

FabLab in Nigeria's Innovation Space: A Report from GreenLab Microfactory's DIWO Event

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Abstract

The present overall impact of the FabLab initiative is tremendous, with records of its significance been recorded across different economic sectors, from the agriculture, energy, education, and to the health sector. However, with recorded advantages, Nigeria a country of approximately 200 million people does not have one. In lieu of this, on the 20th of April 2017, GreenLab Microfactory, the first registered FabLab on Nigerian soil, kicked off with a Do-It-With-Others (DIWO) workshop, appropriately named AJUMOSE meaning collaboration or cooperation in the Yoruba language. The goal of the workshop was to promote the FabLab concept in Nigeria, to the participants, through displaying the significance of collaboration and openness in solving social issues currently existing in the Nigerian community. This article gives an account of the event and its goals, detailing the results and findings from the workshop as well as benefits, lessons learnt which could be applied to future projects, and limitations of the event realised. The report also includes the analysis of feedback collected from the events participants.

Keywords

FabLab, Nigeria, DIWO, Do-It-With-Others, GreenLab Microfactory, digital fabrication, open source, innovation, 3D printing, STEM

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Abstract

The present overall impact of the FabLab initiative is tremendous, with records of its significance been recorded across different economic sectors, from the agriculture, energy, education, and to the health sector. However, with recorded advantages, Nigeria a country of approximately 200 million people does not have one. In lieu of this, on the 20th of April 2017, GreenLab Microfactory, the first registered FabLab on Nigerian soil, kicked off with a Do-It-With-Others (DIWO) workshop, appropriately named AJUMOSE meaning collaboration or cooperation in the Yoruba language. The goal of the workshop was to promote the FabLab concept in Nigeria, to the participants, through displaying the significance of collaboration and openness in solving social issues currently existing in the Nigerian community.

This article gives an account of the event and its goals, detailing the results and findings from the workshop as well as benefits, lessons learnt which could be applied to future projects, and limitations of the event realised. The report also includes the analysis of feedback collected from the events participants.

1. Introduction

For a positive and sustained change to occur Chavis, Florin and Felix (1993) indicated the need for co-production of services by citizens and community institutions. For this particular reason was FabLab, a digital fabrication laboratory established. From numerous articles FabLab has been identified as a facility that creates a self-learning community (Morel and Le Roux 2016; Schelhowe, 2013), as a major facilitator of decentralized production system (Sylvester & Doring, 2014), as a hub supporting local embedded economies (Sylvester & Doring, 2014), as a potential facilitator of reverse migration from urban to rural areas for employment (Kulkarni, 2013), as a promoter of STEM, and as a social hub that encourages unhindered transmission of knowledge from the source to different destinations (Dyvik 2013).

FabLab was quoted as transcending the do-it-yourself (DIY) culture which on its own produces a unique breed of individuals that promotes a sustainable economy. Drawing from the benefits highlighted by Sylvester and Doring 2014, FabLab encourages a Do-It-With-Others (DIWO) which is also known as Do-It-Together (DIT) culture. Kohtala (2016) further illustrated other benefits accrued to the FabLab movement as an avenue for disruptive technologies where new practices around open design and open innovation compliments the effective and efficient usage of raw

materials and energy as a sustainable alternative to bypass the negative ecological impacts of mass production, aligned with empowerment and peer learning for creative making and invention.

Drawing from these acclaimed benefits, the GreenLab microfactory was introduced in the Nigerian community to further provide adequate studies of the FabLab concept in a third world country, to measure its significant contribution to the global competitiveness and innovativeness of a country as depicted in the global competitiveness report and global innovation index (Osunyomi & Redlich, 2015).

In this research paper, section 2 takes a look at the growth of FabLab through the aid of a comparison study of the growth of FabLab highlighted by Osunyomi et al (2016) to the present growth rate as of May 2017. Section 3 provides a detailed analysis of the GreenLab microfactory, the first registered FabLab in Nigeria, detailing its objectives, and the report of its first open source event. Section 4 presents the research approach, limitations, as well as a synopsis of the participant feedback survey conducted on the participants of the event. Lastly, section 5 presents a conclusion and remarks on further study on the FabLab ecosystem.

2. Growth of FabLab

A prior research study was conducted on the FabLab ecosystem in 2015 (Osunyomi *et al* 2016), and during the study, the global density of the FabLab ecosystem was 490 from over 50 countries. Zijlstra (2013) & Gershenfeld (2009) in their articles hypothesized that the numbers of FabLab doubles every 18 months. According to the initial research studies conducted on the FabLab ecosystem, we discovered that on a global presence this hypothesis is indeed valid, as the number of FabLabs in the world is almost triple two years after the conduction of the previous research. To further test this hypothesis we conducted a continental breakdown of the FabLabs which was compared to the initial breakdown down in 2015 (see table 2 and 3 below). From this we discovered that this hypothesis is valid in 5 out of the 6 continents, with Australia and Oceania still 3 FabLabs short, while Africa just slightly prove the validity of the hypothesis.

Table 2: Continental breakdown of the FabLab Network (as of April 2015)

Continents	Numbers of FabLab Network
Africa	22
Asia	50
Australia and Oceania	6
Europe	273
North America	98
South America	41
Total	490

Table 3: Continental breakdown of the FabLab Network (as of May2017)

Continents	Numbers of FabLab Network
Africa	45
Asia	165
Australia and Oceania	9
Europe	636
North America	196
South America	88
Total	1139

From the African perspective, it is a delight that Africa has doubled its FabLab network from 2015 to 2017. However, comparing the density of FabLab in Africa reveals a disproportional distribution of the FabLabs as there are enormous whitespaces between the countries, as of June 2017 there are 18 FabLab countries in Africa compared to the 54 total numbers of countries on the continent (see table 4 below). This gives a ratio of 3:1, indicating that one third of the countries on the African continent are making significant endeavours to promote the FabLab ecosystem. However the distribution of the FabLab in these countries are disproportionate with a lot of room for improvements. Performing a headcount of FabLabs per country shows Egypt as the fore-leader with a total of 9 FabLabs, and South Africa holding the second place with 8 FabLabs. Moreover, a remarkable discovery was made about the functionalities of FabLab in South Africa, as one of the respondent to the survey conducted in 2015 (Osunyomi & Redlich, 2015) indicated that some FabLabs in South Africa were inactive. This importantly provides a glimpse to the sustainability and viability issue presently confronting the FabLab ecosystem which will be concluded at the end of this section.

Table 4: Continental Ratio analysis of FabLab

Continent	Numbers of countries	FabLab Countries	Ration analysis
Africa	54	18	3:1 = 0.33%
Europe	50	36	25:18 = 0.72%
North America	23	9	23:9 = 39.1%
South America	13	11	13:11 = 84.6%
Asia	48	27	16:9 = 56.3%
Australia and Oceania	25	2	25:2 = 0.08%

Moreover, comparing table 4 to table 3 indicates that Africa and Australia and Oceania are still playing catch-up in the distribution of the FabLab ecosystem with both continents having the least ratio representation according to the numbers of countries in the continents compared to the numbers of countries with FabLabs. In addition, it is important to highlight that it is not mandatory to have or replicate the FabLab concept in any country. However, based on various evidences that proves that FabLabs are feasible and viable means of ensuring overall sustainability, it could be worth it to study the contributions of the FabLab concepts to the global innovativeness and competitiveness of a country as indicated by Osunyomi & Redlich 2015.

Lastly, though sustainability of a subsidiary organization is organization-specific and solely dependent on the strategies embedded with the organization, this is also evident in the FabLab ecosystem as the sustainability aspect of the movement is left to the individual perceptions and abilities of the respective labs. However, could the lack of growth and sustainability be linked to the lack of collaboration between the FabLabs as highlighted in existing literatures (Osunyomi et al, 2016)?

3. GreenLab Microfactory

The aim of GreenLab is to encourage small-scale development of valuable artefacts, by providing access to digital fabrication tools and technologies that encourages learning, rapid prototyping, ideation, innovation, and small scale development of artefacts. Furthermore, GreenLab aim to encourage the utilization of dormant, recycled and abundant eco-friendly materials and resources in rural areas to encourage innovation and sustainable development.

From prior research studies, and in the recent published world's innovation index, human capital was identified as the most important resources on which the sustainability and growth of an economy is dependent. Without doubt, we purport that investment in human capitals and capabilities should be the stringent focus of third world countries in order to transcend beyond its poignant developing stage status. From a recent research survey conducted, Osunyomi et al (2016) discovered that a well implemented social digital fabrication initiative not only enhances human capital, but it also provides various empowerment opportunities for the populace irrespective of their social status. Therefore, the envisaged benefits of GreenLab microfactory in the community and country are very enormous, some of which are given below:

- Aid the development of endogenous technologies through communal learning, sharing, rapid prototyping, frequent oriental workshop conduction, and active engagement of the community
- Development of localized innovative strategies
- Enhance the country's educational system by fortifying and reorienting a STEM focus (science, technology, engineering, and mathematics) by initiating the integration of digital fabrication (DF) techniques in school curriculums. This has been identified by the innovation index as the major contributor to the innovativeness and competitiveness of a country.
- Adequate development of the human capital by increasing and encouraging more entrepreneurial flair and opportunities.

- Scalability: - The GreenLab micro-factory will use a scalable model, by localizing and reusing materials, such as using shipping containers rather than building real workshop, which means nodes can be added to the micro-factory without disrupting the productivity and quality of work done within the factory. Which also save quite some time and money.
- Replicability, Flexibility, Applicability, and Feasibility: - Due to the usage of localized resources, open sourced tools and technologies, and other eco-friendly / sustainable equipment. GreenLab microfactory can be easily replicated in other locations, and with a fraction of the developmental costs incurred by existing human capital developmental initiatives.

GreenLab microfactory was launched in Ibadan, Nigeria on the 20th of April 2017. The initiative started with an open source DIWO event tagged Ajumose which spanned from the 20th to the 22nd of April. The following section gives a detailed explanation of the event.

3.1. About Ajumose

The word 'Ajumose' is paramount to the indigenes of Oyo state, and according to the Yoruba language Ajumose could mean collaboration, teamwork, co-working, or cooperation, etc. 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 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.

The workshop started with a brief explanation of the objective of the workshop, explanation of FabLab, its concepts, its technologies, and its benefits. In addition, a brief explanation of the equipment to be developed was given, followed by acknowledging the sponsors, after which the participants were split into three groups. Group 1 comprised of participants below the age of 13, they were given in-depth lessons on the FabLab concept, a basic Arduino lesson covering chapter 1 and 2 of the Arduino project book, as well as a basic lesson on how to use CAD software. Group 2 comprised of participants above 13 years of age but assigned with the task of assembling the 3D printer. Lastly, group 3 also comprised of participants above 13 years of age and they were equally assigned with the task of developing and assembling the solar panels. The following

section entails the lessons learnt from the workshop, the benefits, and limitations of the workshop.

3.2. Lessons, Benefits, Limitations, and Result

3.2.1. Lessons

Using a unique innovative strategy - HIDES which represents Hearten, Ideate, Develop, Explore, and Share. GreenLab microfactory attempted to reverse engineer the learning process by introducing the participants to the 3D printing technologies and solar panel development by charging them with the task of assembling one themselves. Drawing from the observation of the participants, this innovative approach proved to be much more effective because all the participants prior to the event had no knowledge about the existence of 3D printing technology. However, a day after the commencement of the workshop, the majority of them were able to use the technical terms of the 3D printing technologies. This was mostly apparent when the components of the low cost 3D printer purchased for the workshop started giving unexpected challenges due to missing components, differences between the components listed in the manual and the packaged components, as well as some differences between the smooth linear rods of the 3D printer. Which inadvertently hindered the successful assembly of the 3D printer. However, the event participants had already acquired an ample amount of knowledge about how 3D technology works, also they were able to state most of the technical components used in the open source 3D printing platform. From this event, two vital lessons were learnt, these are listed below:

1. As a community it is possible to achieve a considerable amount of work if given a conducive environment. Despite all the setbacks experienced, the successful execution of a DIWO workshop is majorly reliant of the complementarities, accumulation, and utilization of diverse knowledge and experiences.
2. The second lesson learnt, is that the bottom-up approach is not only applicable in small-scale manufacturing. From the event, we discovered that bottom-up concept could be applied in the learning environment with the potential of shortening the learning curve to empower people in rural communities hence bridging the knowledge-divide. The efficacy of the bottom-up learning approach is evident in the genuine approach used to teach the participants about 3D printing. By providing a do-it-yourself 3D printer kit, and not an already assembled 3D printer, the assembly team were able to gain major knowledge about the technical components of a 3D printer, as well as the functionalities of the technology. Which proved to be a breakthrough experience even when the 3D printer could not function as planned.

3.2.2. 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.

3.2.3. 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. However the inadequate access to internet services during the workshop 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 previously downloaded. These proved very useful when 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 which 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/loss of time due to 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, the organizer was literally being summoned by all the groups. Which hampered the progress of the groups.

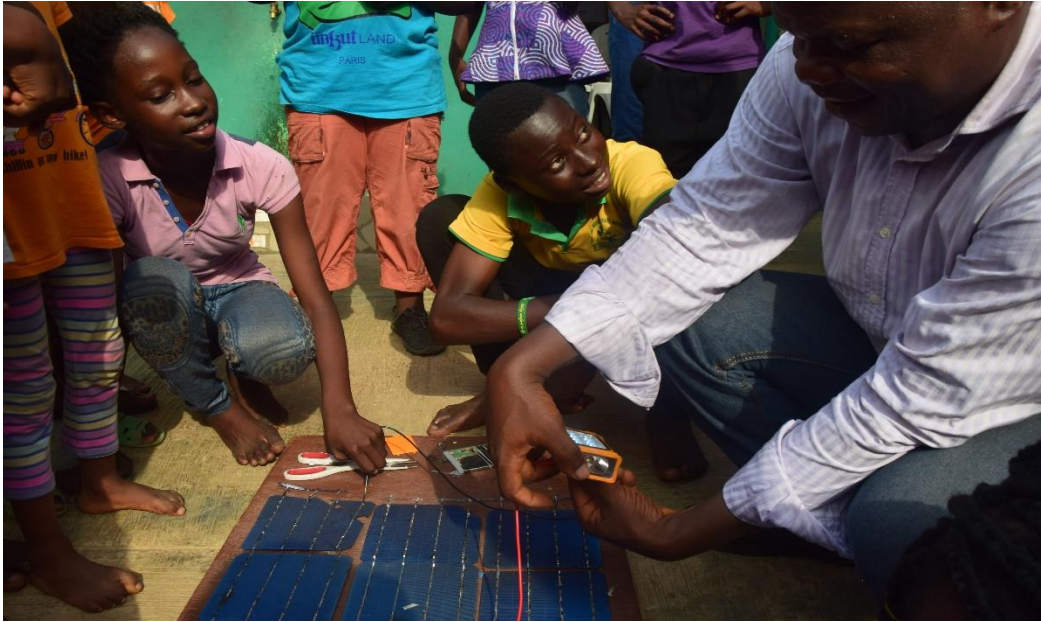
6. **Inadequate tools and equipment:** During the workshop, we had to improvise for some tools. Most of the equipment used for the workshop were brought from Germany. Due to inadequate infrastructural development and technology advancements, some tools and basic resources needed were impossible to get. Which was profound when the 3D printed objects for the second 3D printer (Hang printer) became damaged during the long flight to Nigeria, which after two attempts to fix led to the cancellation of the development of the hang printer. This also crippled the progress of the event.

7. **Insufficient funds:** A majority of activities 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 3D printer, having a functional 3D printer became a mirage.

3.2.4. Results of the Workshop

Below are the pictures of the results of the Ajumose DIWO workshop, more pictures can be found on <http://www.greenlab-microfactory.org/events-and-publications/>



4. Participants' feedback survey Analysis

At the end of the event, we conducted a paper-based participant feedback survey to determine 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. Most of the questions asked in the questionnaire were mostly open ended to obtain detailed information from the respondents. The questionnaires were distributed to the participants above the ages of 13 which comprised of the development and assembly groups (group 2 and 3). The survey was conducted on a population 30 of the participants, out of which we collected 15

responses, which equates to 50% response rate. This section presents analysis of the participants' feedback survey based on the gender distribution of the participants, profession, qualification, awareness of the DIWO event, knowledge of digital fabrication initiatives, factors inhibiting their innovativeness, and suggestions for the GreenLab microfactory.

4.1. Limitation of the Research

In continuation of the limitations of the DIWO workshop highlighted in 3.2.3 section above. One vital limitation of this research study is based on the small numbers of respondents. This in particular was unavoidable considering the total numbers of participants of the DIWO workshop, and out of which 55% are young persons. However, this limitation could have been complemented with a qualitative approach but due to inadequate time we resolved to utilise the quantitative research approach. The following section highlights the gender of the respondents.

4.2. Gender of Respondents

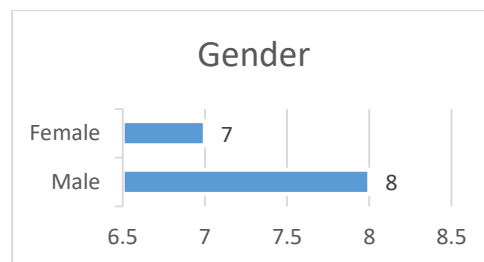


Fig. 1: Gender specification of the respondents (n = 15)

From the figure above, 53% (8) of the respondents were male while 47% (7) were female. However, the gender of the participants had no significant effect on the tasks of the event, as all the participants took equal turns in soldering at least one solar cell and had their opinions voiced, most importantly when faced with some technical limitations, as well as fulfilling a role or task as assigned by their local leadership authority. This typifies the egalitarian structure portrayed by the FabLab ecosystem.

4.2. Profession

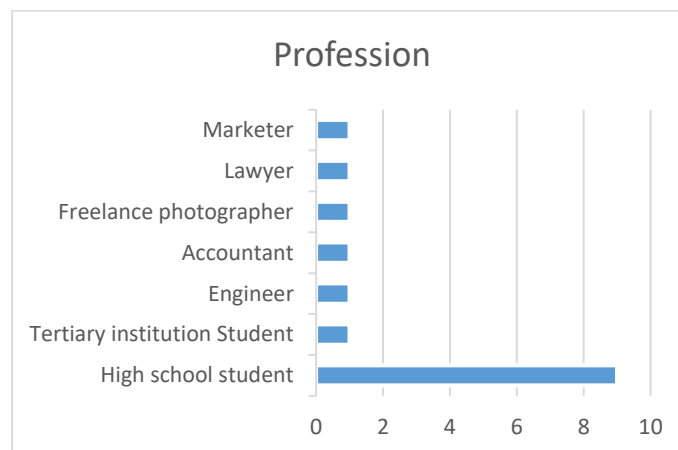


Fig. 2: Profession of the participants (n = 15)

The highest concentration of the respondents 9 (60%) were 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.

4.3. Qualification

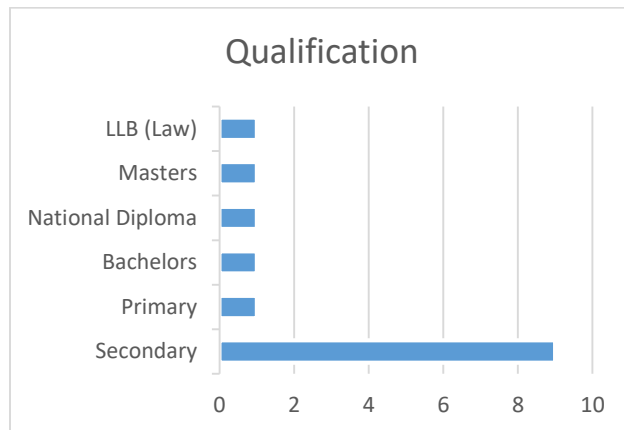


Fig. 3: Qualification of participants (n = 15)

As indicated in the figure 3 above, majority (64%) of the respondents have a secondary school certificate, while the remaining participants ranging between a LLB degree, MSc degree, primary school education, BSc degree, and an ordinary national diploma constitute 7% of the responses.

4.4. Awareness

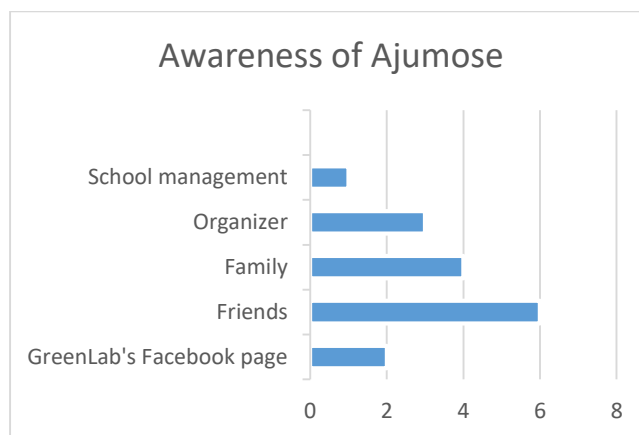


Fig. 4: Awareness of Ajumose (n = 15)

The respondents were asked how they learnt about the workshop, 38% indicated that they learnt from their friends, 25% indicated they learnt from their family members, 19% indicated that they learnt from the event organizers, 13% indicated that they learnt from GreenLab's Facebook page, while 7% indicated that they 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 works better in a rural setting. However, in order to cover a huge area, social media plays a significant role.

4.5. Awareness of Digital Fabrication Initiatives

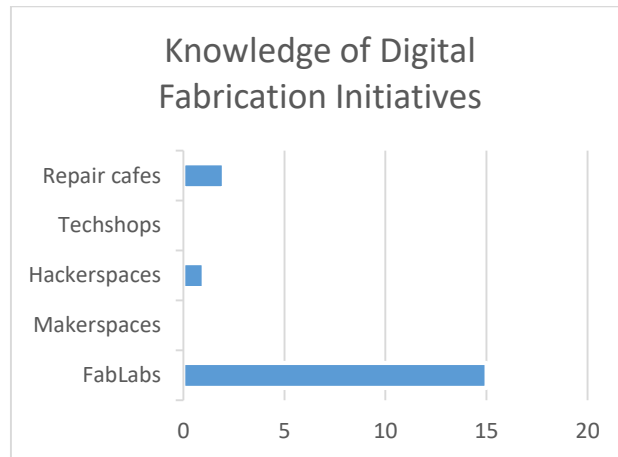


Fig. 5: Knowledge of Digital Fabrication (n = 15)

All the respondents (83%) indicated their vivid knowledge of the FabLab ecosystem, 11% indicated knowledge of the repair cafes, while 6% indicated knowledge of hackerspace. It is worth noting the contribution of Ajumose towards the dominant percentage of the knowledge regarding FabLab recorded, as prior to the event, majority of the participants were unaware about FabLab and its concept.

4.6. Factors Inhibiting Innovation

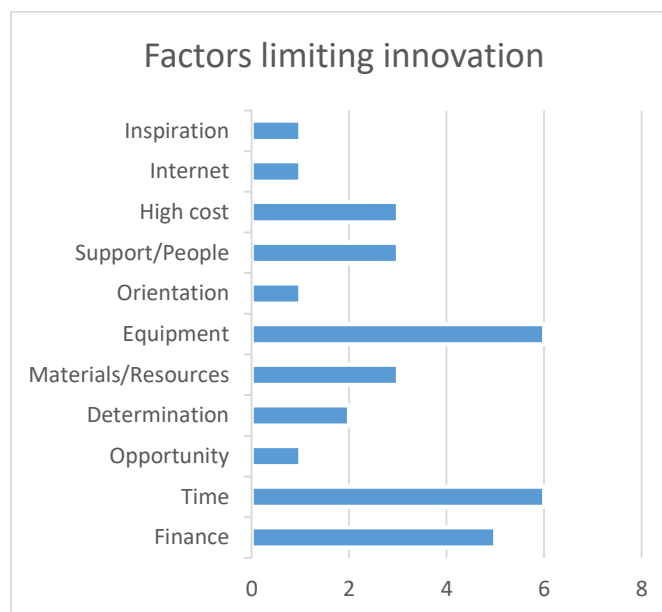


Fig. 6: Factors limiting innovation (n = 15)

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

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.

4.7. Suggestions for GreenLab Microfactory

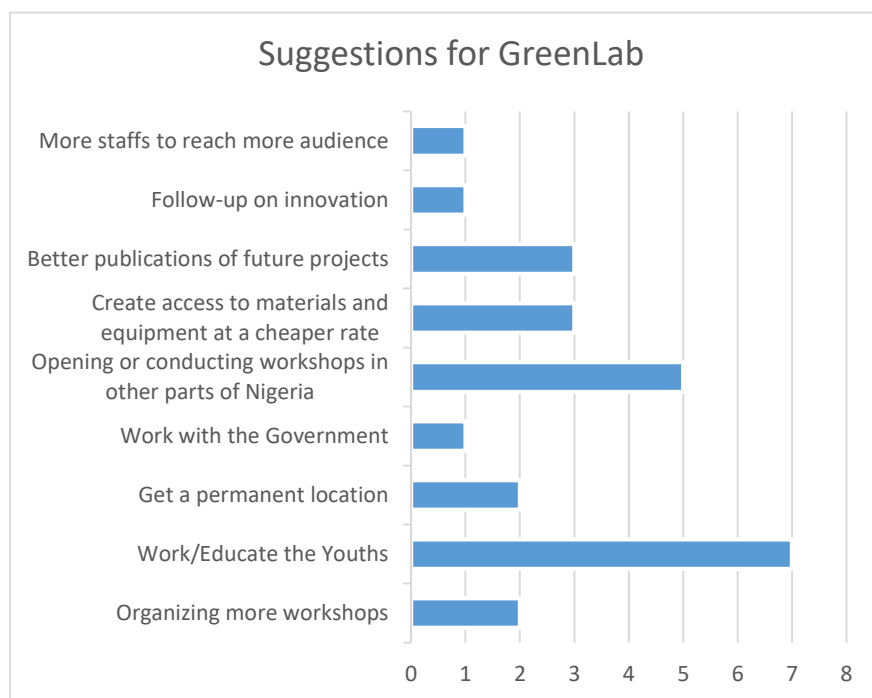


Fig. 7: Suggestions for GreenLab (n = 15)

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, 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, 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.

5. Conclusions and Remarks

Even though most emerging economies are still playing catch-up in the innovation and development space, which could be attributed to inadequate investment and involvement in developmental activities such as R&D, human capacity development etc. From the outline of this research paper, it can be concluded that initiatives such as FabLab that encourages user participations and grassroots/social innovations and development, are the most feasible means to jump the developmental chasm presently in existence within the continent at large. Hence, leading to the development and deployment of policies through which the continent can effectively benefit from its unique resources. However, we recommend more research studies on the significance of the FabLab ecosystem and other digital fabrication initiatives (DFI) in strengthening the innovativeness and global competitiveness of a country. This could be vital to the growth, maximization, and effective dissemination of the FabLab concept.

From the DIWO workshop, an adaptive strategy was developed that could be used by the third world countries to efficiently roll-out FabLabs to cater for the demands of their citizens, as well as to boost their innovative and entrepreneurial flair while leveraging the localization of resources used within the facilities. In addition, the event also revealed vital lessons which could strengthen the sustainability issue presently existent in the FabLab ecosystem. Despite the minor setbacks experienced during the DIWO event, the complementarities, accumulation, and utilization of diverse knowledge and experiences proved to be a significant trait of an average FabLab. Another vital lesson learnt, is that the bottom-up approach could also be applied in the learning environment with the potential of shortening the learning curve to empower people in rural communities hence bridging the knowledge-divide.

Lastly, from the feedback survey analysis, it was discovered that if the benefits of DFIs are to be effectuated or maximized in any community, the factors inhibiting their innovativeness should first be minimized. As discovered in the feedback analysis there is a need for frequent events or workshops that strengthens both the innovation prowess and entrepreneurial flairs of the populace to be conducted, the development or acquisition of more DFI equipment is paramount, collaboration with governmental parastatals as suggested by some of the respondents should be established, and mostly the community should be adequately informed about future open-source events.

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