Impact of the FabLab Ecosystem in the Sustainable Value Creation Process

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***Abstract*:** The value creation concept aims to create not just a paradigm shift in developmental strategies, but also a shift in the distribution of livelihood, thereby providing adequate means of wealth and job creation to the populace in the developed, and developing countries. In response to the need for adequate value creation, some initiatives were rolled out to tackle the urgent issue of inadequate value creation, among which is FabLab. FabLab signifies fabrication laboratory, it is a small-scale workshop equipped with flexible computer controlled tools and systems for the production of digital fabrications of widely distributed products, which are used to encourage creativity and innovation among individuals irrespective of their anthropological status.

This paper provides the result of the research survey conducted to explore the tools and techniques used within the FabLab ecosystems to ensure its sustainability, analyze the growth pattern of FabLab, and finally uncover both the socio-technical and socio-economic impact of the FabLab ecosystems. A total number of 94 (N=94) respondents participated in the online survey globally. From the survey, we discovered that FabLab have been productive up to date, though the lack of a formalized operating structure and unified communication platform amongst other constraints poses as the major impediments to the full effectiveness of the initiative.

***Keywords*:** Collaboration, FabLab, Innovation, Sustainability, Value creation.

Introduction

From the inception of the early industrialization era (export-oriented industrialization and import-substituent industrialization), value creation was deemed to be autocratically for the generation of economic benefits for firms, industries and investors. However, this approach was based on top-down economics which gives little attention to the actual needs and values of the consumers. Moreover, the emergence of the technology era facilitated a paradigm shift from the primitive export-oriented industrialization to a more open collaboration-oriented industrialization.
The collaboration-oriented industrialization characterizes the evolving principles of bottom-up economics, which fosters a reciprocal relationship between the producer and consumer, and emphasizes the bidirectional increase of the participants' potential [1].

The importance of envisaging the value creation process from the perspective of collaboration is to encourage openness and effective knowledge transfer between stakeholders. Hence, creating socially sustainable economic values for all stakeholders. Basmer et al [1] highlighted that the new patterns of value creation (bottom-up economics and open production) based on the new manufacturing technologies generate chances for social sustainability, because they empower ordinary people to produce their own goods on their demand, and it also facilitates the participation of actors from the developing countries in the world's production network.

In order to create self-sustainable environments, there needs to be concrete intervention to facilitate research and development (R&D), product invention, skills transfer, and creation of entrepreneurial ecosystems irrespective of people's demographic and anthropological status. Therefore, the FabLab initiative provides an avenue for cost-

effective R&D, it serves as a driving force in creating and engaging learning environments, and also as an effective means to valorize bottom-up innovation [2].
The objectives of this research study is to analyze the growth pattern of FabLab, to explore the tools and techniques utilized within the FabLab ecosystems, the sustainability strategies, to uncover the socio-technical and socio-economic impact of the initiative, to explore how the impact of the FabLab initiative can be quantified, and to analyze the overall status of the FabLab ecosystems in line with the value creation paradigms.
Thus, in this paper a brief literature review of the FabLab ecosystem is given, its significance in the value creation concepts are stated, its present growth pattern are illustrated, the research questions and method are described, an in-depth analysis of the survey conducted on the implementation rate of the initiative are also stated, and the detailed discussion of the research findings are presented. Lastly, the conclusion of the research and some recommendations for future research works are given.

literature review

What is a FabLab

FabLab signifies 'fabrication laboratory', which is at times known as 'fabulous laboratory'. It is an innovative, sustainable and self-organized concept coined by MIT's Centre for Bits and Atoms (CBA). FabLab is a high tech laboratory or workshop where ordinary people can design just about anything from machines, to other artefacts which stimulates their livelihood [3], [4], [5], [6], and [7]. This is otherwise known as personal fabrication [3], [4], [5], and [6]

The FabLab workshop consists of a collection of tools for design and modelling, prototyping and fabrication, and other electronic tools, with open source software and other dedicated programs to bring advanced manufacturing technologies to ordinary people, by being involved in innovative experimental projects and peer-to-peer learning, and to also provide means to solve local problems creatively. Moreover, FabLab is a user-centric initiative where sustainable or eco-friendly communities are developed, and it is also a platform where innovative development evolves. Subsequently, FabLab creates an ecosystem for entrepreneurial empowerments which initiates unprecedented domestic opportunities (Fig. 1 below).

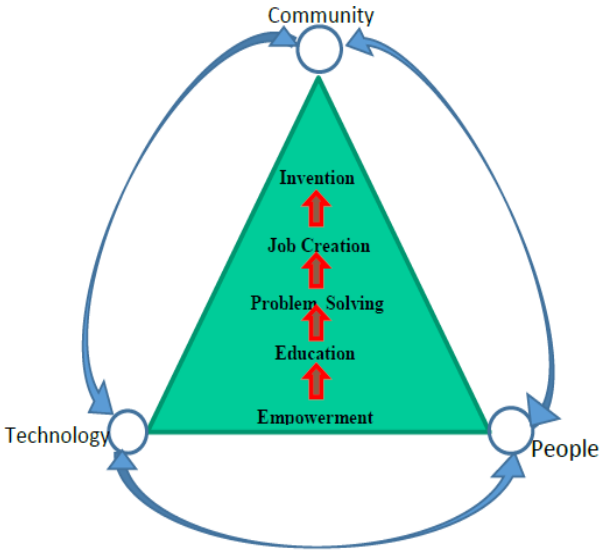

Fig 1 What FabLab offers

The FabLab workshop is opened to people looking for practical training, tinkerers, inventors, crafters, children and youth, community groups, adults, women, small medium enterprises (SME's), innovation teams, researchers, students, and so on. The focus of a basic FabLab is to assist individuals to conceptualize, design, develop, fabricate and test the products, using the various equipment provided within the workshops. In summary, FabLabs are open-source movements that practices rigid egalitarianism [8]. The preceding section outlines the significance of the FabLab ecosystems to the value creation process.

Significance of FabLab in the Value Creation Process

In the value creation process, the interaction between the firm and consumer is locus [9]. According to Redlich et al [10], the value creation processes are broadly dependent on interaction, collaboration, and self-organization of globally distributed actors to cope with emerging complexities. Basmer et al [1], further stated that the value creation process increases the width and depth of co-activity, choosing cooperation as competitive strategy and open source as business model, thereby enabling more actors to participate. The term *'more actors'*, connotes the constant involvement of the users/consumers throughout the developmental processes. Therefore, the value creation process embodies complementary concepts such as the bottom-up economics approach, collaboration, openness, and interconnectedness between all actors in the value chain.
In the preceding section above (see section 2a), it was outlined that the FabLab initiative provides a substantial avenue for all users to transcend the static ideation process into the development of tangible artefacts. Therefore, in the following subsections we aim to highlight the position of FabLab in the value creation processes.

FabLab and bottom-up economic Approach

The bottom-up economic approach facilitates a fusion between the producers and consumers [1], [10]. In terms of the bottom-up economic approach, FabLab is a vector of empowerment and skills development, that enables users/general public become active participants in the development process, by providing technologies and space that encourages technological learning and supports step-by-step development of prototypes [1], [2].

FabLab and Collaboration

One of the outlined focuses of the FabLab initiative is to facilitate networking between the nodes on the ecosystems, and to encourage distribution of evolving inventories of core capabilities, allowing people and projects to be adequately distributed within the FabLab ecosystems. FabLab prioritizes cross-disciplinary and collaborative approaches [2], [11].
Collaboration is essential in the FabLab ecosystems. The collaborative efforts occurs within the FabLab facilities in the following forms:

- Collaboration between basic users/ entrepreneurs for innovation and knowledge transfer,
- Collaboration between business organizations and the FabLab facilities for business development purposes, and
- Lastly, collaboration between local FabLabs and other FabLabs in the network.

As indicated by Basmer *et al* [1] and Redlich *et al* [10], this is effective in the development of a collaborative-oriented industrialization that gives adequate focus on the needs of consumers, thereby facilitating a paradigm shift in the value creation process.

FabLab and Openness

Openness signifies interaction between two or more elements or systems [10]. According to Redlich et al [10], collaboration and openness are complementary strategies. This reiterates the core focus of the FabLab initiative, which is to facilitate sharing of evolving inventories of core capabilities. As part of the outlined goals of the FabLab initiative, inasmuch as designs and processes developed within the facilities belongs to and can be protected by the inventors, the designs should be available to other users or facilities within the global ecosystems [12].
Moreover, within the FabLab initiative, the openness concept is practiced by providing access to tools, and also to products, designs and processes. Therefore, stimulating learning and development through the transference of knowledge, designs, and processes within the global ecosystems [2].

Growth Rate of Fablab

Since the inception of FabLab, the initiative have been duplicated throughout the globe at an exponential rate. In addition, some literatures on the FabLab initiative purported that the numbers of FabLabs doubles every 18 months [13, 14], whose assertiveness we aim to verify in this section.

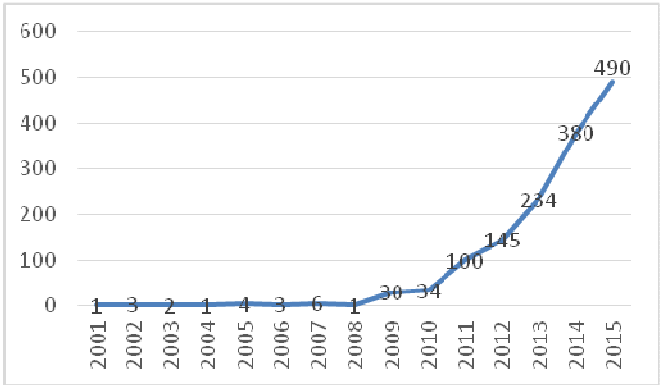

Fig 2 S-curve growth pattern of FabLab

Fig. 2 above illustrates the growth pattern of the FabLab initiative. After its commencement in 2001, the growth rate of the initiative was in the embryonic stage for 7 years. The surge in the growth rate of FabLab only started in 2009, this later increased by 13.33% to 34 FabLabs in 9 countries by 2010 [15]. These numbers further tripled from 34 to 100 in 2011, showing a percentage increase of 194%. This rose by 45% in 2012, 61.2% in 2013, 62.4% in 2014 and as of April 2015, there were 490 FabLabs workshops in 72 countries in the globe which is approximately 29% from the previous year's numbers.

Applying the growth pattern of FabLab to the technology S-curve, we discovered that the FabLab movement is still in its growth phase. The S-curve growth phase signifies that the knowledge about the initiative has accumulated and FabLab is now widely adopted [16]. Moreover, its stage in the growth phase should be further empirically analyzed. From this analysis, we verified that the statement about the doubly effects of the FabLab initiative every 18 months is bona fide.

Research Question and Methods

As indicated in earlier sections, the aim and objectives of this research study is to analyze the impact and contributions of the FabLab ecosystem to the sustainable development of the communities they are located, to explore how the impacts can be measured, and lastly, to uncover the constraints (if any) to the successful implementation of the initiative. We aim to explore these objectives by providing qualitative answers to the research questions given below:

Research Question 1: What are the impact of the FabLab ecosystem in the community to date?
Research Question 2: How can the impact of the FabLab ecosystem be measured?
Research Question 3: What are the impediments to the FabLab ecosystem?

For the purpose of this study, we motivate the utilization of a quantitative research method through the conduction of an online survey, aimed and directed at managers, volunteers, instructors, and administrators of the FabLab facilities in order to gather adequate information.

The online survey was designed and conducted in English, German, and French for approximately two months. In addition, the survey was structured in both open-ended and close-ended questions, which enabled us to gather qualitative information from the survey participants. In total, 94 (N=94) participants responded to the online survey globally, out of the 490 FabLabs in the ecosystem as at the period of the research. Which is slightly more than 19% of the population analyzed. Furthermore, a qualitative case study review method was also used during the research design process. The preceding section provides the analysis of the online survey conducted.

Survey Analysis

The survey analysis were divided into five (5) categories, so the analysis can provide adequate results in line with the goals and objectives of the FabLab movement. Furthermore, these categories are later grouped so as to provide the answers to the research questions posed in section 4 above.

Focus and Equipment

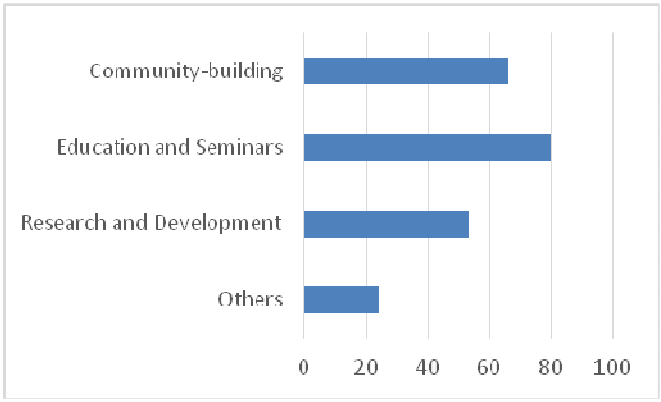

Fig 3 Focus of FabLab

According to Fig. 3, 66 respondents indicated their FabLab is focused on community-building, 80 indicated that they also their facilities to conduct educational seminars within, 53 indicated that they are more research oriented, finally, and lastly, 24 indicated they have additional objectives, some of which includes: to provide open and affordable access to machines and techniques that allows innovation and entrepreneurial flair to flourish, architecture, to create new businesses based on digital designs and digital fabrication, to execute cultural and creative applications through Fab Lab concepts, smart city projects, and fostering digital competencies.

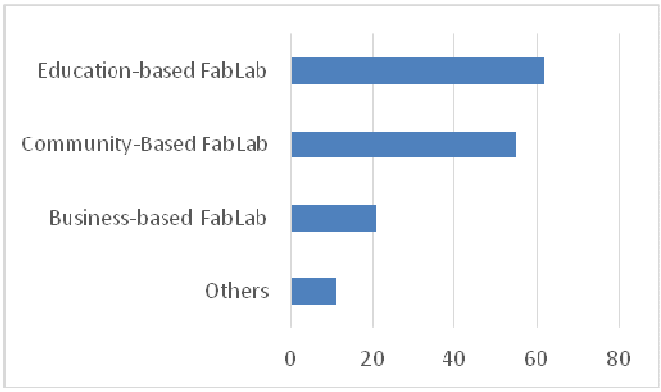

Fig 4 Description of FabLab

According to Fig. 4 above, 62 participants indicated that they are established within an educational institution, 55 indicated that they are located within a community, while 21 indicated that they are established within a business organization, while 11 indicated that they are situated within a city-council/municipal space, independent research facility, and a science center.

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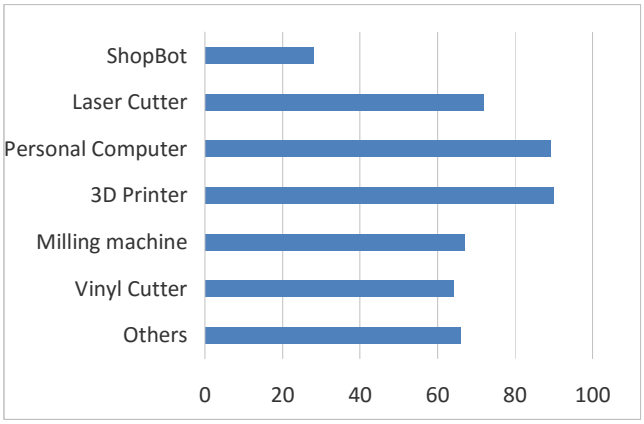

Fig 5 Types of equipment

As indicated in Fig. 5 above, 28 participants indicated they have ShopBot in their FabLab facility, 72 indicated laser cutters, 89 indicated computers, 90 indicated they have 3D printers, 67 indicated milling machines, 64 indicated vinyl cutters, while 66 indicated additional equipment not listed in the online survey. These equipment includes: Lathe machines, digital sewing machine, 3D Scanners, simulations software, CAD Arduino, Raspberry, UDOO, Annikken, Forrest CNC Router, materials for molding & casting, soldering irons, measuring equipment, Drill press, metal chop saw, vertical drilling machine, silkscreen printing, Oscilloscope, Graphics Design Workstation, Paintshop etc.

Accessibility

The aim of this category is to explore the accessibility of the FabLab facilities for an average user, which emphasizes the types of users, the numbers of weekly users, and the opening hours of the facilities.

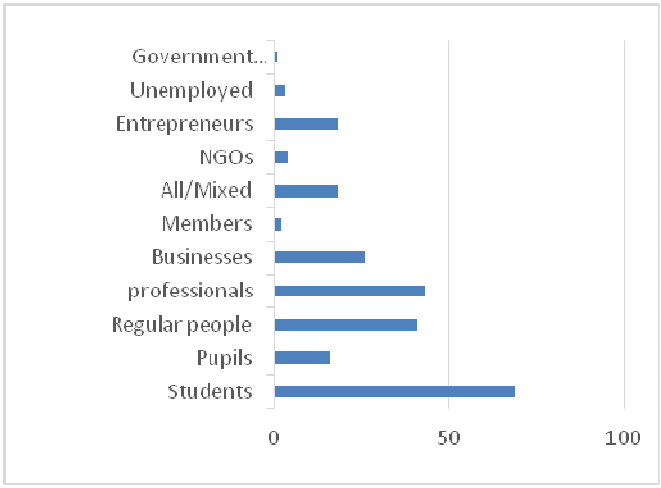

Fig 6 Types of users

According to Fig. 6 above, 69 participants indicated that the types of users that visits their facilities are students, 16 indicated pupils, 41 indicated regular people (which includes retired people, community members, freelancers, and tourists), 43 participants indicated professionals (which includes Software engineers, engineers, artists, designers, teachers, researchers, makers, etc), 26 indicated business organizations, 2 indicated that they are strictly for registered members, 18 indicated mixed visitors (which includes all types of users), 4 indicated non-governmental organizations (NGOs), 18 indicated entrepreneurs, 3 indicated unemployed, and lastly, 1 respondent indicated government organization.

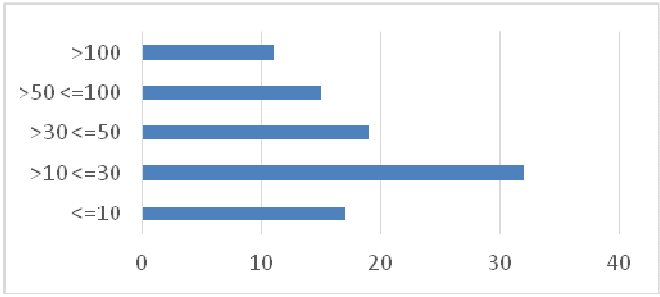

Fig 7 Numbers of weekly users

According to Fig. 7, 17 respondents indicated they have 10 or lower visitors weekly, 32 indicated they have from 10 to 30 visitors weekly, 19 indicated they have from 30 to 50 visitors weekly, while 15 indicated that they have from 50 to 100 visitors weekly, and lastly, 11 respondents indicated that they have above 100 visitors weekly.

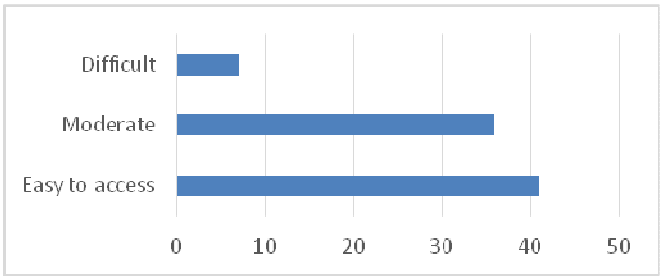

Fig 8 Accessibility of FabLab

In terms of the accessibility of the FabLab facility (Fig. 8 above), 41 respondent indicated that their facility is easily accessible for most visitors, while 36 indicated that their workshop can be accessed by public transportations (that is, buses, trams, and metro rails), and finally, 7 specifically indicated that their facility is a little complicated to access, either due to the lack of public transportations or the distance between their facilities and the communities.

Collaboration

The FabLab ecosystem is a global network of local FabLabs, which shares inventory of core capabilities. Therefore, in order for any facilities to be referred to as FabLab, there needs to be collective participation and willingness to share and collaborate with other workshop on the global FabLab network. This category looks at the state of collaboration between the FabLabs, and lastly stating the suggestions made by the participants on how collaborations within the network can be effectively enhanced.

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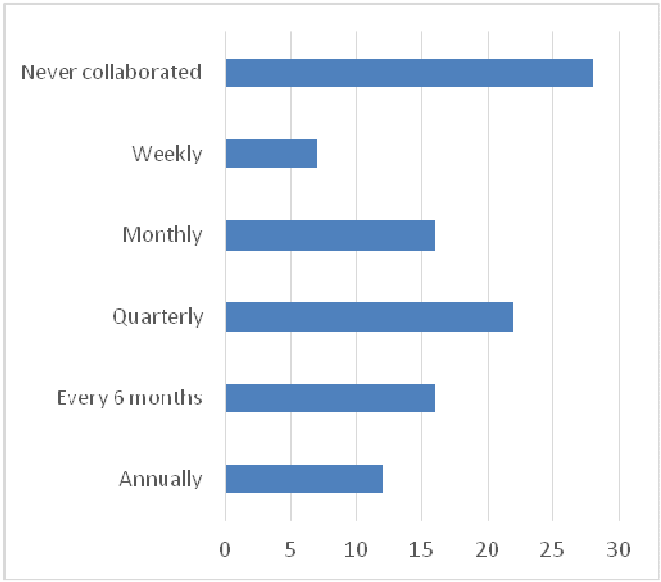

Fig 9 Collaboration within FabLabs

According to Fig. 9, more than 70% of the respondents indicated that they have collaborated with other FabLab. 12 respondents indicated that they do collaborate with other FabLabs on an annual basis, while 16 indicated that they collaborate every 6 months, 22 indicated that they collaborate quarterly, while 16 respondents indicated that they collaborate monthly, 7 participants indicated that they collaborate weekly, while 28 respondents indicated that they have never collaborated with other FabLabs, either due to their stringent work schedule, the novelty of their FabLab facility, lack of technological capabilities, and the lack of standardized approach towards collaboration.

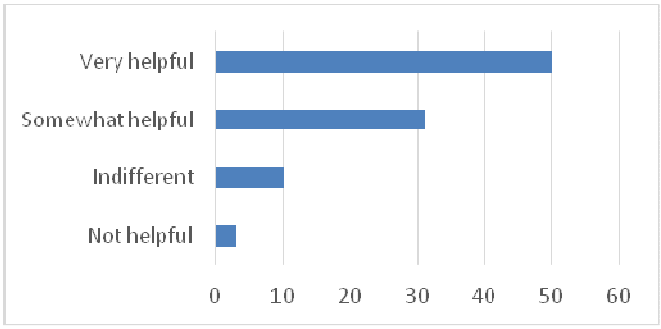

Fig 10 Importance of FabLab

From the survey, we gathered the importance and ease of collaboration within the network. According to Fig. 10 above, 50 respondents indicated that collaborating with other FabLabs has been very helpful, while 31 respondents indicated that collaborating with other facilities was somewhat helpful, while 10 respondents indicated that collaborating was neither helpful nor unhelpful, lastly, 3 respondents indicated that collaborating with other FabLab facilities was not helpful.

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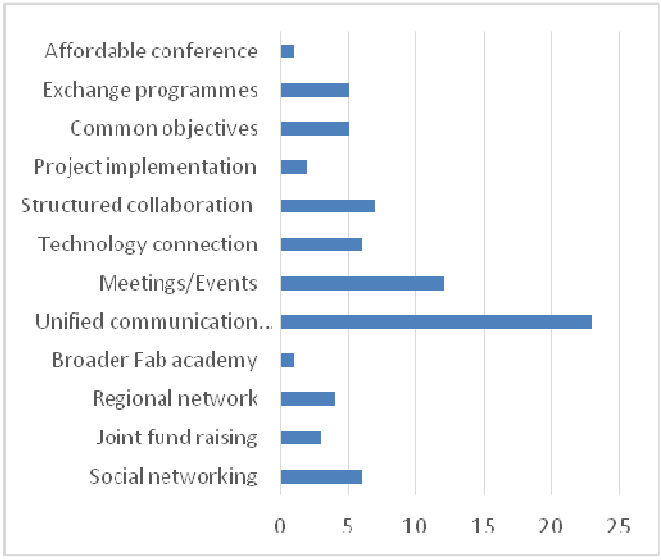

Fig 11 Suggestions on how collaboration can be strengthened

Finally, Fig. 11 above provides suggestions on how collaboration between FabLabs can be effective. Among all the suggestions raised, 23 respondents identified the need for a unified communication platform within the FabLab network to aid content and information sharing, and to also eliminate the confusion caused by dispersed information by different online platforms.

12 respondents indicated that there is a need for more regular meetings and joint events within the network, so relationship and joint focal area can be established. 6 suggested the need for a better technology connection within the network, while 7 suggested having a standardized and structured collaboration channel, 5 respondents suggested having a common objectives within the FabLab network, another 5 suggested promoting exchange programmes and field trips within the network, where volunteers and team members can be shared with other facilities.

4 participants indicated the need for a regional network to promote synergy among actors in the network, to oversee the basic affairs of the FabLab initiative, facilitating the distribution of information and formulation of a structured approach to enhance communication. 3 respondents suggested encouraging a collaborating funding opportunities, 6 suggested the effective utilization of the social media platform. Lastly, the remaining participants suggested having a broader fab academy that teaches anything, making the conferences more affordable, and a move into the project implementation phase rather than just deliberating.

Sustainability

The productivity and longevity of any empowerment initiative is solely dependent on the efficacy of the sustainability plan implemented. According to a survey conducted by Boeck and Troxley [17], the goals of sustainability are to balance dependency on grants, educational and government funding with growth in self-sustained funding, to nurture the Fab ecosystem with products, services and entrepreneurial enterprises, shared across the network of FabLabs worldwide. The aim of this category is to uncover the mode of operation of the facilities respectively, it also uncovers how the FabLab facilities have been sustained since inception, and lastly identifies some impediments to the FabLab facilities.

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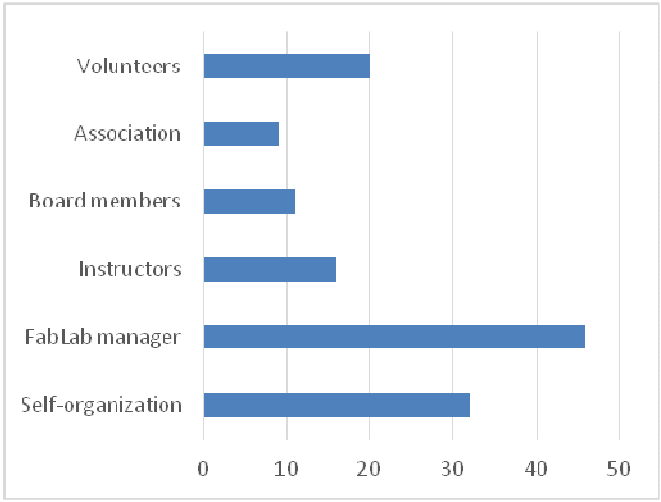

Fig 12 Mode of operation

From Fig. 12 above, 20 survey respondents indicated that they operate with the assistance of volunteering enthusiasts, while 9 respondents indicated that they function as an association, 11 respondents indicated that their functionality is dependent on their board members or board of directors, while 16 respondents indicated that they function by using instructors or advisors, 46 participants indicated that they have one or more managers in charge of their facilities, and finally, 32 indicated that the operate by self-organization.

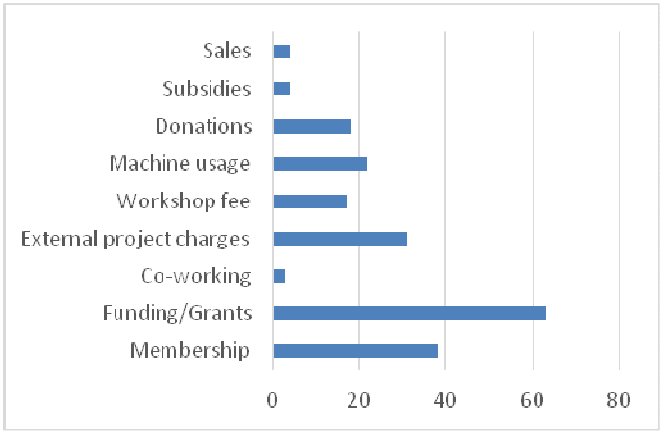

Fig 13 Sustainability of FabLab

Fig. 13 above uncovers the means the responding FabLabs use in ensuring the annual operation of their facilities. From the illustration, 4 respondents indicated they are sustained by selling the products produced within their workshop, such as 3D printers and filaments, open source technologies, and awards and plaques etc. another 4 respondents indicated they are sustained by subsidies from external business organizations and partners.
While 18 respondents indicated that they also use donations from the community, businesses, and government organizations. 22 respondents indicated they charge users certain fees for using their machineries and equipment, 17 indicated that they charge for the workshop organized within their facilities, while 31 respondents indicated that their workshop is sustained by the external project done for corporate business, such as construction of prototypes. 63 respondents indicated that they use funding and grants from government and other sponsors, lastly, while 38 indicated that they charge their members certain amount for sustaining their workshops.

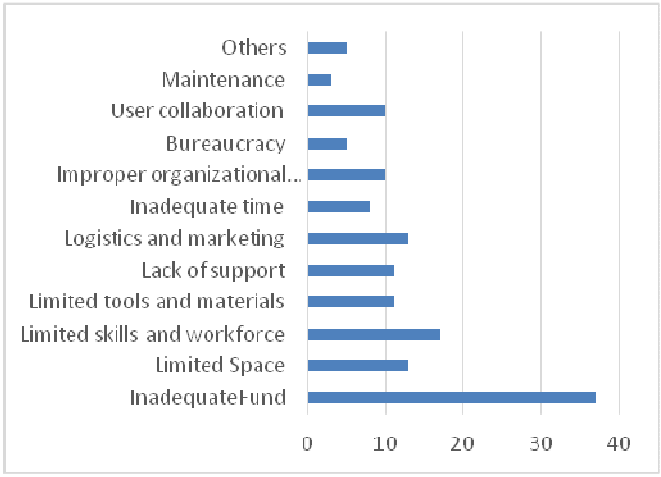

Fig 14 Identified impediments to FabLabs sustainability

Fig. 14 shows the impediments identified by the survey respondents, as expected, more respondents (37) indicated the shortage or lack of funds as the major constraint to their workshop, while some (13 respondents) indicated limited space, either because they have outgrown their present location or the lack of private office, or storage space etc. 17 respondents indicated shortage of skillful workforce and volunteers, 11 indicated inadequate tools and production materials, another 11 indicated lack of buy-ins and support from government and also from the community they are located in.

13 respondents indicated logistic and marketing constraints, 8 indicated inadequate time due to their employment status, which affects their productivity and opening hours. 10 respondents indicated the improper organizational structure used within the FabLab network (that is, the lack of standardized business model and work ethics), 5 indicated indicate institutional bureaucracy as a constraints, while another 10 respondents indicated the lack of user collaboration, while some indicated high cost of maintenance, competitions with other well established business organization, novelty of their workshop, and budget restrictions.

Achievements

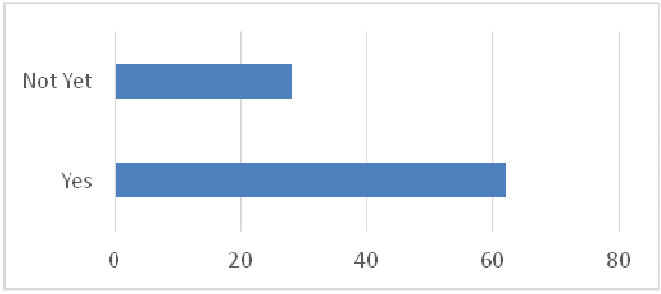

Fig 15 Success of FabLab

According to Fig. 15 above, when asked whether their facility has been successful in their locale, 62 respondents indicated that their facilities has been highly successful, some of these success ranges from the recorded impact the facilities have in the community, to the higher demand from users, to the successful construction and maintenance of the facility with limited start-up funds, to the massive contribution towards STEM (science, technology, engineering, and mathematics), the start-ups of different entrepreneurial vocations, the consultation of external organizations seeking the expertise of the facilities for prototyping and other projects, and the development of innovative in-house products.

While 28 respondents indicated that their facility is yet to record any marginal success, some of which are due to the novelty of their facilities, the irregularities in user participation due to the distance between their facility and the city, lack of awareness of the FabLab initiative, to the lack of space due to lack of support from the local government, to the organizational restrictions on their mode of operation, to the lack of knowledge in the required

field of competence, to the insufficient funds, tools and materials, to the high cost of maintenance, and the lack of a working business model.

Completed projects: In terms of the projects completed within the facilities, we gathered a total of 90 responses, and approximately 93% (84) of the respondents indicated that they have worked on one or more basic or complex innovative projects, some of which include the following:
Online student mentorship, FabLab Kids, Cranial implants, city public furniture, 3D printed flying drones, wireless general purpose sensor aggregation, bus clock, gardening (automated device to monitor and correct greenhouse condition), recycling / reusing old electronics, nautical projects (submarine drone, sail repairs), Educational/research robots, automotive harness design, Flat pack furniture, Robotics competitions, art projects, interactive glasses, FabLab in the city competition, keyboard and kayak kit for a person with a disability etc. While majority of the remaining respondents indicated the newness of their facility as the reason for not having any completed projects.

Entrepreneurship opportunities: Part of the objectives of a basic FabLab is to serve as a business incubation facilities. Therefore, the goal of this section is to ascertain if the responding workshops have accomplished this objective, and to also unveil the ways at which they accomplished this objective. For this section, we gathered a total number of 91 responses.
From the analysis of the survey, approximately 70% (64) of the respondents indicated that there has been at least one business start-up from their FabLab workshop. Also, some of the respondents indicated that they have been of immense assistance to start-ups from almost all economic sectors. While the remaining 30% (27 respondents) indicated that their facilities has not contributed to the development of any entrepreneurial activities.

Discussions

Focus and Equipment

Analyzing the information given in this subcategory reveals that most of the FabLab workshops are in line with paragraph 1 and 2 of the fab charter [2], [12], in providing a well-equipped facility that enables invention by providing access to digital fabrication tools, and also by providing operational, educational, and technical within their facilities.
Moreover, according to Fig. 3, there are more FabLab focused on educating and providing workshop seminars for users, followed by community-building, and R&D. Also, Fig. 4 shows that more FabLabs are situated within an educational facility and communal space. Based on this finding, it is evident that the FabLab initiative intangibly contribute to the human developmental attributes (such as science, technology, engineering, arts, and mathematics (STEAM)), thereby enriching the factors that promotes innovation, and sustainable value creation as a whole.

Accessibility

From the information presented in this category, we observed that most of the users that interacts with the FabLab facilities are mostly students, professionals, regular people, and business organizations (Fig. 6), this was further corroborated by the high frequency of the age groups 21 and above (Fig. 7).
In terms of meeting the accessibility section of the Fab charter (Fig. 8), over 90% of the respondents indicated that their facilities are either easily or moderately accessible for users/visitors alike, and over 50% of the respondents indicated that they are either opened daily or weekdays. Therefore, it can be stipulated that the FabLabs facilities offers adequate access to the populace.

Collaboration

Van der Hijden & Juarez [12] stated in their report that collaboration within the Fab ecosystems can be effectively sustained if there are bidirectional contributions between one or more FabLabs. Based on this statement and the information gathered, it can be stipulated that the present FabLab initiative meets its collaboration objective, though there is a great need for cohesion between the FabLab networks. Moreover, one evident pattern discovered from the survey is that most respondents feel collaboration is solely dependent on their nearness to other FabLab facilities.
One of the effective ways to implement synergy and cohesion within the Fab ecosystems is by establishing a structured regional organization that coordinates, controls, monitors, and facilitate collaboration of innovative ideas and adequate distribution of information and resources within the network. In addition, the creation of a structured communication platform should be elaborated.
Also, the lack of a standardized method of operation for the workshops within the FabLab Network should be focused on. As uncovered from the analysis, though most respondents indicated that they have collaborated, and that they find it helpful, the lack of a standardized method still poses as a barrier in encapsulating the full potentials of collaboration.

Sustainability

From the information presented in the analysis, it is pertinent that the sustainability of the FabLab is reliant on the development of a schematic business model that serves as a guide for both new and existing workshops within the global FabLab network, which is also partly dependent on the development of a unified communication channel, and the formalization or expansion of the existing structure used within the FabLab ecosystem.
By having a formal structure and unified communication platform, information can be effectively distributed within the actors in the ecosystem, information such as how to make the FabLab sustainable (Fig. 13), also it would be useful in creating more awareness of the FabLab initiative, thereby eliminating the identified impediments (Fig. 14). Also, it would also encourage the influx of external researches on additional developmental areas that ensures the sustainability and global effectiveness of the initiative.

Achievements

Reviewing the information presented in this section indicates that, in certain forms the FabLab initiative is contributing to the empowerment capacity/human development capabilities, and technological capabilities of the environment it is established. Though the facilities indicated huge success and creation of entrepreneurial opportunities, just as stated in previous categories, there is an urgent need for the development of a standardized structure which existing and new facilities can use in developing a formidable workshop, thereby maximizing the potentialities of the FabLab initiative.

Impact of FabLab Ecosystem

Reviewing the achievements, collaboration, tools and equipment, and the accessibility categories of the survey analysis and prior discussions, it was observed that the FabLab ecosystem does have an imperative significance in ensuring sustainability of the community space. However, it is worth noting that the scale of production within the FabLab ecosystem is small, when compared to traditional top-down oriented economic production. Howbeit, the FabLab ecosystem which is structured on the bottom-up economic approach possesses a cumulative advantage over the conservative import/export-oriented consumerism approach.
This can be affirmed by the identified creation of various latent and innovative artefacts, which would have otherwise been undeveloped with the top-down approach. Also, we identified that the FabLab ecosystem can be applied in almost any community, irrespective of the geographic location and the economic status of the community. Especially in the context of developing economies, the significance of the initiative can be identified by the development of adequate alternative technologies.

Measuring the impact of FabLab

Burgelman & Maidique [18] defined success as the achievement of something desired, planned, or attempted. Based on this definition, being a successful organization is more than the financial income accumulated, though financial returns is one of the key determinants of success. From this explanation, we outline that the success of an initiative is dependent on the accomplishment of their desired, planned, and attempted objectives. Also we structured the determinant of the FabLab success around the accomplishments of the Fab Charter [2].
As highlighted above, there are no specific ways in which a successful social digital fabrication initiative can be quantified, but for the aim of the research, the following factors were used as the determinants of FabLabs success:
[1] Contribution to innovations and R&D;
[2] Contribution to human development (i.e. in empowering people);
[3] Achievement of its goals and objectives;
[4] Types of users
[5] Contributions to entrepreneurship and business development;
[6] Accessibility for users;
[7] Sustainability;
[8] Collaboration within the FabLab network;
[9] Usage frequency;
[10] Availability of raw materials

Impediments to the FabLab Ecosystem

From the survey analysis, we identified some constraints experienced within the FabLab ecosystem, out of which the lack of a unified communication platform, insufficient funds, limited human and material resources, logistics and marketing issues, and unstructured operation and business model barriers were more rampant.

Conclusion and Recommendation

The present overall impact of the FabLab initiative is tremendous, with its usefulness cutting across different economic sectors, from the agriculture sector, energy sector, and to the health sector etc. Though the lack of a formalized structure, the lack of well-developed unified communication platform, and pending issues such as the development of a sustainable business model impedes the broad effectiveness of the initiative.

Mikhak et al [6] stated that support will be provided within the Fab ecosystem through collaboration between the FabLabs via Think Cycle and the FabLab website. However, the Think Cycle seems to be out of service, and also from further literature survey, we gathered that the global FabLab foundation initiative indeed have developed or are developing other forums to assist in attending to the pending issues or challenges encountered by an average FabLab facility, forums such as Knowledge Exchange, Fab Share, Fab Economy, Fab Connect, and the Fab Markets.
The discovery while reviewing these support platforms are that some of these platforms are either under-developed or still under construction, while the awareness of the well-developed ones are either unknown or not properly publicized within the Fab ecosystems. Therefore it is an important venture for the global FabLab systems to devise plans in bringing these platforms to the knowledge of the individual networks within the ecosystems.
From the literature and survey analysis, it can be gathered that the global FabLab system should endeavor to develop a formalized organizational structure and method which governs the affairs of the nodes within the FabLab ecosystems. Therefore, we recommend the broad promotion and development of a formidable regional network, like the United States Fab Lab Network (USFLN). Testaments from the USFLN shows the potential significance of having such regional networks, these includes: providing assistance for new FabLab start-ups, adequate networking and communication for idea and information exchange, national and international visibility of each facilities, and building credibility in terms of marketing and funding [19].

Also, according to our survey analysis, most respondents indicated an urgent need for a unified communication platform to aid easy distribution of information, knowledge, establishing and creating collaborative network, and also serve as unique information database which pools together existing scattered and conflicting information about the FabLab initiative.

In summary, from the literatures, case studies reviewed, and the research survey conducted. We therefore conclude that the FabLab initiative could be of great significance in ensuring the innovative and sustainable development of communities both in the developed and developing countries, and it also possess an economic significance in facilitating entrepreneurial endeavors. Therefore, FabLab and other digital/personal fabrication initiatives are unique avenues in facilitating adequate value creation.

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