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1.3 Interdisciplinary planning of sustainable value creation modules with low income communities in developing countries

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Abstract
Value creation activities are normally considered to take place in relatively well developed areas of most countries. This is especially true when referring to developing countries where income generation possibilities are normally reserved to urban centers with adequate infrastructure, access to supply chain networks and trained human resources. In order to level quality of life and social conditions of low income rural and urban communities to the regional prosperous areas, opportunities to create local economic development have to be generated. A way to contribute towards the achievement of this end is the generation of sustainable local value creation modules. To achieve this, the integration of several knowledge areas is most of the times necessary in order to secure a smooth implementation in the field increasing thus its success chances. This contribution proposes a method to construct interdisciplinary teams capable of define, develop and conduct projects intending the implementation of value creation modules in economically disadvantaged communities in developing countries.

Keywords:
Value creation modules, interdisciplinary teams, developing countries, capacity building

1 INTRODUCTION

Global community is nowadays a reality. Accordingly to Gurría (2013), developed and developing nations, North and South hemispheres became so interdependent that sustainable development goals, poverty and human development agenda are ubiquitous [1].

Since sustainable development entered the global agenda in the nineties, important results were achieved. Poverty has declined and in 2013 there are 620 million fewer extremely poor people in the world today than in 1990 [1]. Brazil, Bangladesh and Mexico pioneered innovative approaches to target poor households, like the Brazilian Program *Minha Casa, Minha Vida*, which has benefited more than 3.2 million people between 2009 and 2011 [2]. Improvements in health conditions, social protection, food security and school enrolment are also reported (World Development Indicators, 2013) [3]. However, great efforts against poverty are still necessary. According to World Bank estimates globally there are about 4.2 billion people living on less than 5 dollars a day, while the situation is even worse in some parts of the globe. In Sub-Saharan Africa for instance, almost half of the population still lives on less than $1.25 a day. The situation is also reflected by some other figures: close to 2.4 billion people around the world lack proper sanitation facilities and 1.1 billion people lack a safe source of drinking water. Low income and its associated substandard life conditions are related to lack of good quality jobs or rent generation opportunities. For example, in Africa, the unemployment rate reaches 40% in Kenia and 48% in Senegal Poor distribution of wealth makes the poverty situation even worse in some nations. Data from OECD (2011) show that in Chile, the richest 10% of the population have incomes 27 times those of the poorest 10%; while in Brazil this ratio stands at 50 to 1 [4]. Finally, the efforts against poverty are hampered by climate change. According to the United Nations Human Development Report (2013), the number of people living in extreme poverty could increase by up to 3 billion by 2050 unless urgent action is taken to tackle environmental challenges [5].

Therefore, it can be considered that poverty reduction is still an enormous challenge for all the humanity and that we need innovative approaches to face it.

2 VALUE CREATION MODULES

2.1 Motivation

In what is without a doubt a very simplistic economic categorization of the global community, countries are divided in two groups: developed or more developed countries (MDCs) and developing or less-developed countries (LDCs). There are still no absolute criteria to determine the belonging of a country to one group or the other, but it is generally accepted that the first group is composed by countries that present high Human Development Indexes (HDI) and possess a highly developed economy and technological infrastructure. The LDCs in turn, are countries which evidence lower levels in socioeconomic indicators such as the HDI and lack the technology levels of the MDCs. According to the International Statistical Institute (ISI), today there are 144 LDCs in the world, 18 are localized in Latin American and Caribbean and 54 are African states [6].

Regardless obvious differences still existing between the two economic blocks, especially concerning the quality of life and socioeconomic development possibilities, globalization has made possible in the last decades to reduce the breach. According to United Nations Development Program (UNDP), in the last decade, most LDCs accelerated their achievements in education, health and income generation possibilities. By 2020, the combined economic output of the

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three leading developing countries, Brazil, China and India, is expected to surpass the growth of Canada, France, Germany, Italy, United Kingdom and United States [7].

This prosperity however, is benefiting only a limited percentage of the population in the LDCs. In the case of Latin American and Caribbean and according to the Inter-American Development Bank (IDB) every third family lives in a structurally unstable building, constructed with low quality materials and lacking basic services [8].

When it comes to income generation possibilities, the international labor organization reports that the informal sector has gained increasing acceptance in Latin America. Some 30 million persons now work outside the modern economy in low-productivity jobs with marginal incomes; many of them living in poverty [9]. This situation is especially worrisome in rural and marginated urban settlements where the lack of development opportunities, edge the community members to migrate to densely populated but wealthier urban areas.

The concept of sustainable manufacturing refers to the concept of local Value Creation Modules (VCMs) and the generation of regional VCM networks as a mean to decentralize economic development and trigger communities' wellbeing through the rational exploitation of local material and human resources.

According to Seliger, every VCM consists of five main factors, namely: product, process, organization, equipment and human. In modern sustainable societies, each one of these factors are to be oriented towards the generation of value, where value should be understood not only as economical but also environmental and social [10].

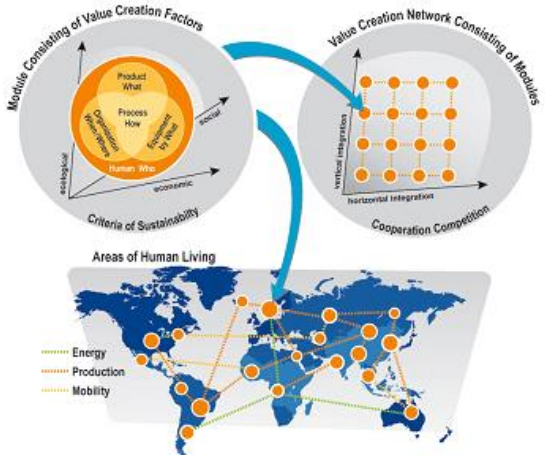

Fig. 1 Factors present in value creation modules and networks [10]

Considering the context of a low income community in a developing country, a VCM can be structured as a set of low to mid-tech value adding processes, usually limited to a few tens of square meters of confined space and producing finished or semi-finished products for the local or regional consumption. These modules have the potential to be part of elaborated value creation networks or act as independent decentralized productive units with local suppliers and customers.

Similar to many activities undergone by modern societies, the planning, development and operation of a VCM requires in most cases, participation of groups of people, commonly known as teams, with a full set of complementary skills to complete a series of specific tasks throughout each one of the project's planning and realization phases. Depending of the complexity and variables of the project, including size, environment, end product or service and infrastructure, involvement of interdisciplinary teams becomes a determinant key to achieve not only implementation success during the development phases but also economic success during its operative life.

These interdisciplinary teams are defined as a coordinated group of experts from different fields who work together towards a unique common goal. Team members operate with a high degree of interdependence, share authority and responsibility for self-management, are accountable for the collective performance, and work toward a common goal and shared rewards [11].

In this sense, this contribution has the goal to present an interdisciplinary initiative to design Sustainable Value Creation Modules for low income communities in developing countries.

The method utilized is the result of several multidisciplinary projects and project oriented teaching activities conducted by the department of machine tools and factory management of the Technical University Berlin (TUB) in collaboration with internationally renowned universities in Africa and Latin America such as the Stellenbosch University, South Africa (SU), the Universidade do São Paulo, Brazil (USP), the Universidade Federal do Espírito Santo, Brazil (UFES) and the Pontifícia Universidad Católica de Chile, Chile (PUC).

This contribution will focus therefore on the activities concerning the planning and realization phases of the VCM as an autonomous entity in a low income area. These activities include, but are not limited to; project scope, project management, value creation processes' design, factory planning and layout, capacity planning, machine tool selection, supply chain design, community integration and sustainability assessment.

2.2 Value Creation Factors

As mentioned previously, every VCM is assumed to consist of five basic factors which are shaped according to the user's requirements or "voice of the customer". These factors have special considerations when it comes to drive sustainable development of low income communities

2.2.1 Process and Equipment

Processes that have to be performed in VCMs can be regarded as manifold. Reichwald et al. states the following processes, VCMs generally have to cover in the operative level [12]:

- Admittance of customer preference or in case of low income communities, customer's necessities and raw materials available
- Translation of the customer preference into customer individual product characteristic,
- Individual production of the desired product,
- Distribution of the product. The community in this case support the VCM whilst the utilization phase and initialization of the rebuy.

In contrast to this, Zäh and Aull define the following main activities in dependence on Porter's value chain [13], [14]:

- Product definition,

- inbound logistics,
- internal logistics,
- manufacturing and assembly,
- external logistics

Machine tools on the other hand are normally tailor-made solutions, usually manufactured by local producers, members of the community or involved stakeholders

2.2.2 Product

Having a deeper look at the core activity of value creation, the manufacturing and assembly, a variety of examples are available that illustrates the production process within VCMs. Postawa et al. (2009) introduces a disassembly process for printed circuit boards (PCB) performed by a value creation network in Brazil. After the separation of electronic devices by help of adjusted manual aids at a manual workstation, reusable units are tested and sorted either into units being inserted into a solar oven or units sold to a refinery. Solder is then removed and components are separated from the resin-board. By help of a manual driven centrifuge, components of the PCB will be removed. The solder is collected extra while the remaining components are grouped by specific categories on different stocks to be sold to a refinery or industry. [15].

Postawa et al. (2011) proposes a VCM to produce cocoa paste. After the breaking of the harvested and dried cocoa beans, a sorting, roasting and grinding of these beans is performed to receive the final product of cocoa paste [16].

Hu and Seliger (2012) introduces in their contribution a further process related to Collaborative Research Centre 1026: “Teaching and training”. Hereby the VCM is regarded as a “Learnstrument”. [17]

2.2.3 Organization Human

The type of business model of a VCM determines not only the source of income but also determines profit utilization of the enterprise. Depending on the focus of profit utilization, a VCM can be categorized as follows: Profit-maximizing companies create shareholder value as an ultimate goal. Non-profit organizations create social value instead by consuming investment from donors. Social businesses create social value too, but aim at achieving at least self-sustainability as a result of their activity.

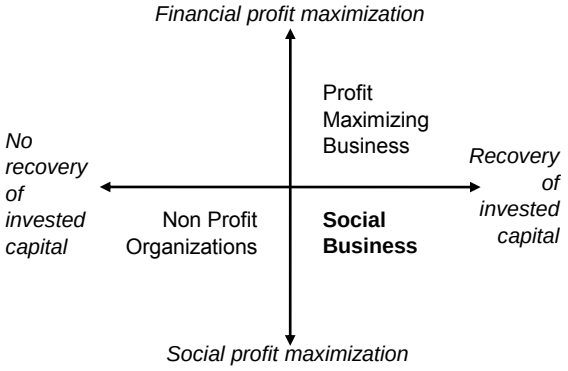

Figure 2: Classification of Social Business [18]

Main goal of traditional business models is to sustain an economic value. The other components of sustainability, namely the ecological and social development are not considered as essential by top managers in traditional for-profit companies [19]. As the necessary equilibrium between these dimensions is challenged in a large majority of ventures, there is a need to balance social, economic and environmental aspects by reforming the logic of individual profit maximization [20].

The design of value creation modules in a specific community of a designed country is closest to the definition of “social bricoleur” classification. The action is specifically tailored to address a well-defined and local issue. The aim is to enable local entrepreneurs to fulfill locally discovered needs of the community with locally available resources. The business model is not intended to be replicated at a large scale and the activities developed are a competitive alternative to the ones of existing private companies.

One possibility to model a business is to define the classic three components:

1. Value proposition of the product or service offered to the final consumers,
2. Value chain composition to ensure durability of the supply and distribution of the products through the sustainability of the local partners of the venture,
3. Revenue model, to indicate how the company will cover its fixed costs and to anticipate the development strategy.

A social business has a social objective. This requires introduction of a fourth component:

4. Social benefits tracking, to measure the effects of the social venture on the local stakeholders, such as employees, customers and suppliers.

3 INTERDISCIPLINARY PLANNING OF VCM

3.1 Academic background

In most MDCs and many LDCs, universities have acted in recent years as driving entities and spearhead of the implementation of sustainable manufacturing concepts in the national production areas, weather through the education of professionals and technicians who will act as practitioners of the methods in the future or, through direct intervention and collaboration with the communities, governmental bodies, industry or relevant stakeholders. In some cases, as the ones described next, a combination of both methods is also possible by means of the development of innovative project oriented teaching programs.

“Engineers without Borders–USA” (EWB), formed in Boulder, Colorado, developed a result-oriented strategic planning of help to poor communities around the world while developing internationally responsible engineering staff [21]. The staff is mixed between permanent board of directors and project managers, centralizing the information for partners universities located in the USA and referred to as “chapters”. Each chapter acts as an independent structure and organizes its own resources.

“Engineers for a Sustainable World” (ESW) uses the same principle of a centralized organization working together with affiliate partners, run independently by local leaders. However, distinction is made between collegial and professional chapters to allow the inclusion of private organizations in the projects led in communities. The collegial partners are encouraged to include the project solving activities in the curricula of students or even develop courses

on the application of sustainable engineering. Local organizations' leaders share monthly on their achievement and the national board initiates the information sharing activities [22]. Similar approach is retrieved in the Engineers in Technical, Humanitarian Opportunities of Service Learning (ETHOS) program focused on the capacity building in the poorest communities.

The Technische Universität Berlin (TUB) has also long experience in the development and management of project-based international student activities. Such programs started in 2002 in the field of production engineering, with the Global Product Development (GPD) course [23]. The GPD course was held until 2008 and gathered students from three universities: Seoul National University (Korea), University of Michigan in Ann Arbor (USA) and TUB (Germany). The primary objective of GPD was to effect systematic knowledge transfer of method and societal competencies by using extensive case studies. Internet lectures were delivered by the teaching staff of the cooperating universities and students recruited from the universities developed prototypes of globally marketable products. Two face-to-face meetings of participants held early and late in the term, supplemented the virtual meetings.

The GPD initiative served as a precursor for further projects, Global Engineering Teams (GET) is an international, multicultural team- based approach at solving practical engineering problems originating in companies. GET groups is led in virtual and international students' teams. The initiative fosters teamwork and digital collaboration among students with different technical and cultural backgrounds, and is providing a unique by opportunity for students to manage concrete industry challenges. GET has three main objectives:

1. Solving engineering tasks in international groups
2. Using interdisciplinary project-oriented and practical best practices
3. Considering engineering tasks holistically to promote global sustainability

The latest of collaborative international capacity building programs of the TUB, is the Housing – Manufacturing – Water project (HMW). HMW was born in 2009 as a collaboration initiative between the Technische Universität Berlin (TUB) and six partner universities in Africa, Latin America and India. Since its inception, HMW pursued the integration of multidisciplinary knowledge fields into yearly common learning projects and workshops where urban design planers as well as manufacturing and water engineers cooperate in proposing adequate strategies for the achievement of UN's Millennium Development Goals, especially those referring to the development of sustainable housing areas, supply of drinking water and generation of income sources. The HMW Project has simultaneously the objective to build capacity in the implementation areas together with its local partners; this is achieved through seminars and lectures for the next generation of professionals and the training of community members.

The HMW project has lately served as platform to develop further the planning methodology to develop VCM through interdisciplinary teams presented in this contribution.

3.2 Proposed Method

The starting point to define a project on VCM for low income communities is to change the preposition "for" to the preposition "with". This change impacts the whole process because the researchers accept they don't have enough knowledge about the low income communities' reality necessary to perceive the value creation possibilities that exist in their environment.

The interaction must be personal and close which means: Identify local people who are interested in promoting local development and became themselves stakeholders. They can be local community leaders or social entrepreneurs that act individually or through NGOs, for example, in the community.

The core team of researchers and implementers conduct following initial activities:

1) Conduct visits to the community sites, interviews and group activities with community stakeholders based on predetermined templates as the Business Model Canvas. Objective is to determine what kind of "value delivery" the community perceive and to whom they think it is possible to delivery such "value", meaning, the customer identification.

2) Roughly define the concept of "business" that can be developed with such preliminary information.

3) Bring together the community stakeholders with representatives of the possible "clients" and other intermediate agents in the business production chain. They become market stakeholders (or enterprises stakeholders). Experts in the specific field are also invited. Altogether, they discuss the value creation proposition and refine the concept of the "business" that the VCM must accomplish.

4) At this point, the academic team formulates a proposition of VCM (a power point slide may be enough). This proposition is then presented to all the stakeholders and, if approved, it is turned into a VCM project. The main requirements of the VCM in terms of end product to be produced, overall production goals, and implementation site are defined by all the involved parties who sign documents that will guide the project development phase.

5) The interaction with all the stakeholders is kept alive during the development phase through regular meetings to evaluate if the project is addressing the stakeholders expectations.

Once the VCM and its goals are defined, the integration of an interdisciplinary team commences by identifying concrete knowledge areas required to conduct and realize the tasks deemed as necessary for the realization of the objectives of the VCM. Experts of the identified knowledge fields, usually academics, industry representatives and NGO members, are then contacted and presented with the project, its overall scope, areas of direct impact, expected contribution and the involved stakeholders. Finally the interdisciplinary team is formed and subdivided in sub teams according to synergy demands and interdependency necessities.

A standard working group formed to plan VCMs would include at least following sub-teams: Project management,

business model and community integration, product development and process design and machine tool design.

The project management group would be in charge of define the scope of the project, set up a timeline, define deliverables by interpreting the voice of the customer (stakeholders) and create the internal communication channels between the sub teams and between the sub teams and the stakeholders. The tasks of the project management team include as well the monitoring of the project throughout its realization and if necessary conduct modifications to the plan after consultation with the stakeholders.

The deliverables expected from the business team can be classified in three main categories. First an analysis of the current market environment is established as well as the potentials for a new entrant in this domain. Based on observations from the potential customers, this part ensures that the technical solution delivered will have excellent integration chances with regard of stakeholders' expectations. Secondly, several concepts suggestions will be deduced from the market analysis. The best concept will be selected for its influence on an agreed criteria list. It will allow the creation of specifications to be respected from the product and process development teams. A last deliverable category will aim at identifying major recommendations for the implementation phase of the selected concept, such as a detailed activities planning and financial projections. The principle of co-creation will be respected all along the project realization thanks to the contact with community leaders through the stakeholder network.

The process design team is expected to, primarily via systematic product design, define the physical output of the VCM, whether this would be a finished or semi-finished good. Common deliverables at this stage are market and raw material research, product's definition and prototypes and price definition. The second task of this team is the design of the value creation chains. To this stage, following deliverables are expected: site layout, value stream map, definition of necessary employee qualification, design of work places, legal framework, etc.

Finally, the machine tool design team will elaborate on the hardware requirements of the VCM in order to produce the goods defined by the process team. The team is responsible to report adequate production technologies to achieve the necessary value creation processes and determine suitability of the machine tools existing in the market. In case it is necessary, the team is also responsible to adapt existing technologies to the necessities of the VCM. This is to be done considering a closed loop lifecycle and the involvement of local producers.

A kickoff event, ideally at the implementation site within the community, serves usually as platform to set specific objectives per sub teams, a project timeframe, resource allocation per area, internal communication protocols and establishment of feedback channels with external stakeholders.

Experience has shown in our case that the biggest challenges are to be expected while interpreting the voice of the customer, means transforming the stakeholders' demands into specific work packages and/or deliverables, and also during the setup of communication and information's protocols between sub teams, where miscommunication or personal biases by individual team members slows or partially hinder delivery of integrated results. Resolution strategies like the one proposed by Behfar-Peterson [24] have been considered and utilized during our experience in the field but will not be discussed further in this contribution.

In the particular case of the projects realized by the TUB and its international partners, the expert teams are complemented with groups of graduate students of the relevant knowledge areas and members of the participant institutions, who participate directly in the planning phases of the project and conduct most of the operative and development tasks throughout the academic semester.

The involvement of graduate students pursues mainly two objectives; on the one hand, suitable solutions towards the achievement of the VCM's objective are provided by the student groups under close supervision of recognized experts, reducing thus development costs for the VCM without sacrificing quality in the results. On the other hand, the delegation of core responsibilities already during the planning and organization phases as well as direct participation during the execution and field work, provides the student with practical expertise through the conduction of project oriented activities complementing his/her theoretical knowledge in a way comparable to professional experiences.

The participation of international students as in the case of TUB's HMW and GET initiative, provides the project as well with a multicultural dimension which benefits not only the result of the implemented solution, through the integration of acclimatized methods and technologies and inclusion of objective perspectives, but also promotes the global dissemination of knowledge and acquired experience, achieving thus a multiplication effect.

Finally, once the final results per area are ready and integrated, a holistic proposal is presented to the local project stakeholders and community members. Since they have been continuously part of the project's development, few modifications can be expected. Further phases of the project, not part of the scope of this contribution, such as implementation and running, are then commenced.

4 CONCLUSIONS

Generation of decentralized VCMs as key driver to achieve sustainable development in low income communities of developing countries has been the motto of international development organizations and academics in the last decades. The department of machine tools and factory planning of the technical university Berlin, together with internationally renowned African and Latin American university partners, have developed vast knowledge in the integration of multidisciplinary teams in charge to set up income generation solutions in form of local value creation units in direct collaboration with the community and other relevant actors. The positive results of this symbiosis namely, improved success chances and community ownership of the project, have been confirmed by sociologist and technical experts alike. A methodology on how to integrate these interdisciplinary teams, based on the involvement of the community and the forming of student groups, has been presented in this contribution.

5 FURTHER DEVELOPMENTS

The above developed method has to be developed further based on new experiences gained through its application in new case studies. Current work of the department centers in

developing integrated small scale factory planning methodologies in so called “mini factories” which takes into account particular socioeconomic conditions of disadvantaged areas in developing countries. Such a methodology has to be further developed in collaboration with social scientists who are able to understand the local requirements of the community in detail, business economists, that can adapt capable business models to the specific local conditions and engineers, who evaluate the technical feasibility under the regional requirements.

To distribute the idea of the generation of local income in poor communities, a platform has to be developed. An open knowledge solution containing detailed material on “how to build my own VCM” should be developed and put to the disposition of potential users in disadvantaged communities. By means of a bidirectional platform, the user would be able to troubleshoot original concepts and generate a continuous improvement loop with others users of the platform.

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