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Published in:
17th Globelics Conference “Innovation Systems and Sustainable Development: new strategies for growth, social welfare and environmental sustainability”, Heredia, Costa Rica, November 3rd to 5th 2021,

Publication date:
2021

Document Version
Publisher's PDF, also known as Version of record

Link to publication from Aalborg University

Citation for published version (APA):
Dirckinck-Holmfeld, L., Nunez, H. C., Coto Chotto, M., & Tabo, G. O. (2021). Universities to lead inclusive innovation for community transformation through participatory approaches – Costa Rica and Uganda cases. In 17th Globelics Conference “Innovation Systems and Sustainable Development: new strategies for growth, social welfare and environmental sustainability”, Heredia, Costa Rica, November 3rd to 5th 2021, Article ID-1547

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Universities to lead inclusive innovation for community transformation through participatory approaches – Costa Rica and Uganda cases

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Abstract

Universities are core actors of research, higher education teaching and learning as well as dissemination of knowledge, and community engagement. Universities are changing from the "ivory tower" oriented philosophy and a traditional view on knowledge production and dissemination towards an interactive mode based on collaboration and interaction between universities and external stakeholders. The National System of Innovation (NSI) emphasizes systematic interaction among universities, firms, and the policy level to promote industrial innovation and global competitiveness. However, from a democratic perspective the NSI should equally link innovation to inclusive and sustainable development and support a concept of inclusive innovation activating all sectors and members of society especially the marginalised people, informal sector actors, indigenous knowledge holders and the educational sector to participate in creating and actualizing innovation opportunities. With a focus on universities in developing countries and emerging economies, this paper is researching universities as key actors for strengthening inclusive innovation. The paper focuses on two cases: Universidad Nacional in Costa Rica and Gulu University in Uganda. The paper is explorative with the aim to look for lessons learned and patterns across the two cases. The two cases share an interest in focusing on partnerships, novel pedagogy, and participatory approaches as means for co-creation, co-production, and co-learning, aiming at developing inclusive innovation practices.

Keywords: National systems of innovation (NSI), inclusive innovation, change lab, research-innovation capacity development, low-resources communities, Northern Uganda, Costa Rica.

1. Introduction

Kruss et al. (2015) present some of the challenges in relation to the national innovation system (NSI) in sub-Saharan Africa. Their analysis indicates that universities need to transform as an important instrument for building innovation capacity, however, the interaction between universities and industry are weak and there are not many examples of building local technological capabilities. Equally, the NSI needs to address the problems of threatening ecological disasters, structural inequalities, deepening poverty and unemployment, and to engage all sectors of society, particularly the marginalised poor, informal sector actors and

indigenous knowledge holders to participate in creating and actualizing innovation opportunities (Petersen & Kruss, 2021).

As stated by the European Commission and the OECD, higher education is challenged to redefine its purpose, role, organization and scope in society and the economy (OECD, 2012). In this line, in the last years, universities have become more aware of the influential and crucial role that their produced knowledge has for the economic and social development, resulting in the third mission function of the university; identified also as third stream, third role, community engagement, outreach, and social and business engagement (Frondizi et al. 2019). This third mission states that besides teaching and research, universities should contribute to local socio-economic development, and universities should foster to "build ties and relationships with their communities to enhance their development and create shared knowledge" (Frondizi et al. 2019, p. 2).

This third mission has been an evolution where universities are expected to collaborate not only with knowledge-based communities (such as high-tech industry, hospitals, and research and development departments) but also with communities with socio-economic challenges, such as rural regions; this new demand push universities to take responsibility toward their less developed communities.

There has been little systematic research in relation to this third mission of universities when working together with less developed communities. Further, most studies focus on the macro-level, policy frameworks and less on the meso and micro levels of developing innovations (Kruss et al., 2015). Therefore, this paper is especially focusing on two universities – Universidad Nacional in Costa Rica and Gulu University in Northern Uganda, and we are especially looking into some of the conditions for doing innovations at micro levels through co-creation projects to enhance local socio-economic development and engagement.

Due to the United States Patent and Trademark Office (USPTO) framework, countries can be clustered in three groups with regards to science and technology production and interaction. Using these clusters as a reference, Uganda is situated in cluster I covering countries having a low technological and scientific production as well low interaction between actors, while Costa Rica is situated in cluster II (Albuquerque et al., 2015). The countries in Africa are at different stages of development in relation to NSI. Firms are a relatively less representative actor as the focus primarily is on supporting rural livelihoods, agriculture, and health (Albuquerque et al., 2015). In contrast to this, Latin America is a more homogeneous continent. Mexico, Costa Rica, Argentina, and Brazil have a less dispersed level of development (they have all been in regime of interaction - cluster II since 1982), a more common set of problems e.g., levels of income inequality, and a more homogeneous historical process – all are former colonies of Iberian countries (Albuquerque et al., 2015).

Even Costa Rica and Uganda find themselves at different stages of development in relation to NSI (phase II and phase I respectively in the cluster analysis) and in totally different geographical regions, we see shared opportunities for these new and rather young universities to play an interactive role in the NSI for local sustainable development and inclusive innovation. Even when young universities are underfunded and located in contexts of limited

resources, the local appraisal and relations, local ownership and trust give them opportunities to come up with new models and fresh approaches to overcome some of the constraints in the old university paradigms. The local universities have the potential to apply new methods for sustainable innovation, to increase the quality of local production and services responding to community needs and to establish a culture of inclusive innovation, which are the topics that we want to discuss in this paper.

2. Problem formulation

This paper explores how universities can adopt methods for sustainable innovation, especially innovation for inclusive development. To respond to this research problem, we will look in detail into the methods and tools for how to co-create co-produce and co-learn with communities, and how to integrate this as core in the universities' missions. The long-term aim is to create a culture of inclusive innovation with the universities as lead.

In order to explore the methods for inclusive innovation the paper is based on two case universities: Gulu University in the Northern Region of Uganda and Universidad Nacional in Costa Rica. These universities have been engaged in long term international collaboration among many others with Danish Universities enhancing their research capacity. After presenting the related literature and identifying core principles from the literature, we are providing some examples of collaborative, innovation projects in these universities. The examples serve to discuss the direction for inclusive innovation and to investigate more closely the concepts of *co-creation* (Trencher et al., 2014)*, co-production* (Carter et al., 2020) *and co-learning* (Jacobs et al., 2019) as they are unfolding in these projects. The paper concludes by summarizing the key principles of inclusive innovation in relation to NSI and universities as leaders in a resource-constrained context.

3. Related literature

The section on related literature is especially concerned with elaborating the concept of inclusive innovation focusing on the roles of universities as change agents and the concepts of co-creation, co-production, and co-learning.

Inclusive innovation

Universities, as knowledge producers, have the capabilities to support and lead the processes of finding solutions in low resource regions (Jacobs et al., 2019; Petersen & Kruss, 2021). Because of this significant role of the university in underprivileged communities, the engagement of universities should be wider than with knowledge-based organizations (OECD, n.d.; World Bank, 2002), especially in developing countries. Therefore, there is a growing interest in the role of universities as change agents to respond to inequality, poverty, and environmental sustainability in these kinds of communities (Petersen & Kruss, 2021).

In South Africa, the Department of Science and Technology (DST) is drafting a strategy on innovation for inclusive development (IID). The draft strategy defines IID as:

> "Innovation that addresses the triple challenge of inequality, poverty and unemployment and enables all sectors of society, particularly the marginalised poor, informal sector actors and indigenous knowledge holders to participate in creating and actualizing innovation opportunities as well as equitably sharing in the benefits of development". (DST cited in Petersen & Kruss, 2021 p. 352).

In the following, we are using the concept of "inclusive innovation" to address IID.

The role of universities as change agent brings "new challenges for universities as it requires going beyond institutional borders to collaborate with non-traditional partners such as informal enterprises or community-based actors, and to stimulate and support innovation that may be seen as relevant to a given local setting only" (Petersen & Kruss, 2021, p. 1). Another challenge is that transformative social change in low-resources communities demands (1) new forms of interactions (not the traditional form of industry-university), which challenge the traditional methods of engagement in the NSI, and (2) new forms of innovations such as social innovations, which is fostered by bottom-up approaches and interactive learning process (Kruss, 2012; Petersen & Kruss, 2021). A third challenge is that this new change agent role is promoted from the outreach/third mission of the universities, but these activities are normally seen as a backseat when compared with education and research (OECD, 2019). Therefore, the task is to get this third mission prioritized at the level of teaching and research, and to find ways for these three missions to converge and complement each other to achieve low-resources communities' development (Jacobs et al., 2019) and inclusive innovation (Petersen & Kruss, 2021).

Co-creation for sustainability

Within the discussion of the role of the university as change agent, not only in low-resources communities, Trencher et al. (2014) argue for an alternative function of the university: co-creation for sustainability, which is a social transformer and co-creator. The role of the university is defined as a collaboration with "diverse social actors to create societal transformations with the goal of materialising sustainable development in a specific location, region or societal sub-sector" (p. 152). In this alternative function there is a conscious use of the term "transformation" as opposed to "transmission". The trend of co-creation that is like other participatory approaches "explicit emphasis on the process of creating physical and permanent transformation as opposed to the co-production of scientific knowledge, which per se, does not necessarily guarantee action or transformation" (Trencher et al., 2014, p. 153).

Co-production

This approach is used by WISER-FCFA – which deals with climate and sustainable issues. As well as the previous perspectives presented above, this co-production approach challenges the traditional dissemination model by recognizing that collaboration between typically-separate groups (producers and consumers) – can generate credible, salient, and legitimate knowledge (Carter et al., 2020).

The aim of the co-production approach (Carter et al., 2020) is to involve citizens in knowledge production, as opposed to having them just consume knowledge, which is a common practice

in developed countries, and is increasingly also practiced in developing countries. The approach is based on an established field of change from a top down approach model of development to a button up one, as well as the incorporation of participatory approaches to avoid solutions designed outside of the context and by external experts. “Instead, including the insights and perspectives of those people intended to benefit from the development can lead to more appropriate and effective interventions and innovations” (Carter et al., 2020, p. 12).

The process of co-production is equally important as the product (Carter et al., 2020). “The nature of co-production means that it is impossible to be prescriptive and define exactly what it looks like. Instead, the form that co-production takes depends on the aim, the context and the parties involved” (Carter et al., 2020, p. 13).

Co-creation and Co-learning

Jacobs et al., (2019, p. 886) argue that traditionally, the NSI concept and The Triple Helix model “restricts itself to actors in conventional definition of innovation, emphasising university-industry interactions and how the government could support technological innovation and commercialization”. In the traditional model, the production and transfer of knowledge, capacity, technology, and skills are underpinned by the pursuit of commercially successful knowledge, therefore relegating the social role and function of the university in producing knowledge for social benefit (Jacobs et al., 2019). Further, the traditional model, many times, engages with the community using a top-down approach which under-represent the perspectives and interests of local communities. The university-community networks and thus the social dynamics of innovation have been neglected. Even when working with communities, this engagement is rarely characterized by mutual interactive learning (Jacobs et al., 2019). In their framework (Jacobs et al., 2019), the emphasis switches to university-based knowledge producers that co-create and co-produce innovative solutions with and for communities who are socially and economically marginalised. The framework gives prominence to co-learning which brings to the fore how knowledge producers (universities, industries, governments, and communities interact to jointly search for novel solutions to socio-economic difficulties. “Co-learning is purposeful and fosters transformative participation anchored in meaningful knowledge advancement and innovation” (personal communication, explanatory note p. 3). A prerequisite for co-learning is that all actors are willing to engage and be transformed by the contributions of others. Co-learning also cuts across modes of knowledge, codified and tacit, local and global.

4. Research design

The research takes point of departure in a long-term collaboration on enhancing research capacity between Aalborg University in the northern part of Denmark, and the two case universities: Gulu University in the Northern Region of Uganda and Universidad Nacional in the central region of Costa Rica. All three universities are engaged in exploring methods of community engagement and community transformation.

The research has been designed as a meta-reflection on three ongoing inclusive innovation projects in Gulu University (GU) and Universidad Nacional (UNA). These projects serve as examples and a specific context for a closely exploration and discussion of the concepts of *co-*

creation (Trencher et al., 2014)*, co-production* (Carter et al., 2020) *and co-learning* (Jacobs et al., 2019) as they are unfolding in these projects. As researchers, we are all involved in the projects. Two of us in relation to GU and the other two in relation to the UNA project. As researchers we are, therefore, both insiders of our own research and outsiders of the other projects. This design facilitates mutual reflection on the projects, benefiting from both insider and outsider perspectives.

5. Presentation of cases

Gulu University case

Gulu University established in 2002 is one of the public universities in Uganda. The University is a government effort to increase access to higher education to nationals but specifically to Northern Uganda that had suffered armed conflict for over two decades (Tabo, 2020). It thrives as a teaching and research institution whose mission is geared towards transforming communities. This is stated in its motto "to provide access to higher education, research and conduct quality professional training for the delivery of appropriate services towards community transformation and conservation of biodiversity". The University understands its mandate to contribute to the development of the region through provision of training opportunities that educate people to innovate and deliver local solutions that spur development. In this case the university is seen as a change agent as in Petersen & Kruss (2021).

In collaboration with national and international universities and research institutions, the university has over the years contributed to addressing health, agriculture, science, and humanities challenges practically and inform policies at regional and national levels. Most research and capacity building collaborations have been in health (for example see www.thrive.or.ug and ENRECA), agriculture and sciences (Nuffic and AfDB) but also the Building Stronger Universities (BSU) in humanities and social sciences. We take a point of departure to illuminate project activities that have directly or indirectly contributed to development, community engagement and possible creation of new small and medium companies within the city. To illustrate this further, we specifically draw on the BSU project designed to create impact through transforming education, enhancement of research capacity, outreach activities engaging the community in and around Gulu city and "access to innovation". In the following we present two projects: (1) education led and (2) research led. Education led takes the point of the departure in novel educational approaches while research led is inspired by co-learning and innovation. Both projects are examples of inclusive innovation. The educational project may run within the existing resources of the educational program, while the research project is dependent on external funding.

PBL and digital learning case

The BSU project has been working with the university research community on exploring new innovative pedagogical approaches to answer 21st Century skills integrating PBL and digital learning (Tabo et al., 2021). In the second phase of the project, the university emphasised the experimentation of problem project-based learning and digital learning in the African context. The approach exposed students and staff to research based teaching and learning in graduate education thereby promoting co-learning through integrating community into the learning and

research activities. To further strengthen research and outreach, the BSU project used a selection of participatory methods to introduce the new pedagogical approach to the university community (administration, academics, and graduate students). Among core activities, the project organised annual PBL workshops for staff and students over the years to experiment with graduate student's semester projects. These bottom-up interactive participatory approaches have shown positive results with students and low-resources communities.

These new approaches are leading to students and academic staff co-creating and co-producing knowledge. Student groups work together to define problem area from where they decide collectively in the problem formulation. One example is on waste management experimentations in Gulu city as a result of human activity, human practices and social agency. (Simonsen and Robertson;2012). The project was initiated by student groups based on their personal experiences and observation of waste management activities by city authorities as a potential challenge to achieving collective wellbeing to public health. An experimental project was collaboratively designed to investigate issues of solid waste management in collaboration with the authorities. Students engaged themselves in the research and engagement with the community representatives and authorities. At the end, a new solid waste management pathway with policy recommendations was documented in the students' final reports and presented at the annual Gulu University conference, showcasing knowledge as an essential part of innovation.

This exemplifies the approach of *co-creation, co-production, and co-learning* as they are unfolding in these projects with the students at the centre of the development of innovative solutions supported by participatory approaches and the pedagogical approach of PBL. The experiences from this ongoing transforming education project demonstrate how important it is to integrate education and the students as a resource and agents for inclusive innovation.

The Change LAB: Unlocking the Potential of Green Charcoal Innovations to Mitigate Climate Change in Northern Uganda (UPCHAIN)

The BSU project is also targeting the big challenge of energy supply for cooking and climate change mitigation as a combined effort of research, education, and community engagement. The project is targeting that the energy needs of over half of Africa's population is met by firewood and charcoal (wood fuel). Despite clear advantages of green charcoal as one of the solutions to sustainable, locally produced, and secure energy resources (Mwampamba et al., 2013; UNDP, Uganda, 2014) the adoption as a substitute for firewood and charcoal remains sparse. Based on a pilot project on green charcoal production at Gulu University (Collins, 2020) the aim is to establish a change lab: Unlocking the Potential of Green Charcoal Innovations to Mitigate Climate Change in Northern Uganda (UPCHAINCIcreation, co-production and co-learning" spaces for the researchers, students, and local stakeholders. Here documented observations and recorded interaction and co-learning using participatory methods (future workshops, design experiments and local production) with entrepreneurs, schools, and households will take place, linking the technical process of carbonisation and briquette-making with the social and cultural process of cooking, fuel use, and marketability. These interlinkages ensure that all participants can explore changing community experiences, which are urgent for innovating the green charcoal production, use and marketability and all creates ownership to the change process. Further the "change lab" will enable and facilitate for the various

knowledge forms: embodied tacit knowledge and codified, research based knowledge to interact. The overall aim will be to develop for a community of practice with the shared enterprise of developing and producing green charcoal to be adopted by households and schools.

The experiences from the two examples give us the building blocks for universities to start working on new ways of engaging communities for innovation through research, teaching and learning and outreach as integrated efforts. The institution needs a pedagogical approach that balances knowledge and practice to cultivate the triple helix into the structure of the operations that leads to development of communities in low resource settings. These two projects demonstrate how new societal solutions and innovation are products of problem-centered pedagogical approaches and socio-cultural experimental research that advocate for the 21st Century skills and somewhat contribute to achieving the sustainable development goals. The projects are illustrations of social and inclusive interventions targeting informal sector actors and indigenous knowledge holders along with municipality agents to participate in creating and actualizing innovation opportunities.

Universidad Nacional case

The Universidad Nacional (UNA) was established in 1973. It is the second largest university and one of five public universities in Costa Rica. It has close to 20,000 students who can study any of the 137 educational programs it offers. In addition to its presence in the Central Region, where its main campus is located, UNA has several facilities throughout the country, such as scientific laboratories, research centres and educational centres.

UNA was founded with a clear mission to provide higher education mainly to the less advantaged sectors of the population, particularly to rural areas, being called “The Necessary University”. Therefore, its outreach activities (third mission) play a strong role, and it is equally recognized in the organizational structure, having the same level as teaching and research, but not the same budget. As a part of its third mission, UNA has a relationship with external agents at the local, regional, national, and international level. These relationships are materialized in the form of (1) reflection and dialogue activities such as congresses, dialogue meetings with communities, conferences, (2) research projects, (3) development projects, (4) training and educational activities, and (5) remunerated knowledge transferred activities, where private or public organization pay for a specific consultancy, research, or training activity. There is a Foundation and a Transfer Office to implement the remunerated activities.

From 2017 to 2020, the university has executed a total of 1084 outreach projects, of which 304 are projects with a single outreach component and 830 are considered integrated projects which means they may have a combination of three components: research, outreach, and teaching. (Vicerrectoria de Extension, 2020). This high number of integrated projects shows an effort towards the integration of outreach, research, and teaching, joining efforts to strengthen the university-society link. With respect to geographic location, 45% of the projects report an impact throughout the country, 21% report an impact in the central region, and the rest are distributed in the different regions. In the regions with the lowest development index, such as the Huetar Caribe region and the Brunca region, only 6% and 9%, respectively, of the projects

were executed. The projects are executed with both internal university funds and external funds (Vicerrectoria de Extension, 2020).

It is relevant to highlight that UNA approaches its third mission from different perspectives and methodologies (González-Alvarado, 2017) being the participatory approach one of the most common to work with communities. An important challenge that UNA has proposed to address is to ensure that students can learn content, skills and values related to outreach practice, to apply them and to have them recognized as part of their curriculum (Vicerrectoria de Extension, 2020).

The CREO project

The CREO project (which means believe and create in Spanish) is an action research project that took place between 2015 and 2018 in a low-performing secondary school (called MT in this paper) located in southern Costa Rica, which is one of the least developed regions of the country, has very low levels of social development, a very low average school completion rate, a tendency of the population to move to the metropolitan area, and a high presence of indigenous population (MIDEPLAN, 2014).

The MT school can be classified as a low-performing school (Corallo & McDonald, 2001; Duke, 2010; Jensen, 2013; Schmidt-Davis & Bottoms, 2012), as it presents: high dropout levels, low achievement, low expectations regarding student achievement and teacher performance, lack of a collaborative culture of knowledge sharing, weak administrative control, weak leadership and almost no parental involvement.

The objective of the project was to facilitate transformational change in the MT school using the principles of transformational leadership to develop its capacity for innovation (Camacho & Coto, 2018). The project focused on creating a joint vision to guide change and promote shared commitment to school change while promoting new ways of teaching and learning. To achieve the project's goal, an action research approach was used as a practical strategy to engage multiple stakeholders in a coordinated effort to address the problems of low-performing schools (Sagor, 2000; Schensul et al., 2004), thus ensuring that all those affected by school conditions had a voice in the project.

The project involved the school principal and teachers in an iterative process of research and action in which they were agents of change and had decision-making power over the phases and actions to be undertaken in the project. In this way, activities were facilitated for MT school members to work together to solve school problems, develop relevant skills, increase their understanding of their socio-economic environment, and have the opportunity to design systems of knowledge sharing, co-learning and mutual support.

In the approach, the university participants intentionally had a role as facilitators and providers of research methodologies and theoretical frameworks to help support the change process. Five cycles of action research were conducted: plan, act, observe, reflect, and act again and multiple activities, methods and tools were used in the cycles to engage participants, to co-create, co-produce and co-learn a transformational strategy for the school. More details of all the activities carried from 2015-2018 are presented in (Camacho & Coto, 2018) and (Camacho et al., 2020).

As Jacobs et al. (2019) argue, knowledge production for social benefits occurs through intensive mutual learning that facilitates knowledge sharing and creation in an interactive learning space. We consider the CREO project to be a good example of this intensive mutual learning spaces between university and low resources communities. The CREO project is an example of an integrated project with long term effects, producing a local change process and creating a culture of hope and change within a less-resourced educational sector.

6. Discussion

Central to the concept of inclusive innovation are to understand the conditions, principles, and methods for creating shared knowledge interaction, production and mutual learning between the partners engaged in the project. Far too often transformation and innovation of processes and products are taking place without engaging all the stakeholders. In the following section we discuss three aspects that might shed light on what to consider when designing university-community interaction with the aim of inclusive innovation.

Establish a learning interactive space

Based on the experiences of the cases and on the literature presented above which claims for new roles of the universities - social transformer and co-creator (Trencher et al. 2014), co-productor (Carter et al. 2020) and co-creator and co-learner (Jacobs et al. 2019), we identify the need to create interactive learning spaces. The aim of these spaces is to foster the bottom-up process and co-creation of knowledge opposite to the traditional knowledge transfer approach. Supporting the co-creation of knowledge requires the intentional facilitation of spaces that can support joint thinking, facilitating empathetic listening and fostering mutual learning among the different stakeholders, which vary depending on the project. The third space (Muller and Druin, 2012), might be a useful concept to guide the design of this type of university-community interaction. In this space, power distance should be reduced so that knowledge can be shared on equal terms; it should be a space where community and researchers come together to seek common understanding with the aim to support the development of the community and knowledge creation. Other terms have been used to identify this space; for example, in research with indigenous people, Hall (2014) refers to it as a “third space of understanding,” meaning that non-indigenous researchers and indigenous participants should find a way to understand each other and to respect their different ways of knowing, which demands “ongoing negotiated reciprocal relationships" (p. 384). Hall proposes methods to promote shared dialogue and mutual understanding. Within the field of participatory design, the third space brings together people willing to explore differences and foster understanding, interacting on the basis of sharing knowledge, exchanging knowledge and reciprocal learning (Muller & Druin, 2012). Researchers in this field use methods such as workshops, stories, games, theatre, and photography, which bridge two spaces (the world of technology designers and the world of users). A third concept that can help to describe this space, is the concept of Ba within the process of knowledge creation proposed by Nonaka and Takeuchi (1995). The Ba consists in both the physical space and the mental space, which includes emotion, cognition, and meaning. According to these authors, knowledge creation cannot take place without context; it is context-specific in terms of who participates and how they participate.

In the CREO project as well in the PBL-project and the Green Charcoal project several methods and tools have been used to create these learning interactive spaces. From the CREO project can be highlighted the use of Lego Serious Play Workshops democratizing participation (all people built, and all people shared), listen to different voices and encourage creative thinking to find solutions. In the PBL-project the use of "Future workshops" also gave all participants a voice and created a "free" space for criticizing and dreaming and not least ownership to the transformation. In the Green Charcoal project, the change lab and the production come together as a third space. Especially for the Green Charcoal project we expect the tangible green charcoal production unite to facilitate mutual exploration and "tacit" learning through production. As it's tangible and visible, the discursive articulation is not that important, which may give "voices" to stakeholders who value a more practical approach. In general, we can not see a project aiming to support the development of the community without conscious considering the creation of a learning interactive space.

Co-creation of knowledge

Looking into the cases from a socio-constructivist perspective (Nonaka and Takeuchi, 1995; Wenger, 1998), we are interested in identifying when knowledge co-creation has occurred and what it looks like. In retrospect, we can see that CREO, and the PBL-project was a continuous process of knowledge creation and co-learning as described in Jacobs et al. (2019), and we also foresee this as crucial for the Green Charcoal project.

In CREO we used generative and participative tools to create knowledge together. We were interacting through the use of drawing, prototyping, feedback sessions and creative workshops, therefore two concrete theoretical concepts can be used to describe how as the project progressed knowledge were co-created: "shared objects of thought" (Kirsh, 2009) and "object-mediated communication" (Roos, 2006). The shared objects of thought deal with the relevance of external representations and their influence on processes of sense-making, problem-solving, and understanding (Kirsh, 2009). The externalization of thoughts (through diagrams, drawings, figures, etc.) makes the process of sense-making easier by representing our thoughts visually, allowing us to process complex situations in a more understandable way, while creating forms through which we can share our thoughts with others (Kirsh, 2017). Kirsh argues that once we make our thoughts visible, they can be reliably identified, discussed, reformulated, rearranged, and transformed, and become "shared objects of thought." An object of thought occurs whenever a thinker can grasp the referent, but a shared object of thought implies that "different thinkers share mechanisms for agreeing on attributes of the referent" (Kirsh, 2009, p. 1105). Similarly, the concept of object-mediated communication are objects that allow us to know, agree, and cope differently. Object-mediated communication results from conversations and interactions among participants who have made use of various materials (Lego bricks, pencil, clay) to mediate communication. According to Roos and Said (2006, p.95) the "possibility of externalizing mental items and sharing them through rich imagery, gives us an overview and facilitates conversations of complex themes". In the cases presented here, the objects allowed us to talk through them and they served as an exchange of tacit knowledge. In the PBL case, the co-creation of knowledge is anchored in the co-writing of a project, including a shared problem formulation. This supports the students in externalising their mental items, and it also force the transformation from tacit and contextual knowing to codified knowledge. Also, the use of rich imagery in projects supports the students to co-create knowledge.

In the Green Charcoal project, we expect the production and testing of briquettes to mediate the co-creation of meaning – not only in relation to new cooking traditions, but also in a broader scope to start a conversation on climate mitigation. In CREO and in the PBL project, the products of each workshop were concrete processes of co-production and co-creation of knowledge; moreover, the whole project was a macro-process of knowledge co-creation in which participants were able to explicitly describe the problem and generate solutions together, sharing a language, an understanding, and a possible solution to the problem.

Tacit knowledge and explicit knowledge

As presented in Jacobs et al. (2019) knowledge transfer or innovation might not be adopted, used, or taken by the community.

In the case of the CREO project, the codified knowledge developed in universities and research institutes was truly relevant for use in a context such as the MT high school. Research community has already identified and tested learning and leadership strategies to transform or turnaround these types of low-performing schools, however, this type of codified knowledge is "out there" but does not directly reach the institutions that might need it and, even then, if the knowledge reaches the institutions, it arrives as codified knowledge, difficult to decode by the communities involved and external to the lived practice in that specific school.

Teachers, principals, parents, students, and the municipalities, such as those involved in the CREO project, may not have the necessary competences to apply codified knowledge. But maybe more important, codified knowledge must be unpacked in each context. In the CREO project, coming with codified knowledge that was well identified and probed in the literature did not solve the problem. It was not possible to apply the codified knowledge to the problem situation. There was tacit knowledge and contextual knowledge that hindered the implementation of best practices, so it was essential to create situated knowledge to generate sustainable solutions to local problems, and that kind of knowledge could only be co-created by researchers-teachers (and the other stakeholders) using tacit, contextual, and explicit knowledge.

Recognizing the value of tacit and contextual knowledge is not enough, university-community actions must use appropriate methods to access this knowledge. In the case of the CREO project, participatory methods allowed accessing tacit and embodied knowledge and gaining a better understanding of the complexity to solve some of the problems in the high school. The different workshops supported the process of co-creation of situated knowledge and developing decisions.

In the PBL project, the student from Gulu University developed the codified knowledge in collaboration and interaction with the municipality, so the codified knowledge was not external to the municipality. Conversely, the codified knowledge was developed in interaction with the contextual situation of waste in Gulu city.

7. Conclusion

In this section we summarize and discuss the lessons learned for universities to facilitate inclusive innovation in low-resources communities.

From the two cases presented (Gulu University projects and Universidad Nacional project) we can learn several things. Firstly,-in the universities the students are a great resource to engage in innovation projects as part of their studies. We call this education-led innovation. The PBL project in Gulu University is a great example of this. Besides providing inputs and contextualized solutions to the waste problem in Gulu city, the students also advanced in their academic performance, even presenting their work in an academic conference. However, it is not a common practice in developing countries to let the students drive the innovation process, among other concerns, because the traditional teacher-centred modes of teaching. Therefore, a first step might be to consider how the educational and pedagogical principles could be transformed for PBL and other change oriented educational approaches to be explored. Secondly, research based teaching is not a common practice in developing countries. From an innovation perspective it is crucial to enhance the research capacity in these universities. However pedagogically, we argue for a problem based learning and change oriented research approach including research publishing at local and international journals. Finally outreach as given in the universities – both GU and UNA – is established with a mission for community transformation. Moreover, for the universities to take the lead in the innovation processes, these three main missions: education, research and outreach should be intertwined into institutional programmes and structures; in other words, to "'cross boundaries' more effectively" as stated by Kruss (2014, p. 18). We argue for a research-based, holistic, integral, supportive, and life-centred educational transformation as the driver (Vicerrectoria de Extension, 2020).

There are several arguments for focusing on research-based educational transformation. First, if we change the perception of students as learners and recipients of knowledge and look at them as a resource for doing research, creation of knowledge and innovation, then the universities in the South have a big resource base with all the young people attending universities. When we argue for the students as a resource in relation to inclusive innovation, it is because students in the universities with their diverse backgrounds have access to many different communities and networks. If orchestrated well the students can function as linkages to the university and mediators of modes of knowledge between the communities, between the small-holder farmers, the informal sector actors, indigenous knowledge holders, the leaders in the municipalities, etc. and focus on problems to innovate, co-create, and co-learn with the community. In the PBL-approach, outreach as co-creation, co-production and co-learning with the communities are in principle built into the curriculum. However, to establish the interaction to research and to available codified knowledge, it is crucial that the students in the education-led innovation are supervised by teachers who are themselves researchers. Because research-based teaching is not a common practice, it is crucial to enhance the research capacity within the new universities, and to use this as a steppingstone for engaging in research-led inclusive innovation and international collaboration. This may nonetheless take many forms. In this paper we discussed two cases and three projects, which are exemplary of local inclusive innovation and international collaborations. Central to these projects are the use of participatory approaches allowing for equal opportunity participation leading to collective understanding of the problem formulation and ways of arriving at solutions across boundaries. Participatory methods such as Future Workshops, user centred design, and other participatory tools have proven to be effective in facilitating co-learning and co-creation of knowledge and solutions in low-resource communities, this is in line with the work of Petersen and Kruss (2021) and their use of multiple participatory methods to collect rich contextual data from the perspective of the

community-based actors. The participatory methods are a must for inclusive innovation. To create novel and sustainable solutions to local problems, all participants must see themselves as equal partners, and all participants should be recognized as experts in their field of experience. Here we summarize major pathways for universities to transform communities, but we also present the magnitude of the internal reorganization that universities must embark on to create the desired social change in low-resource settings.

Back to the concept of national system of innovation (NSI) we are in line with the South African position (Petersen and Kruss, 2021), which underlines the necessary democratic orientation of the NSI, equally linking innovation to inclusive economic growth and inclusive socio-economic development. As our cases illustrate, if societies really want to change structural inequalities and deal with local and global crises, all sectors of society need to be activated, not least the marginalized voices, the informal sector actors, and the educational subdivision in creating and actualizing inclusive innovation opportunities. As public funded universities it is obvious that the universities have a special obligation to take the lead in this development.

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