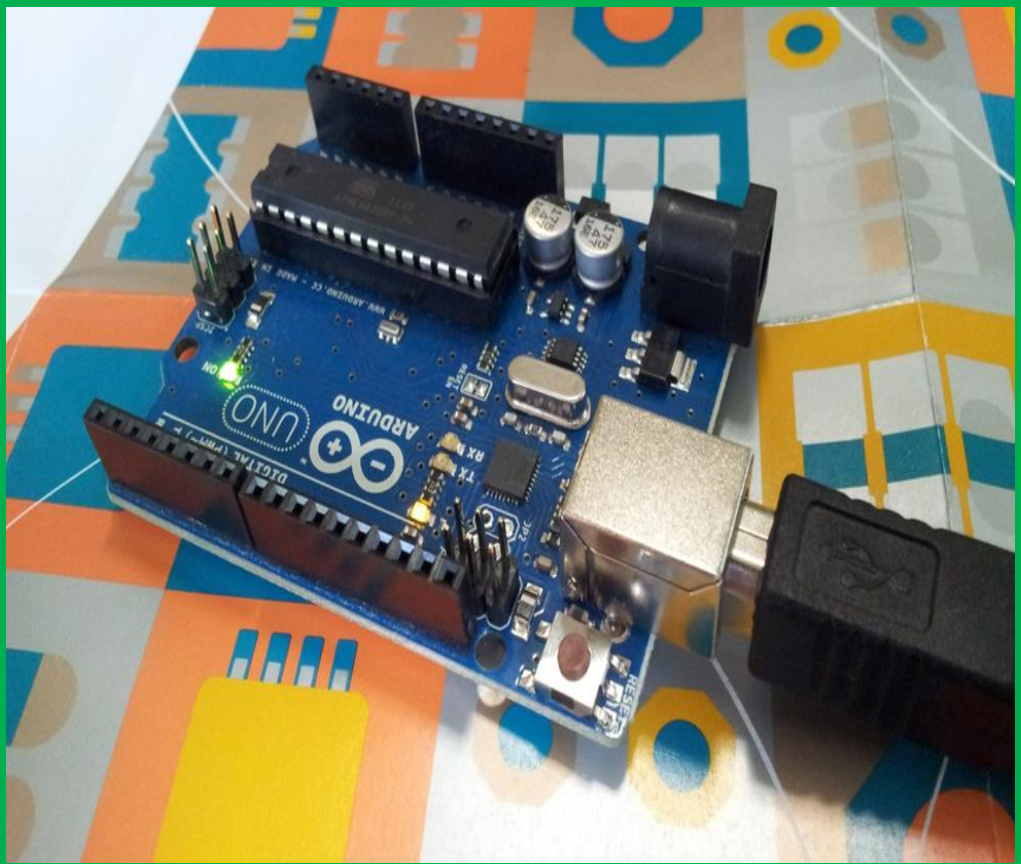
According to a saying from an unknown source which says "God and a good woman is all a man needs to succeed". I as a person can say I have all it takes to succeed because of an inestimable gem, my Tag team partner, my major audience, and best critique. Antonia, I appreciate your support even when I had to wake you up in the middle of the night to strategize on how to launch GreenLab with the purse of a peasant but the mind of a god, and even helping to write and proofread this report. Saying I love you is a part payment for your support.

Lastly, to my fellow Nigerians, I would like to say Nigeria without the passionate people is nothing but a large dormant piece of land. Only evolution not revolution can solve the issues in our beloved country. We have to go back to the drawing board and do what GOD did, which is to *CREATE*, *LOVE*, and *SHARE*. Like Hector's quote in the movie TROY (adapted version) *"All my life I've lived by a code; and the code is simple: Honor GOD, love your neighbor, and defend your country. Nigeria is mother to us all. Fight for her!"* Therefore, I implore you to be a good ambassador of this great nation (NIGERIA), and be a source of inspiration. Nigeria will be great again, if we all work towards achieving it.

I am Nigeria, You are Nigeria, We are Nigeria!

01.

Introduction



Introduction

With a population over 200milion, Nigeria an oil producing nation relies heavily on imports rather than exports. This heavily affects the country's GDP as the price of their main export heavily fluctuates according to world demand and supply. As a result of corruption, high importation and mediocre wages the country currently finds itself suffering a recession which it is unable to progress out of. Despite this, importation is still high and as a result of changing prices of Oil, Nigeria is still heavily reliant on an income that doesn't guarantee consistent returns.

These feelings are widely held by a majority of Nigerians who know 'operations' cannot continue if the country is to achieve its goals of maintaining its stance as a super nation in Africa. As a result many projects (such as co-working spaces, government funded and privately spurred innovation incubator, M.A.D initiatives, and several other social innovation initiatives) have been started in Nigeria aiming to solve a number of the social issues currently found in Nigeria, beyond that of an unstable Oil Price. Some look to battle the power supply issue while some try to battle the lack of infrastructure needed to successfully bring Nigerians ideas into fruition. Encouraging the growth of ideas, trust, collaboration and cooperation between Nigerians is a high priority as these attributes help propel them to a point of self-sustainability and order in life.

Highlighting the words of Schillings (2008) *"Innovation is a beautiful thing. It is a force with both aesthetic and pragmatic appeal: It unleashes our creative spirit, opening our minds to hitherto undreamed of possibilities, while simultaneously accelerating economic growth and providing advances in such crucial human endeavours as medicine, agriculture, and education."*

To this end was the GreenLab microfactory started to solve head on some of these issues mentioned above. A digital fabrication laboratory (FabLab) with keen focus on fostering social innovation/engineering/entrepreneurship in Nigeria. GreenLab aims to encourage the utilisation of dormant, recycled and abundant eco-friendly materials and resources in rural areas, and to encourage innovation and sustainable development. The FabLab will of course need to utilise and further develop the one resource abundantly available and key to the successfulness of solving Nigeria's issues, Human capitals. As a result GreenLab sort to start first with social issues, primarily dealing with how and what people think when it comes to the concept of FabLab. Ajumose was therefore birthed to start the journey that would be a huge Social innovation initiative conducted in Nigeria - a term that has seen its use grow rapidly in the recent years, social innovation is a novel solution to a social problem that is more effective, efficient, sustainable, or just than current solutions. The value created accrues primarily to society rather than to private individuals. GreenLab is a social innovation and through its first event Ajumose began the journey.

Ajumose in the Yoruba language mean Collaboration, teamwork, co-working or cooperation looked to interrupt the social problems seen in Nigeria by being the first free

3D Printer and Solar panel construction workshop coordinated in Ibadan. The aim is to advance and support the grassroot economy of the country, the young generation where change is most likely to be created and implemented if provided with the right stimulus for growth. The event funded by OpenLab Hamburg and participated by more than 80 candidates provided a platform for partipants to learn about Open Source, FabLabs and also have the experience of constructing both a 3D printer and Solar panel, Solar panel in particular a product imported into Nigeria for power generation and hence a desired survival need for many Nigerians, however generating wealth for individual manufacturers outside of the country rather than socially within the country. The goal of the workshop, to encourage a 'Do it yourself' (DIY) and 'Do it with others' (DIWO) growth mind-set within the youth today who would essentially progress to being the future of Nigeria pushing and supporting the "Made in Nigeria" industry. The idea of today through the workshop would enable noticeable developments over 5 year interims spanning well in to the future and thus enriching the lives of many rather than private individuals. A social innovation in its right ensures adequate value is created and accrues primarily to society rather than private individuals whilst being effective, efficient, and most importantly projectable to have future benefits work and encouragement today enable self-efficiency, sustainability and effectiveness in the long term.

The project utilized 3 days to engage with participants, understanding their way of thinking, knowledge levels and finding opportunities to open their minds up to the opportunities that existed around them. This report looks into the workshop coordinated in Ibadan, Nigeria detailing the program, the findings, challenges, limitations and SWOT analysis. With this report GreenLab will progress further in order to establish change in a community that calls for Change.

02.

The GreenLab Microfactory

The Conception

The rise of the technology era, and the persistent social, economic, and environmental sustainability issues in the developing economies especially in their rural settings indicated the need for a different approach to ensure sustainability and broad empowerment of individuals irrespective of their educational, geographical, and anthropological status.

Based on these identified issues, most of which are very evident in Nigeria, in March 2015 while invited as a guest researcher at the Helmut Schmidt University to conduct a research study the success rate of the Global FabLab ecosystem, the significance of FabLab in assisting emerging economies to effectively solve its social challenges, empower her citizens, and have a taste of development became obvious. Thenceforth, the plan to officially launch a FabLab in Nigeria was embarked on in May 2015.

The Objectives

The GreenLab microfactory was designed to be a space that encourages disruptive innovations in Nigeria. A space where egalitarian activities are practiced, where each and every person has equal amount of access to facts, and libraries of knowledgeable resources to specifically meet their needs. Majorly, GreenLab was conceived to bridge the gap between theoretical knowledge and practical experience. It was designed to be a space where students can gain vital hands-on experience that could make a significant difference in their lives and respective community.

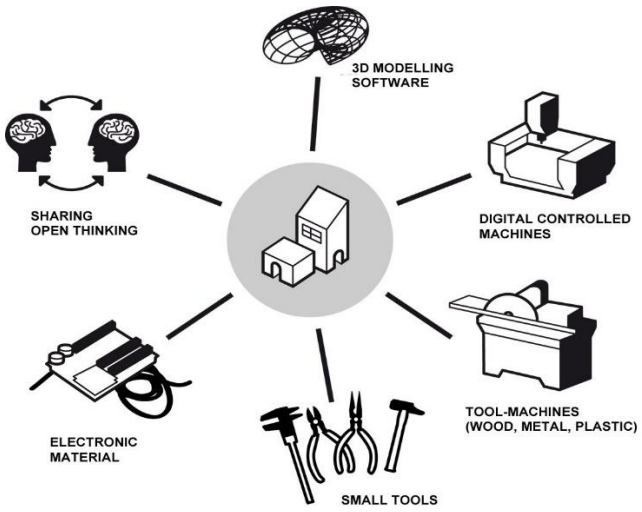


Fig 2.1: Purpose of FabLab (source: https://luxuryactivist.com/high-tech/fab-labs-digital-revolution-checked/)

GreenLab microfactory is a digital fabrication initiative (FabLab). But most importantly, GreenLab is the hybridization of FabLab and Open source Ecology. According to the

website dedicated to the global FabLab ecosystem (www.fablabs.io), “A Fab Lab is a technical prototyping platform for innovation and invention, providing stimulus for local entrepreneurship. A Fab Lab is also a platform for learning and innovation: a place to play, to create, to learn, to mentor, and to invent.

Symbolic representation of the FabLab logo?

Fig 2.2: Logo of FabLab (source: https://en.wikipedia.org/wiki/Fab_lab#/media/File:Fab_Lab_logo.svg)

A lot of meaning has been given to the FabLab logo, According to Walter-Herrmann (2013) “the three-dimensionality of the logo refers to the production of real, material, 3D objects, the symmetrical and precise which are symbolic of the basic tools used in a FabLab, while the surrounding circle represents the circularity of product cycles and a general sustainability of production in the labs.” In addition, according to Neil Gershenfeld the founder of the FabLab movement, the FabLab logo could have different meanings to different individuals. On this reasoning we therefore conducted a short Facebook poll to elicit the opinion of other FabLab mangers on what the FabLab logo represents to them. Below are the responses of some FabLab manager’s opinion of what the FabLab logo symbolize:

Respondent 1: “*It looks like people in a circle, holding hands. Also a machined block*.”

Respondent 2: “*Symbiosis of yingyang, 3rd reich/shuriken, cnc cutted piece in 3D-level and RGB-LED's.*”

Respondent 3: “*humans connecting across the globe, 2D/3D, building blocks*…”

Respondent 4: “*Now when I look at it I see people supporting each other. I just recently found out that there is a slight difference between the shapes that could remind us even though we might be different in some ways we are still pretty similar in most things. I also like how the logo can hold many symbols like .edu .org .com meaning*.”

Respondent 5: “Community, people overall on the world”.

From my perspective, the FabLab logo means thinking in and outside of the box. It means finding a way out, finding a way forward, and creating strings of possibilities out of the seemingly impossible.

What does GreenLab logo symbolize?

Fig 2.3: GreenLab Microfactory's logo

The water droplet logo of the GreenLab Microfactory is based on the logical concept of a rainfall. Just as the rain that could cause a flood always starts with a droplet, so does the background objectives of GreenLab microfactory aim to be the trigger towards a flood of inventors/innovators and inventions not just in Nigeria but also in Africa. The concept is based on the irrelevance of the magnitude but on the bravery of the commencement.

The gear embedded with the water drop of the logo represents the technical orientation of GreenLab. The GL in the logo represents openness, collaboration, and sharing which covers the lessons learnt from the parents of GreenLab. Lastly, the representation of the colour used for the GreenLab logo are threefold:

- It symbolises Nigeria and patriotism
- It symbolises eco-friendliness
- It means growth and serenity.

GreenLab's Innovation strategy

Why?

Innovation plays a significant role in the competitiveness and economic development of an organization, region, and nation. Moreover, the success rate of an organization's innovation is dependent on the innovation strategy employed (Schilling 2008; Guan *et al*, 2009; Burgelman *et al*., 2001).

Guan *et al*, (2009) suggested that having an innovation strategy could be the binding force in creating a compelling vision for organizational sustainability. This means that the success or sustainability of an organization depends on the innovation strategy it uses to

steer its vision. According to Adner (2006), innovation strategy is used by an organization to set performance expectations and to also determine target market. Just like an average organization, GreenLab microfactory has developed its own innovation strategy based on the Nigerian social innovation ecosystem it plans to operate and serve.

What?

The strategy developed at GreenLab is an iterative strategy called HIDES.

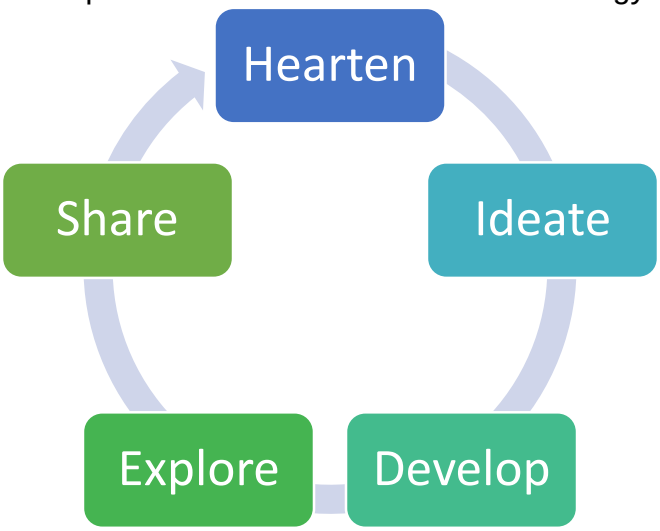


Fig 2.4: GreenLab microfactory's Innovation strategy

Hearten: drawing from the lack of infrastructural development, the inadequate access to developmental resources, lack of trust, and gross mismanagement of funds that has marred Nigeria's innovation cycle and growth. The first phase of GreenLab's innovation strategy is 'hearten' which is to deepen the interest of the users in the project at hand, be it events, or prototyping of artefacts. This can be seen as a pre-ideation strategy to effectively inform and educate individuals on the importance of innovation, collaboration, sharing, openness, and other methods that will be utilized at GreenLab. This phase could be likened to "Theory Y" of McGregor's management theories.

We purport that deepening people's interest would give them the necessary flair to utilize their limited resources in creating the adequate value. Heartened people produce great ideas and use limited resources to get things done,

Ideate: The ideation phase is where most concepts/ideas are noted and broadly elaborated. The process used during the ideation phase could be based on a series of brainstorming sessions, or individuals pitching ideas. In any innovation strategy, as depicted by the innovation funnel, the idea generation phase is very significant to the innovation process and its output thereof,

Develop: The development phase is where selected ideas will be gratified into tangible products. This could include a rapid prototyping phase, or a small scale production of the ideas,

Explore: At the exploration phase rigorous tests on the artefact produced would be conducted to know the resilience, usability, adaptability, reliability and maintainability of the artefact,

Share: Since GreenLab is a member of the global FabLab ecosystem, and imbibes the structure of an open source organization. A distributive economy where ideas, knowledge, information, techniques and technologies are shared will be a key factor in our modus operandi. Inasmuch as commercializing products are encouraged, GreenLab also encourages an open source concept where people can freely interact, collaborate, and share knowledge.

How?

In order to accomplish this strategy, a majority of the technologies used at GreenLab microfactory will be composed of open sourced or self-made technologies. This will provide many advantages to the longevity, productiveness, and management of the workshop considering the envisioned limitations or challenges to the growth of the organization. Such as, inadequate electrical power supply, building our technologies in-house means we would utilize energy saving components during the development phase of the technology, which would give us a greater control on power consumption rate of the workshop.

Most importantly, GreenLab will generate 99% of its electricity using abundant renewable energy resources. Which would further hearten the interest of the populace, and contribute more to the ideation process, as well as the remaining phases of the HIDES innovation strategy.

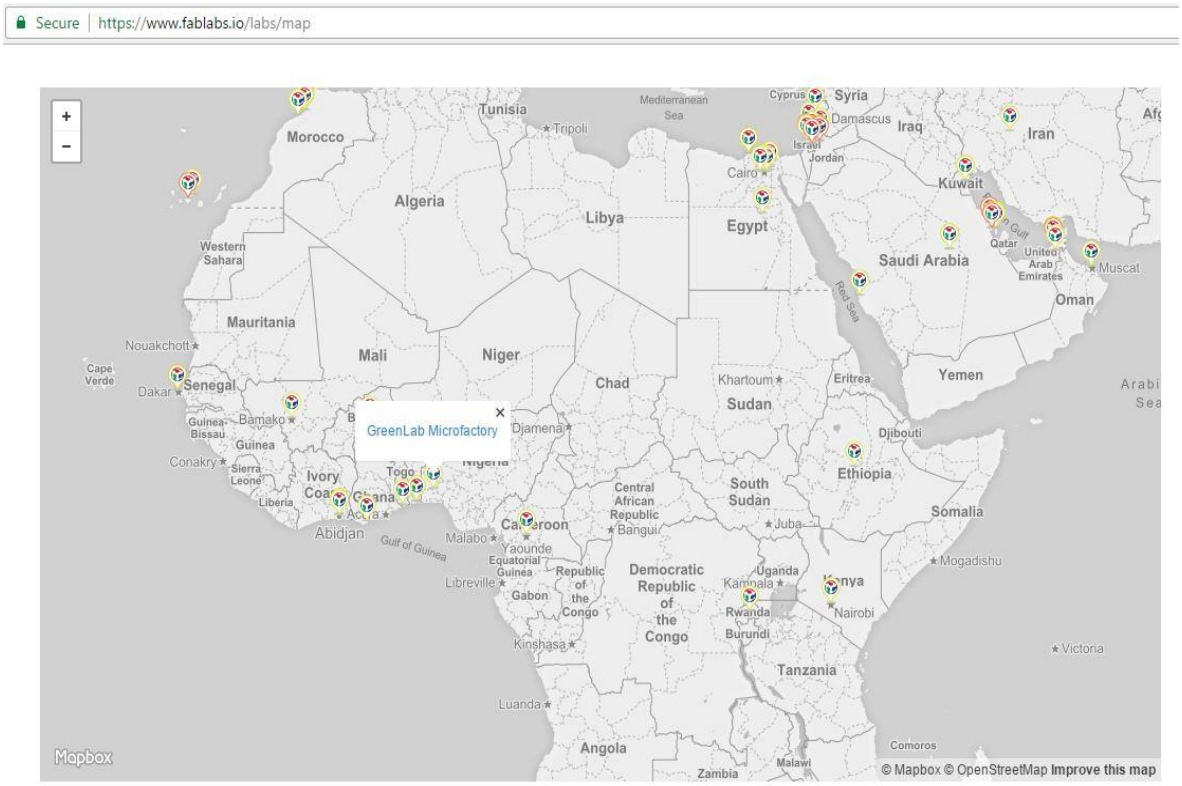


Fig 2.5: GreenLab on the map of FabLabs on www.fablabs.io

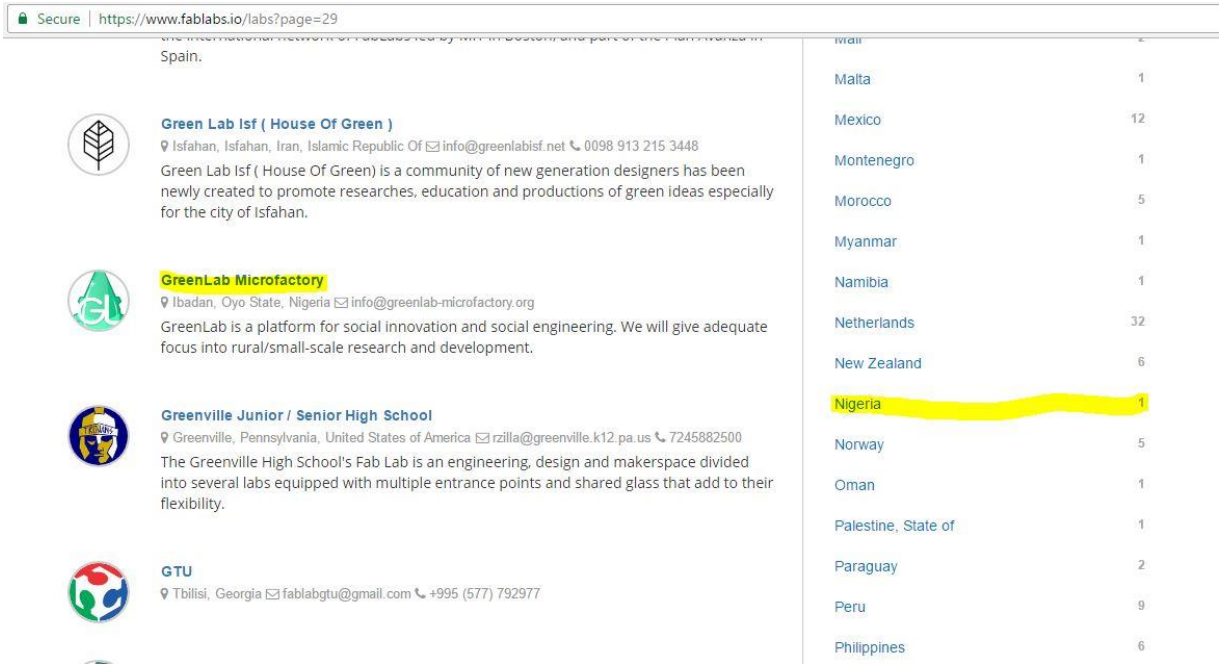


Fig 2.6: GreenLab's details on www.fablabs.io

Poster of GreenLab's first open source workshop

03.

Ajumose

About Ajumose

Ajumose was launched in Ibadan Oyo state, which is also known as the 'pace setter' in Nigeria due to the pace set across the infrastructural development in Nigeria and Africa. This spans from the first television station in Africa (NTA Ibadan), to the first Sky scrapper in Nigeria (Cocoa House), the first university in Nigeria (University of Ibadan), and now to the first FabLab in Nigeria (GreenLab). Without doubt Oyo state is indeed a pace setter!

Agenda or Objectives of Ajumose

The word Ajumose is paramount to the indigenes of Oyo state, and according to the Yoruba language Ajumose means collaboration, teamwork, co-working, and cooperation.

The major agenda of Ajumose was to promote collaboration, openness, communal learning environment and development. It also aimed to show people the magnitude of what could be accomplished if they collaboratively focus on providing solutions to social problems by localizing the resources used for production.

Initially, the set objectives of Ajumose were to build a solar panel from scratch, and assemble 2 RepRap 3D printers. Of the 2 3D printers, one was a hangprinter, a low-cost open source 3D printer that could accomplish an enormous 3D printing, developed by a Swedish/Norwegian confidant named Torbjorn. The second 3D printer to be assembled was an off the shelf RepRap 3D printer produced by Geeetech.

The workshop was unfortunately hit with a setback before any assembly work had even begun. A major component of the 3D printed carrier of the Hangprinter broke during transit to Nigeria and despite efforts to reattach it with a wire, we resolved into excluding the assembly of the Hangprinter due to the inability of the carrier plate to handle the weight of other components such as 4 stepper motors, the Arduino MEGA and RAMPS, and the 4 spools that were to be included in the final assembled piece. Having access to a digital fabrication facility in Nigeria would have been ideal for the provision of a solution to the problem however, there was none known that could have been consulted for support, hence the need for GreenLab microfactory.

As indicated in the poster on page 15, the workshop started with the development of a solar panel system considering the epileptic state of Nigeria's electricity infrastructure as well as the significance of electricity to the innovative development of any country. Without doubt, having access to stable electricity was more important to the success of Ajumose as the RepRap 3D printer needs a constant power supply, and as the name GreenLab implies, an objective of the workshop was to encourage people to live an eco-friendly life and not contribute more to the disintegration caused by industrialization on earth. Hence,

GreenLab aims not to power equipment with electricity generators but instead use green energies such as solar, wind and other forms of renewable energies.

Participation Numbers

The numbers of participants were a little close to 80 with professional backgrounds ranging between, pupils (+ or - 40), high school students (+ or – 20), tertiary students (7), traders (5), teachers (4), artisans (car mechanic and photographer) (2), engineers (3), and Financial managers or accountants (3).The youngest participant was aged 4, while the oldest was 69 years of age.

Day 1

Like any typical event in Nigeria, Ajumose started with a short praise and worship to commit everything to the hands of Almighty God, followed by a short prayer led by a 10 year old with the voice of a fierce angel. I then gave a brief explanation of the objective of the workshop, explained the FabLab concepts, the equipment, the sponsors, and then split the participants into three groups. Group 1 comprised of participants below the age of 13, Groups 2 and 3 comprised of participants above 13 years of age. Group 2 were responsible for assembling the 3D printer and group 3 assigned with the task of developing and assembling the solar panels. The reasoning behind the division of participants will be discussed further later on.

Prior to the commencement of the workshop, a group of 4 participants between the ages 8 and 20, were quizzed about their knowledge of 3D print technology. Not one was able to give a meaningful definition of what the technology was or a 3D printer, even when shown a video of a 3D printer at work. The best answer provided comprised of the words ‘it is a machine’, which was not incorrect but in an exam would have definitely not been enough to achieve full marks. The test was conducted not to embarrass any individual but rather to gain an understanding and highlight the level of exposure the participants had about 3D printing technologies.

In addition, when the same quiz was conducted on solar panel technologies, a majority were able to explain what a solar panel does, but had no knowledge on how solar technology was constructed. This was a huge relief because it confirmed the obvious speculations, lack of infrastructural development in Nigeria was mostly responsible for our laggard innovative cycle.

Never the less, this was the reason the Ajumose workshop was organised, and GreenLab microfactory was there to inject seeds of knowledge which if watered correctly could essentially promote infrastructural development and provide sustainable solutions to the lurking social problems in Nigeria.

Criteria for Group Division and assignment

Group 1

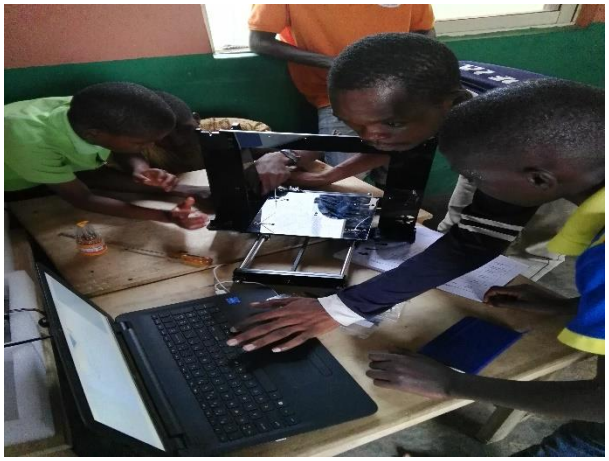
Due to the age difference, the technicality, the fragility of the components, and the complexity of the activities. Participants aged 13 and below we separated from the wider group and injected with an equilibrium of both theoretical and practical knowledge about FabLab, open source, Arduino, Computer aided design (CAD) modelling, and 3D printer. There was an Arduino lecture, where chapters 1& 2 of the Arduino development handbook was covered. This would have been achieved faster and quicker if more than one Arduino component was available to handle the huge number of highly inquisitive participants. However, we were able to patiently display and explain the projects covered to the kids who chorused the components and functionalities in amazing synchrony.


FABLAB
GreenLab


COMPUTER
3D PRINTER
LASER CUTTER
MILLING MACHINE
FABLAB
FABRICATION
OR FABULOUS
ADDITIVE
FAB LAB
GreenLab

Group 2

Group 2 were assigned to construct the RepRap 3D printer. Armed with a manual, the unassembled components of the 3D printer and tools to construct the device, the team were tasked to read, learn and apply knowledge gained in order to successfully construct a functioning 3D printer within their team. The team comprised of a variety of individuals across an age range greater than 13 years and a number of different professions. After day one, it became clear how roles and responsibilities were defined and the impact of age, gender and profession to where participants gravitated to.

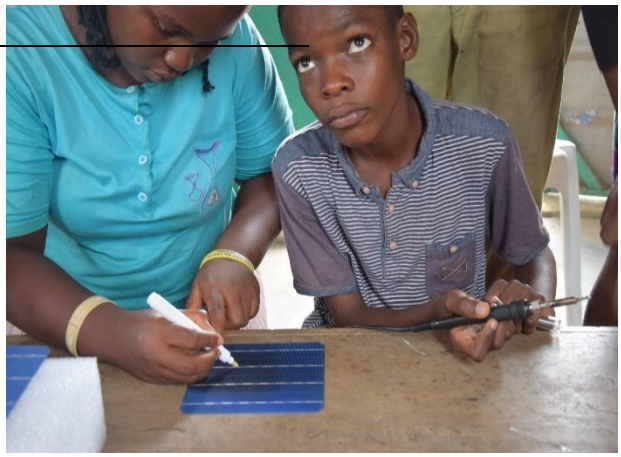


Group 3

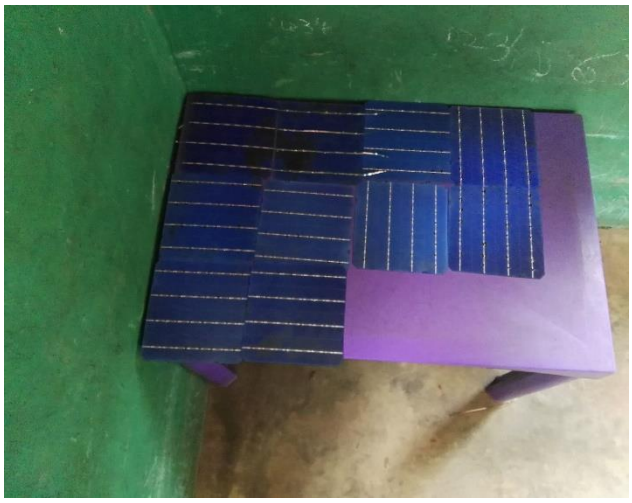
Group 3 like Group 2 comprised of participants older than 13 years. Tasked with building the solar panel needed to generate electricity to power the 3D printer, this group of participants were quickly taught and given an instructional example about the technical and practical skills needed in order to correctly construct a solar cell worthy of passing current. At first it appeared that this group in particular had a relaxed task of simply applying solar flux, soldering lead and strips of tabbing wires to 40 silicon solar cells, however as time went on, it was clear that a careful, steady and soft handed skillset was needed to enable accuracy and reduce waste, something that at the end of day one was learnt to be a foreseeable challenge and required adjustments to the plan to be made.

Each member in group 3 took turns in applying the solar flux solution, soldering lead and tabbing wires to at least one solar cells. Which had both positive and negative effects on

the project. 1 positive effect being the knowledge gained during the development process of the solar panel. 1 negative effect due to the breakages of at least 4 solar cells on day 1.








Day one came to a close promptly by 7pm, due to diminishing natural light and human energy drainage, but with a feeling of accomplishment between the 3 groups. Group 1 successfully being able to explain the concept of FabLab, 3D printing and the difference between normal manufacturing. Group 2 successfully constructed the 3D printer frame and Group 3 after some learning, developed the steady hand needed to create 10 solar panels. As a result the evening was called to a close and participants sent home to reenergise for day 2. Despite the advancements made on Day 1, a lot was learnt about the constraints that posed as a challenge to the project. Some of these became evident on Day 2. The below looks at the lessons and limitations gleamed from Day 1

Lessons and Limitations

Lessons learnt on day 1

- Participants quickly moulded into roles and responsibilities based on their professional background

- In group 2, age played a big factor where the younger the participant was, the lower the level of responsibility assigned. This was particularly witnessed during the 3D printer construction where a young boy of 13 was assigned stock room responsibilities, overseeing the outgoing and incoming of components needed for the construction of the 3D printer. At points this young boy made valuable contributions that sometimes made one wonder whether he should have been promoted to the construction team, but not wanting to depart from the roles and responsibilities put in place, he remained as a stock room assistant, on hand when called.
- The level of understanding at what needed to be done was quickly grasped and applied
- Collaboration quickly came into effect, participants supported one another to grasp the knowledge and apply in order to accurately develop.

Limitations experienced on day 1

- A leadership position was not taken up in group 3. Strangely enough there was no individual who took the role of coordinating, overseeing and leading. Whether this be due to experience, knowledge or lack of, the need for a leader became evident.
- The fragility of the solar cells was quickly noticed. Group 3 had been instructed to work on 40 solar cells, all were to be used, until one broke, and then another. After the 4th solar cell broke, it became evident of the need to re-strategize about the construction and size of the solar panel. If the rate at which breakage had occurred continued, there would have not been enough solar cells to create the solar panel desired and therefore change needed to be introduced.
- Equipment – the ordered 3D printer was not accompanied with a manual about how to set up the 3D printer. The participants were therefore forced to download a copy from the manufacturer's website and utilise this in order to construct the 3D Printer. Sounding seemingly easy and straightforward it became apparent that the item numbering of components in the box did not match up to the item numbering given in the downloaded manual. Furthermore when relying on visual perception only, participants were led on numerous occasions to the assumption that they were missing pieces when in fact the pieces simply took on a different visual appearance to what was displayed in the manual. Participants were therefore forced to learn the art of cross referencing using the downloaded manual (containing varying imagery and conflicting numbering), the item list provided with the 3D printer components and the Quality assurance checklist signed by the overseer at the company. With these 3 pieces of documents, the participants were able to reason the correct item numbers to be used at each stage and deduce items which although visually did not compare to the manual, bared the same name according to the item itinerary checklist provided.
- Facilities: The inadequacy of the facilities used posed a little challenge. There was not enough work tables or space, most participants had to work on a 40cm high

bench, which if used for a very long time could be haphazard to ones back and advertently health.

- Health and safety: Due to the lack of infrastructures at the venue, the workstation setup by group 3 had to use 2 long benches, which after a long time of work posed a negative effect on the backs of the group members
- Internet: The limited data bundle purchased ran out when groups had to watch YouTube tutorials on how to solve particular challenges encountered during the development process.

The vital lesson learnt was how inquisitive the participants were to learn about digital fabrication, FabLab, and 3D printing. If not for the Ajumose

Day 2

Group 1

On day 2, building on the lessons learnt on the previous day group 1 did some CAD 3D model design lessons. Where the participants were given a detailed explanation of the CAD software, the difference between the commercial CAD software and the open source. The lesson of the day was conducted using the open source FreeCAD software.

Participants were shown how to use FreeCAD software, which was going very well until the laptop could not handle the workload bestowed upon it any further. The children in group 1 were able to explain how FreeCAD software worked, however the opportunity to personal handle the software themselves would have been much more valuable.


FABLAB
GreenLab

Group 2

The 3D printer assembling team had a major issue with the late arrival of the self-appointed leader from day 1, which disoriented the whole team as it was noted that some of the 3D components were unidentifiable. After some minutes of deliberation, the group was restructured and work began afresh. In addition, some issues became obvious such as the immobility of the x, y, and z axis linear rods. The problem was identified to be a possible result of manufacturer's error due to the unevenness, difference in thickness and possible structural damage of the rods. Moreover, the incorrect labelling of the supplied 3D components impacted further on day 2 which led to a rigorous task of cross analysing the required components to build a particular section of the 3D printer with the online documentation






GEEETech


Group 3

The solar team discovered that the tabbing wire and soldering lead bought for the workshop were not enough and attempted to purchase additional resources locally. However, all attempts to purchase the right tabbing wires were abortive, therefore the ream concluded that the bus wire should be split in halves to replace the tabbing wires. This ended up working just fine.

With regards to the soldering lead, due to limitations being lack of knowledge where to buy soldering lead and lack of funds, the team were unable to get a replacement immediately. However, one of the participants, an artisan (car mechanic) by profession, acquired soldering lead for the project costing N700 (Naira), and refused to be reimbursed claiming the knowledge gained from the Ajumose workshop was sufficient for him to support the cause. The significance of his effort may look little, however it should not be overlooked, because without this voluntary act, the ability to achieve day two's task and complete the rest of the project would have been severely under risk, which would have hampered the success of the workshop.






Unlike day 1, day 2 ended late in the evening around 21:30, due to the issues with the smooth linear rods experienced supplied with the 3D printer.

Lessons and Limitations of day 2

Lessons

A significant lesson learnt centred around how people thought outside of the box and collaboratively proffer a solution to a problem. In the sense that, when the tabbing wires were exhausted, and all efforts to acquire more proved abortive, the group came up with an idea to split the bus wire into halves to be used as a replica of the tabbing wires. This was a long process, but a very ingenious one because the success of their task was dependent on the acquisition of the tabbing wires.

Limitations

Leadership: This particular issue affected group 2 (3D assembling team). In the sense that the participant that led the group on day 1 did not arrive on time. Which created a little pandemonium with regards to loss or unaccountability of some of the assembling components. After 1 to 2 hours, the group were able to restructure themselves and start afresh with a new leadership and coordination structure.

Inadequate resources: this was paramount on the second day when it was noticed that more than one computer system was needed to teach group 1. Also noted included, when group 2 needed a means to make the linear rods supplied with the 3D printing components even and group 3 needed additional tabbing wires and soldering lead to proceed with their task. Adequate access to internet services would have most likely eased some of the issues. However, just like the concept GreenLab microfactory was trying to introduce to the community, localization and optimum appreciation of available resources is the first step to accomplishing sustainability.

Day 3

The final day had arrived and it was as if the clock had begun to tick in place, as all participants began to display and utilise more fully the previous two days of learning on the final day, being able to easily spot mistakes, propose improvements and even find, propose and implement solutions to problems encountered. In some cases the proposed solutions were simple and successful enabling completion of the task however in other cases it became apparent if time had not been the limitation, the solution could have been implemented and successful. The following looks individually at the 3 groups highlighting the outcomes of final day learnings.

Group 1

Group 1 started with a short quiz/debate separating participants further into age categories of under eights, age groups 9, 10, 11, 12, and 13 respectively producing 6 micro groups. This generated a profound statement on the level of knowledge assimilated by these participants. If not all, most of the group 1 participants were able to explain how the 3D printer works, how to do a basic Arduino project, how to design a 3D model using FreeCAD software, and most were enthusiastic about the FabLab concepts, with questions on when the next workshop would be or when the GreenLab would acquire all the equipment needed to successfully operate her FabLab.

Before the end of day 3, group 1 visited other senior groups (i.e. group 2 and 3) to see the state of their tasks, and to also learn more about the work completed, especially the 3D printer which they were opportune to see the functionalities of the 3D printer but were unable to gain a full experience of its utilisation.

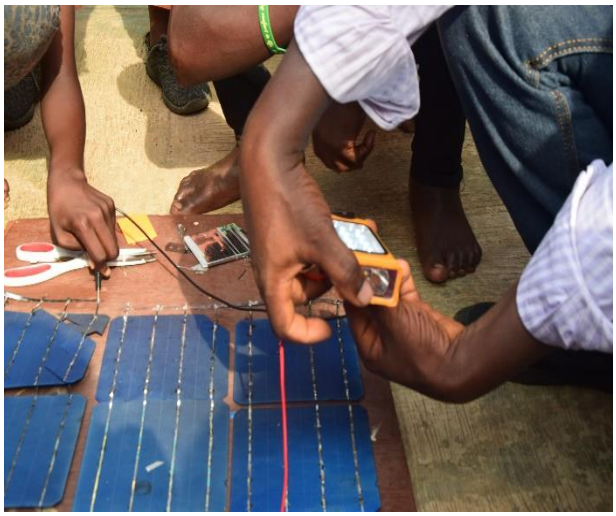
Group 2

Group 2 discovered that the structure in which they had put together over the previous two days was in fact missing some parts due to the lack of knowledge, awareness and manufacturer instruction about what parts should be used when and what individual parts contributed to the functioning of the 3D printer. Despite the 3D printer being constructed to a level of testing and electronic connections, unfortunately the 3D printer was unable to be completed. The group had successfully fixed the issue concerning the linear rods controlling the x and y axis, however were unable to move past the Z axis issue which obstructed the extruder positioning from moving freely up and down across the Z axis as expected. The team noticed one of the threaded rods appeared to be slightly more thick than the other and therefore when attached to the Linear ball bearing and performing a verification test, the rods attached to the Z axis expected to rise and fall along the Z axis according to the command given on the printer's command system, unfortunately did not and appeared to stick at different positions along the threaded rod.

A number of solutions were tried from sanding the rod to smoothen the grip, to even adding oil hoping to give the rod some lubrication that would hopefully enable the attached pieces to slide up and down easier. However neither of these options worked effectively enough to enable the Z axis rods to independently work. A majority of time had been spent trying to fix the challenge regarding the Z axis however as time was a limitation and the end of the day was fast approaching, a collective decision was made to leave activities where they were and call it a day. The efforts made by the team to solve this one challenge were tremendous, utilising a variety of options.


Group 3

Group 3 had successfully completed and joined 15 solar cells in series to one another leaving Day 3 only to testing and fine tuning. After testing the connections with a digital multimeter, the team were stunned to find no voltage output being produced. After careful consideration of each individual cell, it became apparent that some of the cells were incorrectly connected. So the group had to detach and reattach the cells, which at the end generated 6V electricity which was used to power a small pocket torch. This became the success story of the day, and a major contributory reason to the conduction of the workshop.




Lessons and Limitations of day 3

The major lesson learnt on day 3 was that as a community it is possible to achieve a lot if given a conducive environment. Despite all the setbacks experienced, the successful execution of a DIWO workshop is majorly reliant of the complementarities and accumulation of knowledge. This being evident most importantly in group 3 where the quick rebuild job done on the solar panel was led and conducted by an engineer who with

his engineering background was able to detect the major issue with the sterility of the serial connection of the solar cells.

To some extent having a qualified person to chair the group would have also been effective in group 2, but the problems experienced in group 2 were deemed more of a manufacturer's error than structure or leadership problem of the group. This conclusion is confirmed after reviewing peer reviews lodged by a number of customers who had purchased the Geeetech RepRap i3 3D printer. A selection of comments made regarding issues faced were very similar to the comments and negative experience group 2 had. Below are extracts of some of the reviews found at the links below:

Reviewer 1: The issues all stemmed from the lack luster instructions and cheap parts. The instructions are out of order at times or just missing all together… As for cheap parts, the threaded rod was inconsistent in size and a little bent. The inconsistent size caused the bend to be exaggerated, as it would not center in the coupling, which In turn caused one of the "y" axis motors to lock up or stutter (http://forums.reprap.org/read.php?406,484958).

Reviewer 2: The 8mm rods, are very bad quality, Measure them at 7.92mm, (linear bearing can rotate around the rod axis and that is bad), The 2 carriages on each sides for the Y axis (plastic parts), will not be tight enough, your guiding on X, Y, Z will be weak and you will get wave design on your print walls. Change the rod with a good 8mm and this will solve the problem. The Z axis use 2xM8 thread rod, the hole at the top of the machine are not aligned correctly and too tight, this will pinch your Z axis and you will miss some steps. you better increase those diameters a lot (http://forums.reprap.org/read.php?406,484958).

Reviewer 3: Y axis isn't moving, isn't working right / X axis isn't moving, isn't working right, Z axis isn't moving, isn't working right / belts are slipping and seizing. Z axis isn't moving, isn't working right, is seizing in certain areas (http://3dprintboard.com/showthread.php?17027-prusa-I3-X-common-issues-diagnostics-and-calibration-help-thread).

The major limitation on day 3 was due to the smooth linear rods and the threaded rods provided with the Geeetech i3 3D printer. These rods were uneven resulting in a number of seizures and frictions.

Benefits of Ajumose

The most humbling benefit of the workshop occurred on the second day of Ajumose. On this particular day, a group of final year students from a nearby high school attended the workshop to participate right after their national examination. In order to explain the FabLab concept, open source, GreenLab, and other topics, I decided to reverse engineer the teaching process by quizzing the participants in group 1 about all the concepts, and to my greatest surprise the children displayed an impeccable level of gathered knowledge

by confidently answering all questions asked correctly, therefore imparting knowledge to the high school participants that were on average 7 years their senior.

Other benefits include:

1. Provision of new knowledge, information, and technology
2. Social and community togetherness where Ajumose noticeably brought joy and opportunity to a community of individuals that otherwise may not have had such an opportunity
3. Empowered participants and the community to think about and be drivers for change in their innovation space therefore enabling the solving of social issues, especially in the region of electricity generation, through the development of a solar panel system.
4. Introduced opportunities for participants to develop both technical and intellectual skills in the form of soldering, equipment construction and critical thinking
5. Recycling and reusability of resources otherwise rendered useless in the form of the salvaged wood used for the frame of the solar panel.
6. Tinkering: This became obvious when the 3D development team noticed some differences in the rods of the y-axis and z-axis of the RepRap 3D printer being assembled. They collaboratively solved the problem with the y-axis, but the z-axis was unable to be fixed.

Limitations of Ajumose

No matter the yardsticks used to measure the success of Ajumose, it would have been seamless without the following limitations:

1. Inadequate access to Internet services: In this day and age, the Internet has been the fastest, convenient, and one of the most reliable source of information. Which made it impossible to gain access to the assembling /building video of the 3D printer. Fortunately, with regards to the development of the solar panel system, videos on how to build a DIY solar panel system were already downloaded. This proved very useful when the information were needed.
2. Epileptic power supply: Though the GreenLab microfactory was conceived to be self-sustaining and to a large extent independent on external resources that are not ecology-friendly. Right from day 1, due to the inconsistent power supply we were humbled to resolve into using electricity generators to power the tools used during the development process. Most importantly during the development of the solar panel that needed a constant electricity due to the soldering and connection of the solar cells.
3. Inconsistent Group Leadership: This had both positive and negative effects on the success of the project. The negative being that there was a huge waste of time due to the lateness or nonappearance of the leader of Groups 2 and 3 (3D assembling and Solar panel) on the following day's activities. However, the inconsistencies gave opportunities to some individuals to assume the role of leaders, fix the problems at

hand, and decipher a way forward with regards to the specified objectives of the workshop.

4. Unparalleled assignment of roles and responsibilities: this limitation builds on the previous limitations of inconsistency with the group leadership. This would have been adequately handled if roles and responsibilities were assigned to the members of groups 2 and 3, but due to the novelty of the organization, event and the community. Vital lessons were learnt that would be built on for future events
5. Cumbersome workload of the workshop on the organizer: At some point during the workshop, I was literally being summoned by all the groups. I was solely responsible for group 1, which is the group of participants under the age of 13, but my attention was needed at the remaining two groups. Which created a reasonable amount of impossible division of my attention
6. Inadequate tools and equipment: During the workshop, we had to improvise for some tools. Most of the equipment used for the workshop were brought from Germany. Due to inadequate infrastructural development and technology advancements, some tools and basic resources needed were impossible to get. Which was profound when the 3D printed objects for the second 3D printer (Hang printer) got damaged during the long flight to Nigeria, which after two attempts to fix it led to the cancellation of the development of the hang printer. It also crippled the progress of the event.
7. Insufficient funds: A majority of things done during the workshop would have been easily accomplished if there was sufficient fund. As indicated earlier, Ajumose was solely sponsored by LaFT, who basically covered the acquisition of the technologies used for the workshop. Due to the size of some vital equipment, we resolved into trying to see if we would be able to find those technologies in Nigeria which proved abortive.
8. Non-functioning 3D printer machine: Due to the unexpected issues with the linear rods supplied with the Geeetech i3 3D printer, having a functional 3D printer became a mirage.

Despite the limitations stated above, Ajumose attested GreenLab microfactory's HIDES innovation strategy. Ajumose was conducted to test the efficacy of the incremental phases of the strategy. However, we were only able to test the first phase (Hearten). The unique approach of allowing the participants to learn about a technology (3D printer and solar panel) by assembling one deepened their interest and also expanded their knowledge of the technology. Which could be highly significant to the innovative input, process, and output in a resource-scarce environment such as Nigeria or other emerging economies. However, this is still open for more tests.

Inasmuch as the GreenLab does not presently have a functional 3D printer or any of the equipment recommended for a fully functional FabLab, we draw courage from the success stories of the relentless efforts of some existing FabLabs in Africa (such as BabyLab in Abidjan, and OuagaLab in Burkina Faso) started by social entrepreneurs to proffer solution to some social problems, and inadvertently empower the community.

According to Bosqué (2013) *"FabLabs are more about the people than the machines".* We also attest to the statement given above that FabLabs are about knowledge acquisition and dissemination through participatory involvement of individuals which to some extents relies on having adequate access to technologies. So, we would rather carry on with the little apparatus possessed than to keep waiting for the acquisition of the technologies before launching the facility.

04.

Measurement of Success

Ajumose's participant feedback survey

In order to properly learn from the participants, we conducted a participant feedback survey to know how the participants learnt about Ajumose, their general interest, their level of innovativeness, lessons learnt, and suggestions on how to improve the Green vision of the GreenLab microfactory. The questionnaires were distributed to the participants in the development and assembly groups (group 2 and 3). The questions asked forming the feedback survey can be found on Appendix I.

As indicated in previous sections, Ajumose hosted a total number of 80 participants, from ages 5 to 69, and every walk of life, ranging from students, engineers, artisans, accountants, photographer, teachers, and unemployed individuals to name a few. From this population we conducted a feedback survey for 30 of the participants, out of which we collected 15 responses, which equates to 50% response rate. This section contains the analysis of the participants' feedback survey.

Gender of Respondents

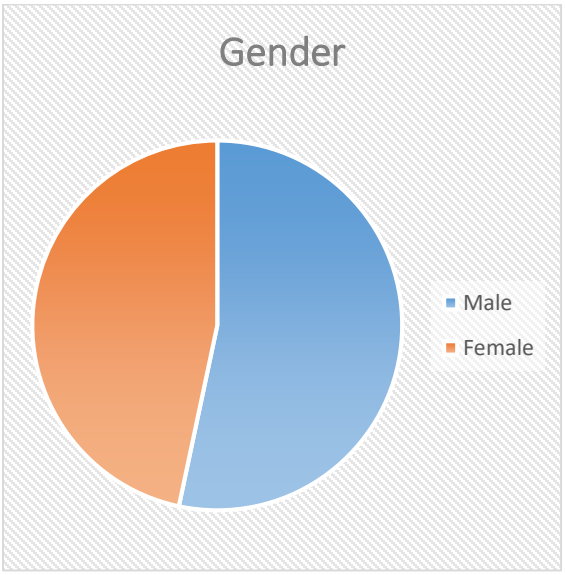


Fig 4.1: Gender specification of the respondents (N = 15)

From the figure above, 53% (8) of the respondents are male while 47% (7) are female. However, gender of the participants had no significant effect on the tasks of the event. As all participants took equal turns in assembling the 3D printer or developing the solar panel. It was interesting to see a slight difference between the genders when interpreting the word careful. The females during the soldering process gave the impressing of a steady and careful touch whilst the males provided speed. Either way all participants soldered at least one solar cell, and most importantly ensured the contribution of their opinions voiced

when faced with technical limitations. All roles and tasks were dutifully fulfilled or completed as assigned by their local leadership authority. This typifies the egalitarian structure portrayed by the FabLab ecosystem.

Profession

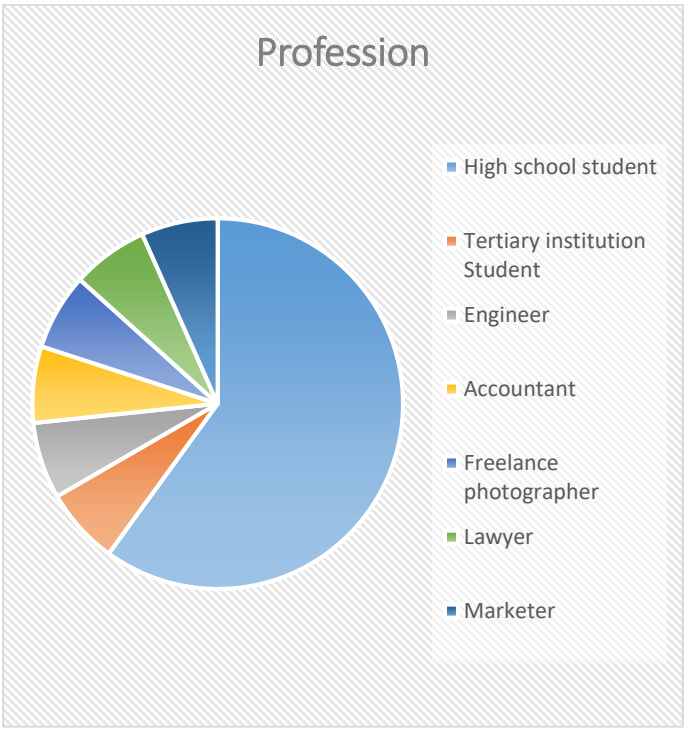


Fig 4.2 Profession of the respondents (N = 15)

The highest concentration of the respondents 9 (60%) are high school students, while the remaining respondents which ranges from engineers, accountants, lawyer, marketer, tertiary institution students, and freelance photographer constitute 7% of the responses. This typifies the sole purpose of the event which is to give equal learning opportunities to everyone irrespective skills or experiences.

Qualification

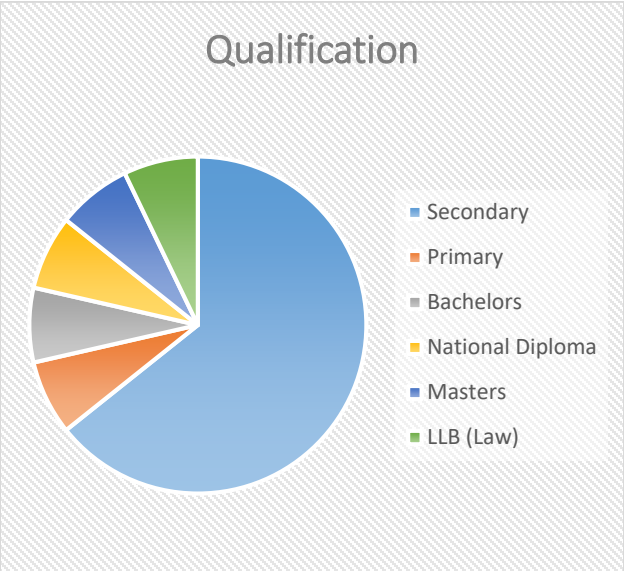


Fig 4.3: Qualification of the respondents (N = 15)

As indicated in the chart above, 9 (64%) of the respondents have a secondary school certificate, while the rest which ranges between a LLB degree, MEng degree, primary school education, BSc degree, and an ordinary national diploma constitute 7% of the responses.

Awareness

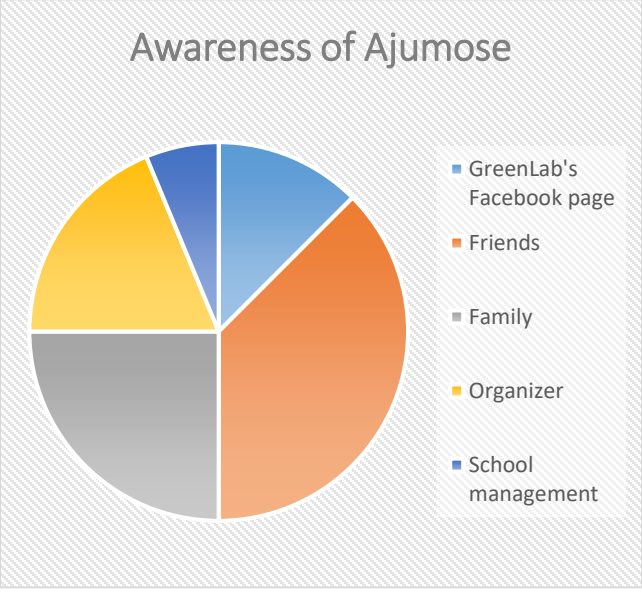


Fig 4.4: How respondents learnt about Ajumose (N = 15)

The respondents were asked how they had come to learn about the workshop, 6 (38%) indicated that they had learnt from friends, 4 (25%) indicated they had learnt from family members, 3 (19%) indicated that they had learnt from the event organizers, 2 (13%) indicated that they had learnt from GreenLab's Facebook page, while 1 (7%) indicated that they had learnt from their school's management. This shows the effect, lack of technological infrastructure has on socially oriented initiatives, therefore in the case of Ajumose, word of mouth or personal referrals worked better in a rural setting. However, in order to cover a huge area, social media plays a significant role.

Interest in Ajumose

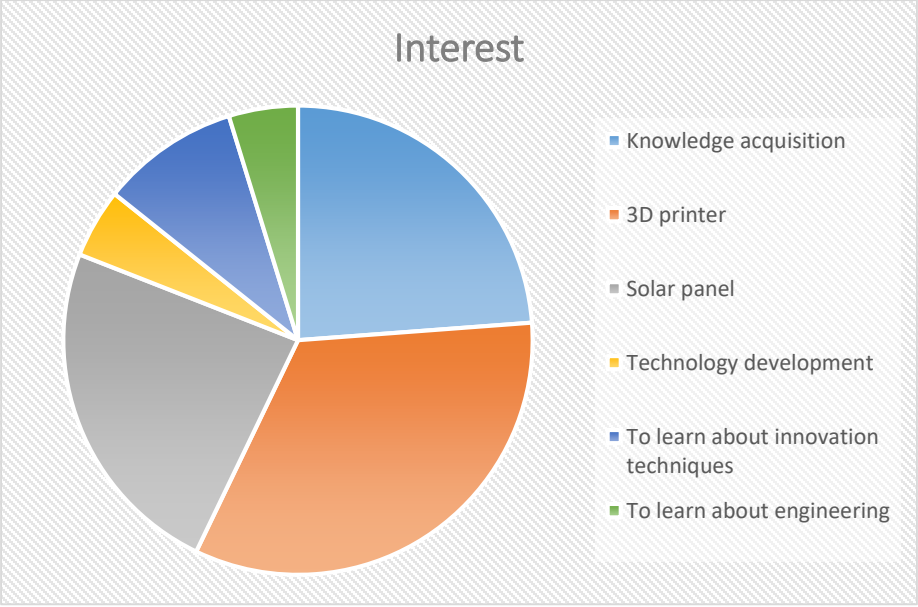


Fig 4.5: Reason for participating in Ajumose (N = 15)

When poised on their interest in Ajumose 7 (33%) of the respondent indicated they would like to learn more about the 3D printing technology, 5 (24%) indicated they would like to learn how to build a solar panel, another 5 (24%) indicated that they would like to gain knowledge, 2 (10%) indicated that they would like to learn about new innovation techniques, while the remaining 5% indicated that they would like to know more about technology development and how to become an engineer.

Awareness of Digital Fabrication Initiatives

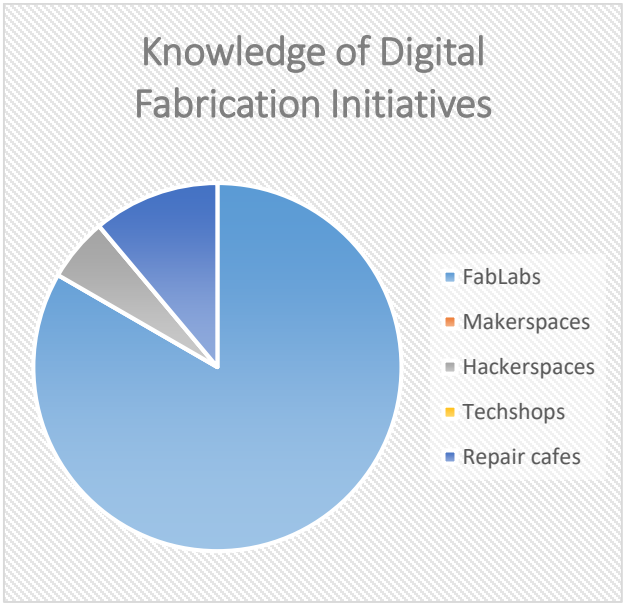


Fig 4.6: Existing knowledge of Digital Fabrication Initiatives (N = 15)

All the respondents (83%) indicated their vivid knowledge of the FabLab ecosystem, 2 (11%) indicated knowledge of the repair cafes, while 1 (6%) indicated knowledge of hackerspace. It is worth noting the contribution of Ajumose towards the dominant number of the knowledge gained of FabLab, as prior to the event, majority of the participants were left in the dark about FabLab and its concept.

Inventions

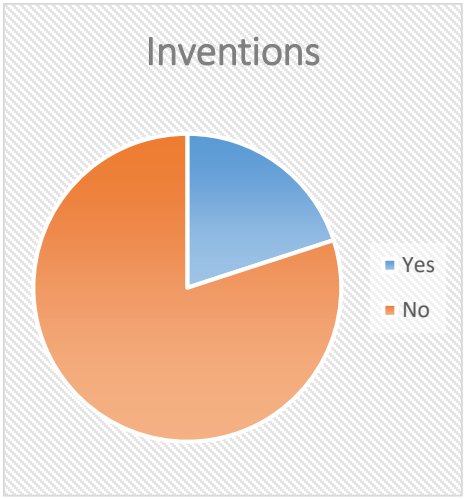


Fig 4.7: Inventions made by respondents (N = 15)

When asked if they have invented anything before, 3 (20%) of the respondents gave an affirmative response, while 12 (80%) answered NO. The respondents that answered yes were further asked to elaborate on the kind of artefacts they invented, 2 mentioned that they both collaborated on developing a miniature car that glides on water, while the last inventor indicated that he has built a solar panel. It is worth noting that the 2 inventors that collaborated on the water gliding car were high school graduates, they indicated that they utilized scrap materials like electric rotors for their project. Hence their invention cost them nothing and it was not done for commercialization purposes.

While the remaining 80% were asked on the reason behind their lack of inventiveness, and majority (20%) indicated lack of knowledge, 13% indicated lack of technological resources as the reason behind their lack of inventiveness, 6% indicated lack of opportunities, while the remaining 60% did not give any reasons.

Level of Innovation

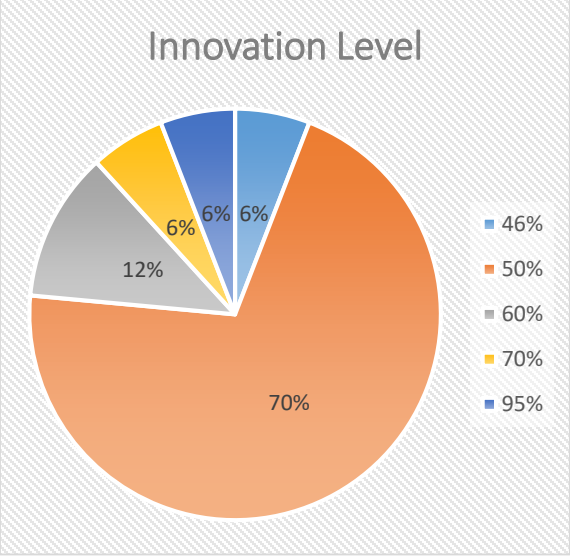


Fig 4.8: Innovation Level of Respondents (N = 15)

When asked to rate their level of innovativeness, 12 (71%) of the respondents rated themselves as average, 1 (6%) respondent rated him/herself as 95% proficient innovatively, 1 (6%) of the respondents indicated 70% proficiency, 2 (12%) of the respondents indicated 60% proficiency in innovations, while the remaining 6% rated him/herself as below average.

Factors Inhibiting Innovation

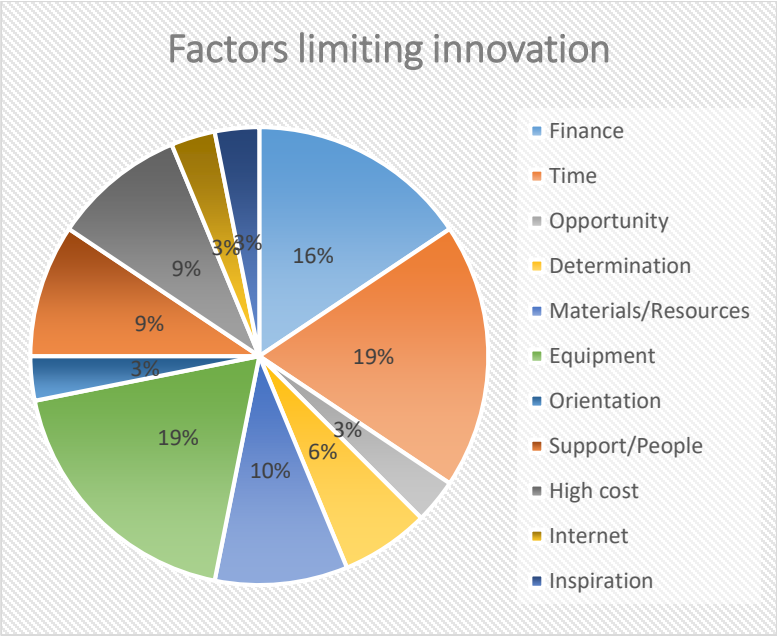


Fig 4.9: Factors inhibiting the innovativeness of Respondents (N = 15)

When asked to indicate the factors that inhibits the innovativeness of individuals in the country, 6 (19%) of the respondents indicated lack of time, another 6 (19%) indicated inadequate equipment, 5 (16%) indicated inadequate funds, 3 (9%) indicated high cost of innovation, lack of support and inadequate material resources, 2 (6%) indicated lack of determination, while the remaining 3% indicated lack of orientation, weak internet connection, lack of opportunity and lack of inspirations.

Knowledge of Inventors

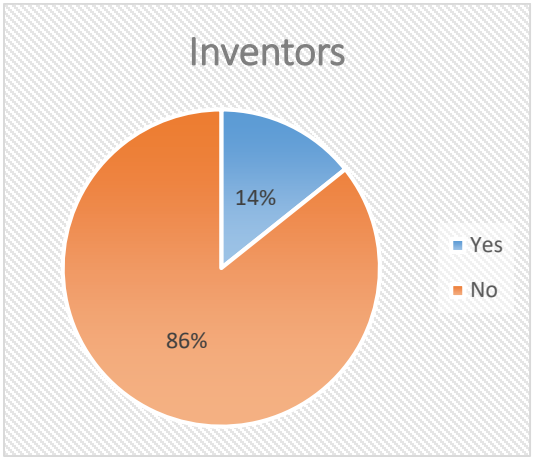


Fig 4.10: Knowledge of any inventors (N = 15)

The respondent were asked if they know any inventors, 12 (86%) responded with NO, while 2 (14%) out of the respondents indicated on the affirmative. They indicated that the inventors were their tertiary institution friends, one built a low cost solar bank charger, while the other indicated that the inventor built a solar panel.

Suggestions for GreenLab Microfactory

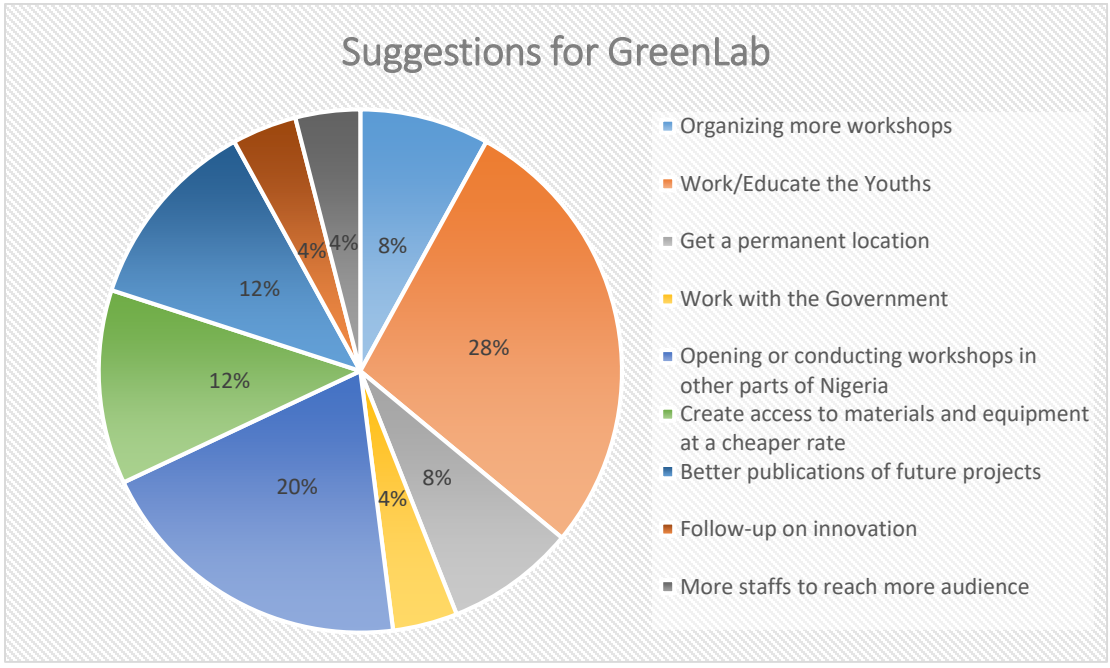


Fig 4.11: Respondent's suggestions for GreenLab (N = 15)

According to the figure above, 7 (28%) of the respondents suggested that the GreenLab should establish and consider working more on empowering the youths irrespective of their location, 5 (20%) suggested opening and conducting more developmental workshops in other part of Nigeria,3 (12%) suggested that the GreenLab should endeavour to create access to cheaper and more affordable materials and resources, another 12% suggested that GreenLab should employ other methods to publicize future events/workshops, 2 (8%) suggested to organize more open source workshops, another 8% recommended to get a permanent physical location, while 4% suggested to conduct a good follow-up on innovation, get more staffs so as to reach more audience, and also to consider working with the government on future projects.

User's response to the measurement of Ajumose's success

A day after the conclusion of the Ajumose workshop, a Facebook poll was conducted to propose how the success of the workshop should be measured. The question asked was:

"How should the success of Ajumose be measured? I leave this to the participants of Ajumose to determine. Would you measure the success based on the tangible items produced? Or would you measure the success based on the knowledge gained? Tell us how you would measure the success of the workshop and have your voice and opinion known"

Below are the comments gathered from some of the participants:

Participant 1: I think it should be measured based on the items produced as well as the knowledge gained. I've never seen young kids so vibrant, happy and willing to learn. Ajumose was a huge success! Looking forward to part 2...

Participant 2: I think the main aim of Ajumose is to create awareness of the abilities inherent in us, and the elasticity of our mind when tasked and to baptize us with the spirit of "If they can do it, I too can". To this end, the program's success is 90%. Because of the program, I now have enemies who, after interacting with the participants, accuse me of not inviting their wards for it.

Participant 3: For I gain a lot in terms of knowledge and on items produced.... I will love to be among next participant.... Ajumose agbe wa oooooo Amin (meaning 'May Collaboration favour us Amen)

Participant 4: Am really really speechless..... The success to me is measured on the 3 days fun packed workshop...
From the seminar, to the practicals (creating of the solar panel and 3D printer) which was really an Ajumose work...the knowledge gained was awesome!!!!!!
Less I forget, also the football match they also played to crown the closing of the workshop

was really thrilling...
I will really be on the move for the next workshop....

Participant 5: Ajumose was no small success but to measure the success based on the items produced would be to belittle the huge success. Therefore the best way to measure the success would be by THE much attained level of knowledge because the participants who built a manual writing pen, for example, are already preparing to build an Automatic Writing Pen, and other mighty projects for benefit of the human race, on their own based on the knowledge gained. Moreover it would only be a matter of time before the world sees a new horizon of technology rise because of the Greenlab imbibed knowledge. So we measure the success by the KNOWLEDGE GAINED!
GOD BLESS Greenlab Microfactory!

Participant 6: The Ajumose workshop with Benny Group of Schools was a great success, all glory to God Almighty. The students went home with the knowledge impacted by the Facilitator of the workshop. The students enjoyed every bit of the training program. They even wished that it should still continue. It was fun packed from the beginning of the program till the end of it. It was a great opportunity to be a part of the participants. It was really a DIY - Do It Yourself - program. God bless Openlab Hamburg, Fablab, and Greenlab microfactory for the wonderful opportunity given to Benny Group of Schools. Waiting for the Part 2 soonest.

Participant 7: To measure the success of Ajumose one would need to take an objective view and rate the workshop based on 3 aspects. Product, participation and purpose. Product wise a functioning solar panel using energy from the sun powered a torch. If the limitation regarding the y and Z axis on the 3D printer had not existed, the possibility of using the solar panel to provide power for the 3D printer brings a glimpse of excitement at what could have been an amazing finish to an already impact full workshop. Participation saw interest from every avenue, age, gender and profession were key. Children as young as 6 learning about 3D printers to the elderly lending a hand in the production process. Lawyers, engineers, political scientists, sales specialists and more with varying expertise in their profession, all in one place collaborating and contributing to the production of the solar panel and 3D printer to even a parent of a participating child, a mechanic by trade, joining the session, sourcing and supplying us with a key resource desperately needed helping steer the completion of the solar panel. The participants displayed collaboration, tenacity, humility and motivation which successfully enabled a group of different people, different minds to come together and achieve something great. Finally Purpose. Ajumose the name of the workshop clearly defines what happened in this workshop and so if we were to tick the success box for each of these aspects, the workshop can be hailed as an impact full success leaving one to ponder if one more day had been available, the more possibilities that could have been achieved?..

Participant 8: Yours sincerely, the best part of success attained is not the product but the invaluable experience that amounts to knowledge gathered by not just a participant but

the whole members of Ajumose.
Let's also measure the success of Ajumose in this sense. The knowledge gathered becomes so powerful that even the next generation of green Nigeria will now know, with ease what a 3D printer is and how to make life much easier with naturally green equipment. Indeed, Ajumose was an outstanding success!

In conclusion Ajumose, just as the name implied, lived up to its reputation as people who had limited knowledge and resources of the digital fabrication techniques prior to the event were able to come together with the sole purpose of learning, developing, and sharing knowledge. Despite the unavoidable technical issues with the 3D printing technologies, Ajumose was able to report an astounding result that will be developed further in the future events.

05.

SWOT analysis of GreenLab Microfactory

SWOT analysis and its importance

SWOT is a synonym for strength, weakness, opportunity, and threats. It is a strategic analysis tool used in the development of effective innovation strategies (Dyson 2004; Cetindamar *et al* 2016). As illustrated by Hill and Westbrook 1997 “A good strategy means ensuring a fit between the external situations a firm faces (i.e. threats and opportunities) and its own internal qualities or characteristics (i.e. strengths and weaknesses). With this being said, the importance of illustrating the SWOT analysis is significant in effective decision making, thereby outlining the potential factors useful for the organization in order to achieve set goals and objectives.

GreenLab microfactory’s SWOT analysis

Strength

The strength of an organization are the factors that exists within the internal environment of an organization. The following are the envisioned strengths that we at the GreenLab microfactory hope to adequately maximize and utilize:

1. The first FabLab in Nigeria, which means
2. Access to highly enthusiastic people (community)
3. Access to abundant renewable or ecological friendly resources (e.g. Sun light, plastic wastes, Bamboos
4. Great innovative strategy
5. Access to great human capital
6. Encouragement of collaboration in and out of the GreenLab
7. Constant facilitation of open source workshops
8. On the road conduction of workshop (i.e. visiting the schools in our local environment)
9. Tour for school students
10. Established contacts with other FabLabs across the globe
11. Established contacts and relationships in the open source community
12. Established connection with highly intuitive open source individuals

Plans to utilize the strengths

Being the first registered FabLab in Nigeria has already given us the opportunity as the pioneer of the much needed social initiative that promotes egalitarian, grassroot, sustainable, and social innovation. We intend to use micro-production methods to

increase the growth and longevity of the GreenLab, which will in turn lead to the rapid replication of the GreenLab concept in every streets, villages, and states of Nigeria.

By micro-production, we mean the modularization of our production processes, localization of materials either by using recycled materials or ecofriendly resources. Also, we plan to personally build and develop 80% of the technologies used at the GreenLab microfactory. We envision that using all these methods stated here would create a suitable and affordable means for the GreenLab concept to be easily replicated.

Weaknesses

Just like the strength, the weaknesses are also factors that are derived from the internal environment of an organization. The following are the envisioned weaknesses of the GreenLab microfactory:

1. Permanent physical location

2. Inadequate technology capabilities (3D printers, laser cutters, milling machine, computers, Arduino kits,

3. Inadequate financial resources

4. Inadequate material resources

Plans to mitigate the weakness

The major plan to mitigate the issue of inadequate open source technology capabilities will be handled by consulting the pool of contacts already established with other open source organization within and outside of Africa.

Meanwhile, having a permanent site location to aid the growth and viability of the GreenLab could cost the organization between 800,000 Naira to 2 million Naira. This we plan to conduct either through a call for donation, or crowd funding. While the issues of inadequate financial and material resources would be presently solved using the same approach. But in the future these issues would be easily handled by the sales of artefacts, consultation fee, and subsidies.

Opportunities

Unlike the strengths and weakness, the opportunities are factors elicited from the external environment of an organization. The following are the opportunities of the GreenLab microfactory:

1. Introducing and developing open source hardware projects in Nigeria

2. Exploring and testing the efficacy and durability of open sourced projects in Nigeria

3. Empowering Nigerian students with practical experiences

4. Integrating digital fabrication in school's curriculum

5. Coordination of grassroot oriented research studies

6. Proper quality focus and strategy

7. Collaboration with other digital fabrication initiatives, and open source community

The opportunities listed above would be utilized conducting more open source hardware projects in Nigeria such as the global village construction set developed by open source ecology, the precious plastic, to test their resilience in a novel environment, thereby creating a local open source community in Nigeria to partner and contribute to the global open source community.

With regards to integrating digital fabrication and techniques into school's curriculum, after Ajumose with the help of one participant we developed a 12 weeks study curriculum for students from the ages of 5 to 15. There would be series of areas of studies, such as 3D printing, Arduino electronic programming, and subtractive manufacturing. The first serie of the curriculum is an introduction to digital fabrication and techniques I with a focus on Arduino electronics and programming. Please consult appendix III for the curriculum.

We have already done a test run of the curriculum on the 5th of April 2017, and based on the reception from the students, we will proceed with the initiation. Which we hope to strengthen with our next project titled "One Student One Arduino" program. More information about this will be found in the next chapter.

Threats

The following are the envisioned threats to the growth and viability of the GreenLab microfactory:

1. Custom fees or charges for the importation of components shipping and logistics

2. Bribery and corruption

3. Inadequate access to digital fabrication resources in Nigeria due to lack of demand (e.g. 3D printing resources, Arduino kits, Raspberry, etc.)

4. Theft and vandalisms

5. Epileptic power supply

6. Internet

The adequate strategy we have in response to the issue of theft and vandalism is to build our own equipment in-house, which could deter the interests of thieves and vandals by 50%, and would also beat down the technology acquisition cost, and gives us a better control on the energy consumption rate of our equipment.

The strategy we have for the epileptic power supply in Nigeria is to make GreenLab a totally green initiative, by being powered off-grid that is, we would generate our electricity through renewable means such as small scale solar panel and wind turbine. As indicated in the paragraph above, we will also build and construct our small scale power stations in-house.

The strategy we plan to use for the inadequate access to digital fabrication components is to become a supplier or distributor of the digital fabrication components in Nigeria, and also to consult and patronize manufacturers on the African continent first before looking elsewhere.

Unfortunately, we do not have any strategy for the first 2 factors listed. However, we hope to use the vision of our FabLab, the projects completed, and the accrued benefits to express the significance of having access to more digital fabrication techniques and initiatives to the Nigerian authorities.

06.

Next Agenda for the GreenLab Microfactory

What next after Ajumose?

Like any future-orientated organization, after assessing Ajumose based on personal lessons learnt and participants feedbacks, we decided to launch another project titled 'One student One Arduino' project. The aim of the project is to encourage innovations right from the cradle level, that is, from the primary education level in Nigeria.

The concept was birthed after reviewing the success of the 'One student one laptop' project conducted in the united states in the early 1990's (McMillian & Honey 1993), replicated in Canada in 2004 (Canuel 2006), and some other countries in the world. This produced astonishing results that proved that the program participants (students) were more productive than their peers who are not participating in the program. Moreover, if the laptop, being a readymade product could aid such developments, how much more a an innovative project that gives the pupils the opportunity to create anything electronics which could also include a laptop, as well as the opportunity to learn about the technical orientations of electronics which include software and hardware developments.

The project will start by providing Arduino starter kits for 100 pupils in the rural settings in Ibadan, Oyo State Nigeria. The target recipients will be primary school students in class primary 4 to primary 6 in the rural areas of Ibadan. Predominantly between the ages of 8 to 10.

The benefits of this project does not only lie in its uniqueness but also in the envisioned possibilities of rearing a new breed of enthusiastic inventors in the Nigerian innovation space. On the long run, it will adequately eliminate the digital divides that exists between first world countries and the third world countries, as well as the digital divides between urban and rural settings. Moreover, it will also give us undivided access to suitable information that would be used to conduct a comparative analysis between the innovativeness of the participants of the project and the nonparticipants. With the goal of revolutionizing a new cross-sectional educational standard in Nigeria's laggard education system.

The cost of this project could range between 8,000 to 12,000 EUR, depending on where the Arduino kits are acquired.

Envisioned limitation of the project

The only envisioned limitation of this project lies in the inadequate knowledge about the numbers of pupils with a personal computer. From speculations, this should not be a hindrance because most parents should have access to a personal laptop that could be used by the kids to learn.

What's next for GreenLab?

We would like to acquire our own property and equipment, so as to give stability and growth to the GreenLab microfactory, and also opportunities for research, development, training, and experimentation to the users.

GreenLab was launched to promote grassroot innovation, research and development. Which with the acquisition of our physical property and tools would be a vital direction towards achieving the set out goals and objectives.

Also, we would commence the registration procedures of the organization as a non-governmental organization before the middle of the year 2017.

With the help of some participants, we were able to develop a curriculum that integrates digital fabrication into the academic curriculum of Benny groups of schools. With this we aim to conduct a short research on the significance of digital fabrication in the primary and secondary education in Nigeria, which would be the first of its kind in Nigeria. Depending

on the outcome of the project, we also aim to integrate this curriculum into other primary and secondary institutions in Nigeria after the first 3 years of commencement.

***** Please consult appendix iii for the curriculum

In addition, we would also like to conduct a tour of the South-west Nigeria in the nearest future, teaching from pupils to high school students about digital fabrication, FabLab, Open source, and collaborative technology development. By using a small scale mobile FabLab facility.

A mobile FabLab facility could range from a small commuter bus to a truck equipped with basic digital fabrication equipment. This mobile FabLab facility would give us the flexibility of reaching and serving more people, while adequately spreading the knowledge of digital fabrication in a faster and cheaper manner.

Fig 6.1: Interior view of Global Innovation Gathering Makerspace's mobile lab

About the Initiator

Babasile Daniel Oladele-Emmanuel is a member of OpenLab Hamburg, and a PhD candidate at the Institute for Production Engineering and Manufacturing Technologies at HSU. He holds an MSc degree in Technology management, from the University of Pretoria, South Africa. Coupled with his academic prowess, Babasile Daniel is a certified PRINCE2 project management practitioner, he is also a CompTIA Project+ practitioner and Lean Six Sigma Black Belter to name a few.

His research interests are on innovations management, value creation, sustainable development, and other significant focus that promotes the aforementioned topics especially in developing countries.

He is a member of the Value Creation Systematics team at the Faculty of Production Engineering, Helmut Schmidt Universitat. He was also a member of the Moshood Abiola polytechnic Junior Chambers International (Mapoly JC) in Abeokuta, Ogun State, Nigeria.

He has published some scientific journal on the topics listed above, which can be found on the link below:

https://www.researchgate.net/profile/Babasile_Oladele-Emmanuel_osunyomi

Would you want to contact, support or partner with us? Kindly contact us using any of this mediums. We sure would be happy to hear from you.

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Appendix I

Participant Feedback form for Ajumose (GreenLab Microfactory)

Name:

Date:

Location:

1. What is your professional background?

2. What is your highest qualification?

3. How did you hear about this workshop?

4. Why did you sign up for the workshop?

5. What are your interests generally?

6. What do you aim to gain from the workshop?

7. Have you heard of any or all of the following? If yes explain

☐ FabLab ☐ Makerspace ☐ Techshops

☐ Repair cafes ☐ hackerspace

8. From your opinion what does openness or open source mean?

9. In your opinion what is open source hardware?

10. Have you created any technology or artefacts? If yes, what type? If no, why?

11. If you answered yes to the question above, how much did you spend during the innovation process?

12. Did you commercialize (sell) the product or did you make them open for others to use and modify?

13. What does innovation mean to you?

14. How innovative would you rate yourself?

15. What are the factors inhibiting your innovativeness?

16. Do you know anyone either a relative or close friend that has created any innovative product? If Yes, what kind?

17. What did you learn from the workshop?

18. Would you participate in any future workshop organized by the GreenLab microfactory?

19. Any suggestions on how GreenLab can better serve the community?

Appendix II

Bill of Materials (BOM) for Ajumose

BOM for Ajumose						
Name	**Volume**	**Dimension**	**Things bought in Nigeria**	**Price (EUR)**	**Shipping fee**	**Tax**
Solar Panel system						
Monocrystalline solar cells	40			73,32	Free	
Solar charge controller	1			22,99	7,99 shipped together	
MC4 M/F connectors	5			5,07		
Solar junction box	1			13,61	Free	
Plexiglass	1	128mm X 56r	4800 (Naira)	15,02	???	
EVA solar film	???	???	???	???	???	
Wood board (Recycled)	1	128mm X 56r	Free	Free	Free	
Plywoods (Recycled)			Free	Free	Free	
Tab Wire	2	10m		11,42	Free	
Bus wire	1	10m		8,07	Free	
Rosin Flux PEN	1			4,45	Free	
MC4 M/F connectors				9,06	Free	
Electrical wires (Recycled)	???	???	???	Free	???	
Bamboo frames	Free	Free	Free	Free	Free	
Bolts and Nuts	???	???	???	???	???	
Screws	???	???	???	???	???	
1kva Inverter	1		39,500 (Naira)	120,16		
3D Printer development						
RepRap Prusa	1			234,99	Free	
Power pack	1			17,95	2,99 Shipped together	
RAMPs, MEGA 2560, and motor drive	1			29,95		
NEMA 17 motor	4		12,95	51,80		
Extruder	2			10,05	3,99	
fishing line	1	500m		8,57	Free	
3D printed objects						
623 Bearing	10			4,95	2,99 shipped together	
608 Bearing	10			2,95		
MK8 Drive Gear	2			7,54	9,01 shipped together	4,81
MK7 Drive Gear	2			2,70		
Miscellaneous						
Hot glue gun	1			13,99	12,88 Shipped together	
BOSCH hand drill	1			89,99		
Soldering Iron Set	1			14,99		
Silicon glue	2			14,78		
Arduino starter kit	1			83,99	7,99	
Silicon glue gun	1			10,51	Free	
			Total	882.87 EUR	47.84 EUR	4.81 EUR
			Overall Total	935.52 EUR		

Appendix III

Academic Curriculum for Introduction to Digital Fabrication Techniques I

4/25/2017

GREENLAB MICROFACTORY

INTRODUCTION TO DIGITAL FABRICATION AND TECHNIQUES I : ARDUINO ELECTRONIC DEVELOPMENT AND PROGRAMMING

TEACHING AGE TARGET OF 8-15 | GreenLab Microfactory

CLASS TIME :Monday- 10am-12pm

Wednesday:10am-12pm

Saturday:10am -1pm

Venue: GreenLab Microfactory [available within the school premises]

Subject Instructive: [GreenLab Instructor]

Description:

This course is going to be lab-based in nature. This is because it is majorly practical course which requires description, practical analysis and class projects. That is why it is one –pupil Arduino course.

Subject goals:

This course aims to equip young pupils (between age 8 and 15) in the basic classes (say basic 4,5 and 6) with foundational and basic knowledge of Arduino : how it works, basic composition, tools and techniques; its relationship with other courses in the basic education, its importance to the pupils' career and more importantly, its essential benefits towards the development of their society.

In addition to school fabricated resourceful learning aids pupils will be introduced to a series of contemporary techniques, practices and creative methodologies.

Key goals included:

The key goals of this pedagogical innovation are into two parts:

1. **Immediate goal**: this is to empower Nigerian community technologically in order to be able to measure up with her contemporary nations around the world by introducing Arduino to the common/less privilege/ deprived young Nigerians between ages 5-15, in schools.
2. **Methodology:** the pedagogical methodology that may be employed, since it is lab-based course, will be participatory in nature. Whereby, the instructor does not have to play the main role of showing the pupils examples all the times but ask them to give or make out examples from the knowledge already gathered from teacher. The instructors' explanation, the instructor is expected to give a do-it-yourself class exercise or project.

However, a brief recap of the previous knowledge should open every class section.

*Assignments

This course will include visual test, practical demonstration, small practices/ test, relevant technical and textual reading.

* recommended tests

- class notes by GreenLab's instructor

- practical diagrams

- course workbooks

- other resourceful materials

***Grading procedure**

-20%– attendance in class

-20%- class activities/project

-20%- active participation in group projects

-40%- Final individual projects

*Special needs

For physically challenged students/pupils, basic aiding facilities may be provided to help facilitate learning.

Course Schedule

Week 1: INTRODUCTION TO ARDUINO

Class 1: brief history about Arduino

Class 2 : the relevance of Arduino to other subjects

Class 3 : the importance of Arduino to you

Week 2: ARDUINO IN OPEN SOURCE PROJECTS

Class 1: Types, features and functions of Arduino.

Class 2 : Uses of Arduino in 3D printing technology

Class 3: Examples of other open source projects with Arduino.

Week 3: INTRODUCTION TO CIRCUIT

Class 1: Definition/Description of circuits (Physical examples of circuits).

Class 2: Description and Definition of resistor (multiple or simple), diodes, switches, LEDS, conditional statements, Block diagrams, and named circuits.

Class 3: Features and Functions of the above components of circuits.

Week 4: INTRODUCTION TO DIGITAL PINS

Class 1: Block Diagrams and LED circuits

Class 2: Introduce Loops, PWMs and shift register.

Class 3: More complex coding with function.

Week 5: INTRODUCTION TO ANALOGUE PINS

Class 1: Introduction to analogue pins (using circuit analysis, block diagrams, LED circuits

Class 2: Introducing analogue inputs, uses of a PWM and Photocell

Class 3: Flex Sensor, temperature sensors soft spot

Week 6: INTRODUCTION OF BASIC PROGRAMMING CONCEPTS

Class 1: Describe how loops, conditionals, variables, functions and parameters can be used.

Class 2: Describe how it can be used with LED circuits and simple Arduino sensors

Class 3: More Exercises.

Week 7: INTRODUCTION TO ARDUINO

Class 1: Setting up the programming environment

Class 2: Basic introduction to the Arduino micro-controller

Week 8: Using an LCD Display

Class 1: Introducing how to use premade Arduino libraries

Class 2: How to use the LCD display

Week 9: Using the sensor stick

Class 1: Introducing how to use the spark fun, a degree of freedom-sensor stick.

Week 10: Using Motor

Class 1: Introduction to 3 different types of motors

(I) Servo
(II) DC motor
(III) Stepper motor

Class 2: How encoder's can be used to change motor speed

Class 3: Introduce the H-bridge

Week 11: Adding Audio

Class 1-3: How to use speakers and stimulate a sound file, using an array with frequencies and create one therein

Week 12: GPS Shield and Micro SD Cards

Class 1-3: How GPS works

: How it is used with Arduino

: How to use the GPS Shield and SD Card for data acquisition.

: How two Serial pins work: the receiver (RX), and the transmitter (TX)

Note: the above topics and sub-topics are subject to modification and creativity of the instructor for effective learning.

INTERMEDIATE GOALS

(I). Help make technology relatively free and accessible by all in Nigeria as it is in the developed world, using Arduino board.

(II). Help build a solid trust for locally made technologies using localized raw materials, ecofriendly, and open sourced equipment.