

Fostering peace engineering and rethinking development - A Latin American view

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Abstract

This paper explores how peace engineering initiatives relate to the critique of development in the Latin American context. Development is an essential condition for peace, and structural violence is closely related to patterns of development. In engineering studies, the critique of development has increased attention, explaining the initiatives towards peace engineering engaged in social transformations. We discuss the evolution of the modern notion of development and argue why we should reject the mantra of neoliberalism. Next, we shift our look to the contributions of the Latin American critique of development, from the historical liberation movements to new concepts such as post-extractivism, solidarity economy and political ecology. A decolonial view is proposed departing from the 'epistemologies of the South', followed by a review of how science, technology and innovation relate to specific exclusion forms. Further, an empirical view on peace engineering initiatives in post-conflict

Colombia and in Brazil is presented, including three streams of how engineering initiatives relate to social change, from the social economy to grassroots movements. Finally, we suggest a few questions for further research in peace engineering and development.

Key Words

Peace engineering; critique of development; exclusion forms; Latin American critical thinking; engaged engineering; structural violence.

1. Introduction

Peace engineering has many dimensions. Vesilind (2010; 2006, p. 286) remarks that thousands of engineers have been active using their skills and talents to promote peace and social justice. However, *'probably none of them has ever thought of defining it'*. In this paper, we problematize the role of peace engineering initiatives in active peacebuilding and its connection to the critique of development in the Latin American region. We do so by combining theoretical analysis in the first sections to investigate empirical cases of peace engineering in Colombia and Brazil in the following sections.

Following the introduction, section 2 draws on how development and peace (engineering) connect by exposing the relationship between direct, structural and cultural violence and clarifying why development is an essential condition for tackling structural violence. Section 3 asks why development is a core concept for peace engineering initiatives. We present the movements in engineering schools and organizations towards engineering engaged in social transformations, arguing that engaged engineering is peace engineering and vice versa. The section evolves to outline a critique of development and innovation concepts, introducing social and community innovation issues.

The insights of the Latin American debate over development are the focus of section 4. After elucidating what the idea of Latin America stands for, we examine the Latin American liberation movements, underlining their economic, religious, and educational matrix. We debate recent trends in the critique of development, presenting concepts such as (neo-)extractivism and the Latin American view on political ecology. We recur to the decolonial critique of the 'epistemologies of the South' and the indigenous and traditional communities' perspectives to rethink development. Finally, the last subsection discusses the role of science, technology, and innovation (ST&I) in public policies, in the light of the Colombian post-conflict

peace initiatives. Here five forms of exclusion are pictured: social, sectorial, territorial, ontological and epistemological.

Section 5 scrutinizes cases of peace engineering and guerrilla post-conflict management in Colombia and Brazil. The Colombian cases represent two experiences of building engineering alternatives in rural areas affected by guerrillas. Next, we investigate three forms of framing peace engineering initiatives in the Brazilian context: grassroots engineering, social entrepreneurship and what we call a third stream. The conclusion summarizes the lessons learned and propose questions for further research in peace engineering and development.

2. Three forms of violence, development and peace engineering

A skeptical reader could raise the objection that there is no apparent connection between development and peace (engineering). In the views of experts in peace and conflict studies, one key understanding is that development is an essential condition for peace, and peace a condition for development (Galtung, 2007). The more society provides a high degree of equality in wellbeing and respect for plural cultures and ways of life, the less fertile ground for violence will thrive. Moreover, there is a close connection between the three primary forms of violence: direct violence, structural violence, and cultural violence. In short, structural violence is a structure of exclusion of basic needs, rights, and dignity, in a given economic and political order, which causes massive suffering. Cultural violence types are narratives, forms of thought, symbols, and other cultural dimensions, legitimizing direct and structural violence. Direct violence, which is made possible by structural and cultural violence, harms others deliberately, in armed conflicts, homicides, and other physical and non-physical forms of abuse and aggression (Galtung, 2007; Johansen, 2007). These considerations lead us to conclude that peace engineering initiatives, when applied effectively and based on a critically built development approach (as we argue in the next sections), are powerful tools to reduce structural violence and strengthen positive peace.

Possibly, not all of us are aware of the extent of the appalling patterns of violence in Latin America. Unfortunately, violence is an overwhelming reality, particularly for the vulnerable populations living in the region. Let us take the case of Brazil as an example. According to the “Atlas da Violência 2019”, the reference in research in this area, the number of homicides reached its highest peak in 2017, with a total of 65.602 casualties, making it 31,6 per hundred thousand (data is provided since

2007 and is not yet available for later). Most homicides victimize individuals of lower social classes, so at least 74.6% of the male victims had up to seven years or less schooling (Atlas, 2019, p.72).

Moreover, racial inequalities lie most heavily on Afro-descendants. The proportion of the total casualties is 43,1 for black, to 16 to non-black per hundred thousand inhabitants. In 2017 female homicides reached 13 per day, and the total of homicides of LGBT+ individuals over the same period was 193. Further, 55% of the male perpetrators were young, between 15 and 29 years, and often involved in drug cartel wars (Atlas, 2019, p. 7-8). Violence has not only a social cost but also an economic and a political cost. The research institute IPEA estimated that the financial cost of violence in Brazil is equivalent to up to 5.9% of the Brazilian GDP (Atlas, 2019, p. 12).

Clear evidence in how direct violence goes hand in hand with political intolerance is the assassinations of the left-wing Brazilian politician Marielle Franco in 2018 and the Mexican Isabel Cabanilla in February 2020. Both were feminist and human rights activists. Such direct violence is widely spread in Latin American.¹ It demonstrates a problematic state of femicides in the region, shedding light on how violence operates by explicitly targeting social activists and leaders struggling for fundamental social and political rights and challenging the power structures of sharp inequalities.

Mushakoji (2007, p. 87-88) maintains that reasoning about injustices and exclusion goes across national borders, leading to the Gandhian principle of 'antiodia', that "unless the wellbeing of the smallest [the most vulnerable] is taken into consideration," the rights, security and development of the global North will not prevail. The global North and South are here not understood as strictly geographical, but metaphorically. The distinction draws the line between the world citizens who enjoy high living standards and those who destitute and marginalized wherever they live. Applying the principle of antiodia in international affairs, the condition for a peaceful world lies in cosmopolitanism, interdependence, and collaboration. Simultaneously, tackling contemporary forms of violence lead us to examine how exclusion structures come about and how structural violence is linked with development and innovation concepts.

¹ Ed Vulliamy. 'Why did she have to die? Mexico's war on women claims young artist.' The Guardian. <https://www.theguardian.com/world/2020/feb/11/mexico-war-on-women-artist-isabel-cabanillas-ciudad-juarez> (accessed Feb 11, 2020); S. Ramalho. "Who Killed Marielle Franco?" The Intercept. <https://theintercept.com/2019/01/17/marielle-franco-brazil-assassination-suspect/> (accessed Jan 20, 2019); J. P. Daniels. "Colombian death squads exploiting coronavirus lockdown to kill activists." The Guardian. <https://www.theguardian.com/world/2020/mar/23/colombian-groups-exploiting-coronavirus-lockdown-to-kill-activists> (accessed March 23, 2020).

3. Peace engineering initiatives, development and social innovation

3.1 Peace engineering initiatives and development

Development is a crucial concept for engineering as it provides a general framework of goals and means (what shall we achieve and how). Now, development is a contested concept, as we shall see below. Development is generally understood as raising the living standards and society's well-being. It is primarily concerned with those socially deprived of rights (social, human, political rights) and opportunities (liberties, equality). In the last two decades, a new movement in engineering towards social justice has arisen (Nieusma, 2011), searching for socio-technical solutions to improve marginalized communities' lives. The movement is usually known as humanitarian or community development engineering or, in Latin America, as grassroots engineering (Smith, Tran and Compston 2019; Kleba, 2017; Reina-Rozo and León, 2017). As Lucena, Schneider and Leydens comment, *"these many development-oriented engineering programs and initiatives have as their primary goal that engineering should be used to help those who are disadvantaged or in need."* (2010, p. 85).

We call 'engaged engineering' the diversity of initiatives which seek social transformations, combining public interest activism with research and new engineering education service learning and concepts (Kleba, 2017). The idea of an engaged program draws on Science and Technology Studies and is inspired by the Science for the People Movement (Sismondo, 2018; Schmalzer, Chard, and Botelho, 2018). Engaged engineering claims that the significant challenges of development goals, following the United Nations 17 goals of the 2030 Sustainable Development Agenda (UNO, 2015), are linked to the way engineering is conceived, taught, and applied in political agendas at national and international levels (Amadei and Sandekian, 2010).

We argue that engaged engineering is always peace engineering, thus being interchangeable concepts, as both seek social justice and nonviolence alike. Many engaged engineering initiatives do not yet identify themselves as representatives for peace engineering (issues concerning peace and conflict still must be integrated in their educational and social intervention concepts). However, it makes all sense to do so, as they are actively working against the multiple forms of violence.

The idea of engineers as professional solvers of underserved communities is widespread, and a step forward in involving engineering teaching, service learning and professional commitment with new new challenges. However, according to Schneider, Lucena and Leydens (2009), unaware engineers may unknowingly entwine themselves in the long histories of colonialism, imperialism and neoliberalism. So, a critical view of the idea of development is due.

3.2 A critical examination of the concepts of development and innovation

The modern development concept was born in 1939 when Colin Clark, for the first time, measured national income figures providing a framework to compare rich and poor countries according to the gross national product (GNP) (Sachs, 2001, p. 4-6). Since then, development has been a critical concept in establishing a new world order, led by the United States. Countries had to follow a linear and Western-based model, centered on economic growth as the mantra of relentless progress. The mantra of development, to continuously expand the market economy base, has ignored the diversity of historical and cultural contexts and undermined the natural and social foundation of livelihoods. It has further spread new forms of misery: *'Dams displace people, machines substitute for rural workers, cash crops replace subsistence crops, urban migration follows the loss of self-affirmation'* (Sachs, 2001, p. 14). The Human Development Index (HDI), has attempted to place development at the service of people's wellbeing by including literacy, health, and participation in its index. However, the HDI seems to continue to rank countries, assuming that there is only one universal set of criteria to compare societies, ignoring their distinct historical and cultural contexts.

Another critical concept in the frame of development is that of innovation. The dominant conception of innovation is centered on economic growth since Joseph A. Schumpeter's early classical works on the capitalist society. In this perspective, innovation would create products and services to satisfy social needs. These needs are created and defined by their capacity to curb endless material consumerism and growth based on non-renewable resources, to oil the prevailing system's machinery. A naive technological optimism and its market-focused innovation have been the norm in development interventions and defining the relationship between university and society (Reina-Rozo, 2019). As a result the discourse of innovation has been used to spread the logic of market expansion worldwide, transforming all dimensions of life, from genes and arts to health, in private assets and intellectual property, hence building new enclosures and restricting liberties (Ostrom, 2000).

However, there have been attempts to re-signify innovation as a critical approach to

development and socio-technical change (Jimenez and Roberts, 2019; Reina-Rozo, 2019). Whereas social innovation was left entirely out in the dominant paradigm established by the Oslo Manual, which narrows the idea of innovation to the business sector, a “paradigm shift” towards issues of empowerment, fighting against social exclusion, and for good governance seems to be happening (Edwards-Schachter and Wallace, 2017, p. 71-73). Social innovation is undoubtedly not a panacea for all global problems, but it has the potential to curb ‘transformative social innovation’ (Avelino et al., 2019, p. 203). In this sense, transnational networks of creative resistance have arisen, combining collective action, sharing economy and a critical stand to profit centered innovation, such as Seed Exchange, Co-housing, Via Campesina and Credit Unions (Avelino et al., 2019).

Accordingly, alternatives of development have emerged in Latin America from a multitude of social movements. In this sense, the term ‘communal innovation’ (CI) depicts an emerging concept, which we defined as the process of iterative innovation carried out by marginalized communities in response to contextual factors. CI allows the autonomous design and creation of pertinent, contextual, and collective solutions to challenges, opportunities, and aspirations to generate common goods and move towards commonality. This process, mainly inspired by the indigenous communities in the Andean-Amazonian region, is always mediated by community members, communities and organizations in their territory (Reina-Rozo, 2019). Communal Innovation is one of the insights provided by the Latin American critique of development, which we are looking at in the next section.

4. Latin American insights on decolonization, social exclusion, and development

4.1 What does Latin America stand for?

This section presents an overview of the Latin America critique of development. To begin with, Latin America is a contested concept. Should it be defined by the spoken languages based on Latin?² Or should it be determined by a geopolitical area South of the US border, identified as Latin America and the Caribbean? According to the definition, the range of countries (beyond the dependencies) vary between 20 and 33.³ The adjective “Latin America” has been criticized for not considering Indigenous and African populations’ major role in this region, who

² With a few exceptions, such as English in Guyana and Belize as well as English and Dutch in the Caribbean islands.

³ United Nations. “Groups of Member States.” <https://www.un.org/en/model-united-nations/groups-member-states> (accessed July 12, 2020).

speak other languages than Latin-based ones.⁴ Narratives about Latin America seek to problematize what is familiar (and different) in the area. Latin America share features such as the central place of ancestral indigenous peoples, who are the majority in some countries, common languages, the history of colonization, the presence of Afro-Americans, and immigrants from almost all over the world. For instance, Brazil has 256 indigenous peoples, most speaking their unique languages, of which 48 peoples live across the borders with neighboring countries.⁵ The region also shares a history of much violence, having endured slavery, genocides, civil wars and dictatorships. Most of all, it shows sharp contradictions between rich and poor, Western and non-Western ways of life, and the intense conflicts between the political left and right wings, driving the political trends of the region in complex social dynamics.

4.2 The Latin America liberation movements

Postcolonial studies started in the early 1960s and 1970s with the seminal works of Frantz Fanon (1967) and Edward Said (1978). Latin American decolonial thinking has its roots in the Philosophy of Liberation as early as the 1960s, raising the claim of a distinct historical character of the region and a “*critique of colonialism, imperialism, globalization, racism, and sexism, ... in the name of the projects of liberation, autonomy and authenticity*” (Mendieta, 2016: introduction, para. 3). This line of thought is a “*synthesis of a series of intellectual and cultural movements*”, from which we highlight the following (Mendieta, 2016: section 2, para. 3):

a) An economic matrix built around the *Theory of Dependence* (which explains underdevelopment due to the dependency of the peripheral countries from the technologically developed ones). Here, the works of intellectuals working with the Economic Commission for Latin America (ECLAC - the Spanish acronym is CEPAL), have delivered a significant contribution to outline the economic challenges of the region, from industrialization and innovation to financial vulnerabilities, the limits of neoliberal reforms, and the role of inequality (Hofman and Torres, 2008).

b) A religious matrix with the emergence of Liberation Theology, providing a new understanding of the Catholic Church with the “preferential option for the poor”, and the related nourishing of a broad social movement, the “*comunidades de base*” (base communities). This left-leaning religious movement had a significant impact on

⁴ For the sake of simplification, we continue to use the concept of Latin America, having in mind that it is a contested concept.

⁵ ISA - Instituto Socioambiental. “How many are they?” Povos Indígenas no Brasil. https://pib.socioambiental.org/en/How_many_are_they%3F (accessed Jan 27, 2020).

policies favoring the disadvantaged. For instance, the Catholic Indigenous Missionary Council (founded in 1972) has struggled for the territorial and cultural rights of Brazilian Indigenous Peoples since the Brazilian dictatorship (1964-1984).

c) An educational matrix is founded on the seminal work of Paulo Freire “The Pedagogy of the Oppressed”, published in 1968 in the original language (Portuguese), and two years later in the English translation. His work still serves as a reference for almost all contemporary critical pedagogy (Walsh, 2015). Freire’s approach rejects the “banking education”, like an arsenal of technocratic tools and misconceptions of education, to propose instead the pedagogy of liberation, which fosters the capacity of developing independent, critical, creative and context-based thinking (Freire, 2019).

These intellectual and cultural movements, which also encompass other dimensions, such as the artistic and broader intellectual movements (Mendieta, 2016), set the historical background for Latin American critique of development today.

4.3 New trends in the Latin American critique of development

Since the late 1990s, Latin American critical thinking has provided new insights (Escobar, 2005; 2016; Mignolo, 2008), including concepts such as extractivism, political ecology and solidarity economy, that are of great value for rethinking development and putting peace engineering initiatives into a contextual frame. For instance, ‘extractivism’, according to Eduardo Gudynas (2019), refers to an economic model based on the exploitation of natural resources and the production and export of non-processed commodities, supplying the demands of technologically more developed countries, and leading the supplier countries to financial vulnerability. Gudynas uses the term neo-extractivism for the new pattern established with the rise of the left, progressive governments since the end of the 1990s, including Argentina, Bolivia, Brazil, Venezuela, Uruguay and Ecuador. In neo-extractivism, the state is much more active in the economy and provides comprehensive social programs (Gudynas, 2009).

Neo-extractivism reproduces the core failures of conventional market-based extractivism, and in some cases, even increasing social and environmental impacts, maintaining a social structure of high inequalities and of technological dependency. Further, “deterritorialization” means that the setup of productive enclaves, often in remote areas, with contingents of workers, technicians and machinery, are destroying the livelihoods of indigenous and rural communities, such as the case of large-scale oil extraction projects in the Amazon rainforest (Gudynas, 2009).

In this sense, Latin America movements have been looking for alternative sustainable developments. Post-extractivism aims at decreasing technological dependence and building resilient local economies. 'Social technology' and 'solidarity economy' are concepts associated with the socio-technical co-construction with communities and grassroots movements of living and working places based on social justice, empowerment, and participation (Kleba and Cruz, 2020), driven by an engaged motivation with society and ecosystems. Further, the conception of 'political ecology' has been related to the power struggles over conflicting cultural and economic rationalities over the appropriation of nature, and the diversity's rights, to construct sustainability rooted in specific cultural territories (Leff, 2015,p. 41).

These concepts are having a significant impact on social movements, advocacy workers and socially engaged professionals. For instance, the term Abya Yala has become a common political ground for decolonial mobilization and representation of Latin American indigenous peoples since 2004. Abya Yala (from the Kuna people of Panama) refers to "land which gives life" or "the land we live in" and intends to re-signify the territories in which the ancestral peoples of the continent live (Porto Gonçalves, 2015).

Above, we have drawn a broader overview. In the following, we debate two issues of the Latin American/Abya Yala critical thinking, which provide new insights to peace engineering and critique of development: the 'epistemologies of the South' and the reflections on ST&I policies for peace engineering.

4.4 The 'Epistemologies of the South'

Forms of exclusion and violence go beyond the awareness of social injustices. At stake is what kind of knowledge and understandings we are producing when peace engineering is conceptualized and practiced. In this line of thought, the 'epistemologies of the South' is a breakthrough concept. In a nutshell, the epistemologies (the study of knowledge systems) of the South reject the dominant Western worldview, which is still reproducing and imposing colonial structures of thinking,, destroying community-based livelihoods and biocultural diversity (Sousa Santos, 2011). Again, the 'South' here is not geographical. The forms of marginalization are present everywhere, even in the so-called rich countries, although with their particularities.

Latin America is a region where, for more than five hundred years, traditional peoples and communities were regarded as inferior (to the point of debating if they were more similar to animals than humans), as primitives and outdated. So, the

colonizers had the mission (given by God, the king, and science) to civilize these populations by force when necessary. We may well know this story, but probably not the whole dimension of violence, the radical vulnerability of the cultural minorities, and how colonial worldviews continue to threaten the traditional and indigenous' peoples lives and territories today. Not without international astonishment, the far-right Brazilian President Bolsonaro has managed to pass laws to allow mineral exploitation in indigenous reserves,⁶ among other policies, disregarding the rights and vulnerabilities of indigenous peoples.

More importantly, however, the South's critical theory points out that our ways of seeing the world (ontologies) and knowing the world (epistemologies) continue to ignore completely, to make invisible and speechless, the richness of non-Western cultures (Souza Santos, 2011). The critique goes on to claim that science and technology have played a central role in reinforcing the abysmal colonial state of injustice by placing itself as universal (regardless of the local cultural context) and superior, as a way to frame other systems of knowledge as primitive, superstitious and underdeveloped, and as a result, legitimizing their active eradication. By contrast, traditional knowledge systems are not always ancient, as they continue to evolve in the communities.

Traditional peoples use science-like methods such as empirical observation, selection, experimentation, and interest in efficacy, reinventing themselves continually. They often cleverly combining traditional with modern techniques, as we can see in the practices of the herbalists and midwives spread in the Brazilian savanna Cerrado, who are organized in the non-profit association Pacari, that is engaged in environmental protection, empowering communities and valuing traditional medicinal practices (Kleba, 2013). Traditional knowledge systems are better understood as *embedded knowledge*, giving a sense of belonging to their holders and not just conveying information, being *embodied* in people's socialization rather than in textbooks. So, they stay in clear contrast to (natural) science which can be characterized as both disembedded and disembodied (using the classic indicators of objectivity, universal validity, and accessibility through publication) (Daele, 2001).

Dussel (2006) proposes the idea of transmodern pluriversity - also called the 'pluriverse' debate (Kothari et al. 2019) -, meaning that plural cultural worldviews and knowledge systems provide how thinkers of the periphery and those from border spaces join in a communicating space between movements and theories, in dialog against colonialism.

⁶ A.Machado. "Brazil's Bolsonaro moves to free mining, hydro dams on indigenous lands." Reuters. <https://www.reuters.com/article/us-brazil-indigenous-mining/brazils-bolsonaro-moves-to-free-mining-hydro-dams-on-indigenous-lands-idUSKBN1ZZ2TG> (accessed Feb 5, 2020).

4.5 ST&I policies for peace engineering and the challenges of exclusion patterns

Now let us change the focus to reflect on ST&I policies for peace engineering in the Colombian peace agreement, including concerns for relevant and participatory research in the terms of Fals Borda (Arond et al., 2011). To better account for the South's critical thinking, we look at specific exclusion forms, providing a checkup framework for peace engineering and for 'bad development' (any undesirable development outcome).

Peace agreements open the door to new possibilities in a wide range of dimensions of civil society. After years of social conflict, people can explore options to create new futures. In this way, science and technology are tools to transform their reality from situated knowledge in synergy with academic knowledge. Potentialities are in the people of those regions that have been excluded from scientific and technological policies, processes, and narratives. Public policies on research, discovery and impact of engineering are a powerful instrument of the ST&I work. There is a large pool of literature on science, technology and society, but the intersection with peace studies has barely been explored.

According to Ordoñez-Matamoros et al. (2017), the decontextualization of ST&I's public policy in Colombia has adopted a neoliberal and elitist model, ignoring the local context. The Colombian Peace Agreement signed in 2016 between the Colombian Government and Fuerzas Armadas Revolucionarias de Colombia - Ejército del Pueblo (FARC-EP) is a milestone in the country's contemporary history (Presidencia de la República and FARC-EP, 2016). The peace accord did not mention ST&I. However, it is possible to find traces of exclusion in those policies that govern technology research and engineering education. Ordoñez-Matamoros et al. (2017) suggest three forms of exclusion in ST&I policy linked with the development, which we expanded to five forms, explained in the following table:

Table 1. Forms of exclusion in ST&I Policies

Social exclusion	It refers to the segments of society that are typically excluded by and from ST&I and its promotion policies. The patterns of exclusion comprise race, gender, class, and cultural minorities.
Sectorial exclusion	Economic activity sectors with a high concentration of capital, such as those linked with the extractivist or neo-extractivist model, are prioritized over other sectors..
Territorial	Traditional ownership forms of land of Indigenous and Afro-descendant

exclusion	peoples and traditional peasants are not recognized and protected, making them vulnerable.
Epistemological exclusion	ST&I policies, based on the Western paradigm of science and technology, have excluded the traditional knowledge of communities.
Ontological exclusion	Public policy on ST&I follows a development paradigm centered on economic growth, ignoring alternatives worldviews based on ecology, reciprocity, solidarity, and community.

Source: Adapted and expanded from Ordoñez-matamoroz et al. (2017) and Reina-Rozo (2020).

When engineers embrace development projects and strive to design effective forms of ST&I with high standards of social justice, they need to consider solutions to avoid the conventional forms of exclusion mentioned above. As a result, engineers and policy makers should build peace engineering projects upon principles of social, sectorial, territorial, epistemological, and ontological forms of inclusion.

4.6 Lessons learned from the Latin American development and ST&I critique

So, what may peace engineering learn from the considerations of the Latin American critique?

First, there is a new way of understanding ST&I. Whereas acknowledging the many virtues and potentials of science, other systems of knowledge are regarded as rich and complex. Knowledge systems shall dialogue, recognizing the different virtues of each one. Mutual understanding among the distinct cultures should be sought, for example, between engineers and indigenous peoples, by development tools of 'intercultural translation' (Sousa Santos, 2011). For instance, only recently scientists have discovered the complexity of the intertwining of social rules (intermarriage) and agricultural techniques of indigenous tribes in the Amazon to assure a constant adaptation and variation of the genetic pools of the Cassava (*Manihot esculenta*), the leading food in the region (Simas and Barbosa, 2019). Indigenous and local communities have been collaborating closely with climate, food and agriculture science to ensure conservation and experimentation with crops' genetic diversity (De Boef et al., 2013; Pecl. et al., 2017).

Second, awareness of cultural differences is not enough. Instead, a deep understanding of cultural diversity in worldviews (ontologies) is necessary. The Western development model based on private property and individualism stands against non-Western cultures of indigenous and traditional peoples grounded in

common ownership and shared knowledge. In this sense, anthropologists and lawyers working with indigenous peoples' advocacy have pointed out that: *"property for indigenous peoples frequently has intangible, spiritual manifestations, and, although worthy of protection, can belong to no human being. Privatization or commoditization of their resources is not only foreign but incomprehensible or even unthinkable"* (Posey and Dutfield, 1996, p. 95). However, market commoditization of tangible goods (territories; sacred places) and intangible goods (knowledge; arts) is continuously eroding and threatening non-Western cultures' lifestyles. This process lead to inequalities, exclusion, divisiveness and is biasing ST&I policies negatively.

Third, self-determination and community livelihoods are strongly connected. The milestone contributions of indigenous and cultural minorities in providing communal self-reliance concepts, their social and affective institutions should be recognized. Central hereto are notions of reciprocity and 'Buen Vivir'. In the Andean cultures, reciprocity is a complex principle, expressing individuals' duties to their land ('Pachamama' - the mother earth), to co-operative working forms and to their families (Estermann and Pena, 1997). A milestone in the advancement of indigenous rights was the integration in the constitutions of Ecuador and Bolivia of the notion of Buen Vivir (in Quechua '*sumak kawsay*' and in Aymara '*suma qamaña*'), as a legal principle and a cornerstone of the political and economic social order, representing cultural conviviality, communion with nature and a new republicanism of the commons (Lisboa, 2014).

Fourth, sustainable relations to nature and self-determination over territories are essential for protecting indigenous and local communities. Research on those communities' ecological management systems has shown very sound and complex ways of sustainable economies and practices we can learn from (Berkes, 2009). In Brazil, the legal creation of sustainable and indigenous reserves under Lula's government in 2007⁷ and the legal recognition of 'quilombos'⁸ as living spaces for Afro- descendants are crucial institutional innovations in this regard. Today indigenous and local communities play a central role in preserving forests, biodiversity, and water resources, providing ecosystem services and minimizing the vulnerabilities associated with climate change.

Five, ST&I policy can learn by considering the five exclusion forms to promote programs for inclusion. The following section will explore peace engineering cases in Colombia and Brazil.

⁷ The rights of these communities are established by the National Policy of Sustainable Development of the Traditional Peoples and Communities, Brazil, Decreto n 6.040, 2007, Article 3 (I).

⁸ The hinterland settlements founded by slave fugitives.

5. A view of empirical cases in Colombia and Brazil

Next, we discuss some peace engineering initiatives in Latin America. We choose to focus on Colombian and Brazilian cases due to the following reasons: a) both countries provide milestone interventions in peace engineering; b) both countries score highest in structural violence, having the highest GINI index in Latin America, with a coefficient of 50.4 and 53.9 respectively in 2018;⁹ c) both countries are amongst the top four Latin American countries (besides Mexico and Venezuela), accounting for 1 in 4 homicides globally by 2017 (Muggah and Aguirre, 2018); d) we rather draw more in-depth into the analysis of a few initiatives in their national context than present a shallow overview of many countries; and e) the authors have been actively working in peace engineering projects in both countries, with the immersion in real experiences.

5.1. Peace engineering initiatives in Colombia

In this section, two Colombian experiences are described and analyzed through the lens of integral peace engineering. The two processes are in places where the guerrilla conflict was dramatic, the Amazonian and central regions. Both share rural commonalities composed mainly of peasant communities and a history of structural violence, expressed in inequality, exclusion, and displacement. The first initiative is the space for co-designed low-cost technologies with rural communities and former FARC members in the Guaviare department. The second one is the Lab Campesino, involving capacity building of the rural youth population in agroecology in the Sumapaz province in the country's central region.

5.2 Co-design space in a postconflict territory

The Guaviare collaborative design space was implemented in January 2018, two years after the peace agreement. The project started in the area called Espacio Territorial para la Capacitación y Reincorporación (Territorial Space for Capacitation and Reincorporation - TSCR) - Antonio Nariño, located at San José del Guaviare municipality, department of Guaviare, south-east of Colombia, in the transition between Andes mountains and Amazonian Region. For 30 years, the area was under FARC's control, the Colombian state being barely present. Universidad Nacional de Colombia (UNC) led this initiative to impact victims of the war positively. Before the event, the University undertook a series of workshops with the communities to

⁹ The World Bank. "Gini Index." <https://data.worldbank.org/indicator/SI.POV.GINI?end=2018&start=2018&view=map> (accessed June 30, 2020).

identify challenges and opportunities from the peoples' viewpoint and experience (Pérez Molano et al., 2018).

The participants of this experience were mainly peasant communities around the FARC TSCR area, around 20 people, who were invited to participate in the space based on previous consultation. Other prominent participants were former FARC militants who had been members of the subversive group for many years and are now being relocated in a designated area for reincorporation into Colombian society. These people have never participated in science and technology activities before, nor enjoyed their benefits. According to Reina-Rozo, Thompson and Leal, (2018, p. 5) after the peace agreement, *"the tensions in the area have not been markedly reduced... The lack of energy, water, sanitation, health services and education are the norm. Then, each space has to create their own ways to deliver and fill those basic needs"*.

The curriculum created for this experience was focused on creative capacity building, do-it-yourself, manufacture of small devices, and learning by doing (See Image 1). All the participants are immersed in a collaborative design methodology, in teams mixing people with diverse walks of life. The work is based on a previous participant diagnosis and focused on agriculture, tourism, and education. Those populations were considered up to this project as mere clients or technology buyers and not as active actors in creating solutions. Now they should become the participants in a grassroots action to change this situation.

Image 1. Former FARC member prototyping



Source: Juan David Reina-Rozo

This space of performing peace engineering in practice resulted in nine prototypes in education, sanitation, agriculture, tourism, and leisure,¹⁰ combining academic knowledge and the empirical knowledge of peasant and former guerrilla members. The project has involve the people's epistemologies enabling them to dream new futures. Co-design was used to be immersed in conflict. Change-makers were working hand in hand with the affected communities. The prototypes manufactured are the following:

- Abonando la paz – Hakuna bioresiduos (Composting device).
- Bicimolino para concentrado animal – Recolectores nativos (Animal pedal-powered mill).
- Conexión cacao (Cacao roaster).
- Guaviare – Retoteca (Games for children).
- Herramientas para la agricultura – Arrieros (Agriculture tools).
- Juegos de paz – Educación temprana (Peace games).
- Lactiare – Lácteos del Guaviare (Dairy processing).
- Módulos de botellas PET (SODIS) y sombrilla captadora de agua lluvia. (Rainwater collection system).
- PARDO – Turismo para la reconciliación (Tourism for reconciliation).

¹⁰ Innovation Journey. "Resultados preliminares del Encuentro de Diseño para la Construcción de Paz – Colombia 2018." <https://innovationjourney.wordpress.com/2018/02/28/resultados-preliminares-del-encuentro-de-diseno-para-la-construccion-de-paz-colombia-2018/> (accessed Sept 10, 2019).

Some readers may wonder why we have pictured engineers taking part in projects going beyond the creation of 'hard' artifacts. According to ABET's Criteria for Accrediting Engineering Programs 2019-2020 in the US (ABET, 2019), and, for instance, the related Brazilian guidelines (BRASIL, 2019), soft skills in engineering formation and practice are essential. Engineers are defined as producers of artifacts and systemic solutions, which must consider the cultural, social, and environmental context. So, in our view, organizations and faculty working with peace engineering projects shall consider both, hard and soft skills as essential and complementary goals when engineers investigate and co-create solutions with local communities.

According to Pérez Molano et al. (2018), the Guaviare peace engineering initiative has identified a series of challenges. There are sustainability issues, such as how to continue those activities, based on the lack of long-term funding and institutional support. An additional problem is the absence of design concepts (a key component of engineering) adapted to the rural and post-conflict context.

5.3 LabCampesino for Agroecology transitions

The LabCampesino was an exploratory education experience created by Colectivo Enraizando and Tierra Libre, a rural organization located in Fusagasugá (Tierra Libre and Enraizando, 2019). This organization has been working in the territory since 2005 on peasant empowerment and autonomy of the rural population. The project is located at Sumapaz province (Cundinamarca department), in the lower part of the worlds' largest Paramo (an alpine tundra ecosystem): the Sumapaz Paramo. It is a region of environmental and agricultural great relevance, close to the capital Bogotá. The area is one of the leading food producers in the Andes.

The LabCampesino initiative seeks to support small-scale agroecological producers through open access technologies and collaborative creation dynamics in the municipality of Fusagasugá (Reina-Rozo and Ortiz, 2019). This peasant's lab decided to collaborate with rural and urban youth because the rural population is at risk of abandoning rural areas due to lack of opportunities. Simultaneously, the urban youth lacks the chance to learn about agricultural practices (See Image 2). We are losing the knowledge that rural inhabitants have been built for a long time in those territories.

Image 2. Youth peasant learning about communication and community radio



Source: Felipe Otalora

The situation in the countryside is affected by various problems and limitations in the access to services, basic infrastructure and policies that should promote peasant capacities. Rural areas in Colombia also have a history of conflict caused by land property. The projects at stake sought to create spaces of encounter and participation to promote the rural dwellers' protagonism, particularly the youth, in reflecting on their prospects. The rural population will become less vulnerable if engineers engage in working with social movements and policymakers.

Traditionally, young people in rural and urban areas have been excluded from advocacy and decision-making spaces in their territories, especially in science and technology policies. Despite this, the motivation and collective spirit that characterizes young people allow for the participative processes increasing youth autonomy. In the project, they have developed the capacity to give their opinions, understand and influence their daily lives' latent realities, and strengthen their agency.

In this context, LabCampesino was born to generate an inclusive space for youth to learn and build prototypes that can contribute to a good life in rural areas throughout the co-construction of technology and services considering their own epistemologies and ontologies expressed in motivation and dreams for the territory. In opposition to a controlled room where experts create state-of-the-art artifacts, the laboratory sought to create a space close to the community to construct knowledge and prototypes, allowing many hands to build creatively together and recognizing the life experiences of all participants (Tierra Libre and Enraizando, 2019).

From a conceptual framework, LabCampesino uses three pillars its work basis: co-creation, agroecology and community organization, The pillars were embedded in

the perspective of promoting peace engineering. This effort aims to face the structural violence in rural areas through a space and empirical knowledge to generate communal innovations. The material results of the rural laboratory were five technologies, as follows:

- Yurt and dry toilets
- Composting machine
- Mountain microorganisms fertilizer
- Alternative communication and communal radio
- Participatory biodiversity recognition

Campesino Lab's challenges encompass measuring the appropriation and replication of what has been learned, seeking a long-term evaluation and follow-up process with the participants and practitioners in the projects. Further, Campesino Lab aims to implement a monitoring strategy to follow up the agroecological transitions in the territory to evaluate better their environmental impact (Tierra Libre and Enraizando, 2019).

5.4 Three streams of peace engineering in Brazil

When effectively applied, peace engineering initiatives can reduce structural and cultural violence, strengthening positive attitudes to conflict resolution, and establish the institutional conditions for lasting peace. In this sense, how engaged engineering initiatives have been providing solutions for social inclusion and empowering the vulnerable?

Looking into a few Brazilian examples, we may distinguish three streams in which peace engineering initiatives in Latin America have been embedded: a) grassroots engineering, b) social entrepreneurship, and c) an non-aligned stream.. Whereas the first two streams have a clear alignment to political ideologies, the grassroots engineering towards anti-capitalism, the social entrepreneurship to social-democracy and social economy, the third stream is skeptical about strong ideological allegiances (Kleba, 2017).

In Brazil grassroots engineering (Cruz, 2018) relies on concepts such as autonomy, cooperativism and 'solidarity economy', that is, economic activities based on the self-government of producers ("*autogestión*"). Examples of grassroots engineering are given by the ITCP (Technological Incubator of Popular Cooperatives) Network,

comprising 62 university incubators spread across the country working with self-managed community initiatives to generate income and tackle unemployment and precarious work (Felizardo, 2015). An additional example is the well-established university program Soltec (Technical Solidarity Center), of the Department of Industrial Engineering at the Federal University of Rio de Janeiro (UFRJ). Soltec has a strong commitment to community engagement.¹¹ seeing itself as grassroots engineering, aiming to foster 'solidarity economy' and anti-capitalism. The activities of Soltec include supporting the Landless Workers' Movement (MST), the artisanal fishing communities, companies recovered by workers, and social movements in general, especially those concerned with the protection of threatened minority and identity rights (Kleba and Cruz, 2020). The MST has been the target of much violence, with deaths and evictions in recent times.¹²

However, the idea that small entrepreneurship represents undesirable features of capitalism leads this approach to show discomfort with small and family businesses, even when this is the dream of slum dwellers.¹³ Nonetheless, grassroots engineering represents a thriving movement in the experimentation of new forms of social economies. Its aims to strengthen the (left wing) social movements in making democracy and civil society's role in Latin America more robust.

A second stream engaging engineers is social entrepreneurship, including social hubs and social start-up accelerators and incubators, such as the Yunus Youth, Artemisia and Endeavour. For instance, the organization Enactus has about 120 university teams in Brazil (Enactus is present in 37 countries), with the vision of 'changing the world' by stimulating social businesses' creation with social impact.¹⁴ Social entrepreneurship portrays market initiatives focusing on social ends, not on profit, in variable arrangements about what is allowed to be done with the profits (reinvesting in the mission, donating for the poorest, and so on) (Abu-Saifan, 2012).

However, social entrepreneurship uses the same tools of conventional for-profit business, pursuing efficiency, productivity, measurements, and high competition (there is a national and an international level of team competition). The social economy has been seen as the primary solution for what the market fails to

¹¹ NIDES. "Soltec - Quem Somos." <http://nides.ufrr.br/index.php/projetos-soltec/tifs/19-programas/soltec/soltec-quemsomos> (accessed Jan 26, 2020).

¹² N.Lacerda. "2019 in Review - Bolsonaro targets the MST, violence grows in the countryside". Brasil de Fato. <https://www.brasildefato.com.br/2020/01/02/2019-in-review-or-bolsonaro-targets-the-mst-violence-grows-in-the-countryside> (accessed Jan 26, 2020).

¹³ Carneiro, R. Dutra. "Ódio à classe média, "pobrismo" e empreendedorismo." Carta Capital. <https://www.cartacapital.com.br/blogs/vanguardas-do-conhecimento/odio-a-classe-media-201cpobrismo201d-e-empreendedorismo/> (accessed Dec 12, 2016).

¹⁴ Enactus. <http://www.enactus.org.br/> (accessed Jan 26, 2020).

accomplish (eradicate poverty, making the economy green, and so forth). At the same time, neoliberal policies have been instrumentalizing this idea as a means to substitute, shrink and dismount the welfare state and its social and environmental policies (Avelino et al., 2019). The social economy is almost exclusively market-driven, narrowing the search for broader transformative social innovations encompassing smart public policies, civil society organizations' funding, and community-driven innovations.

A remarkable example of what social entrepreneurship can achieve is Moradigna ("Living with Dignity"), a social business founded in 2015 by Matheus Cardoso, when he was a 20-year-old civil engineering student. Cardoso grew up in a 'favela' (slum) of the megacity São Paulo in poor conditions; his house and neighborhood were frequently subjected to flooding and mold. Many homes had neither windows nor ventilation, leading to bad health conditions.¹⁵ He managed to get a scholarship for undergraduate studies and became enthusiastic about engaging in his university Enactus team. Today Moradigna has already reformed more than five hundred houses in São Paulo and Rio de Janeiro's favelas, at a low cost and extended credit schemes.¹⁶

After his experience of joining in to solve shared problems in his favela through 'mutirões' (collective action), the business idea came to Cardoso. The business primarily employs local people, generating income and thus establishing trust among neighbors. Several house repairs for the poorest are donated through partnerships.¹⁷ There have been many examples of social business directed at the most vulnerable in society, including initiatives with women in prison or dealing with violence against women, Afro-descendants, and LGBT+.

Finally, the third stream of peace engineering initiatives is portrayed as the non-aligned stream. It follows its own set of values but rejects allegiance to ideological systems. There is a political-ideological antagonism between the two first streams. By contrast, the non-aligned stream recognizes both self-governed cooperatives and social businesses as legitimate forms of self-organization, leaving it up to community partners to decide how they wish to organize themselves (Kleba, 2017).

Probably, most Humanitarian and Development Engineering initiatives in the global North, as identified by Smith et al. (2017) and Schneider, Lucena and Leydens (2009) are placed here. Transformative actions encompass different shades of

¹⁵ El País. "O engenheiro que quer transformar a periferia onde cresceu". (23 Aug, 2017). https://brasil.elpais.com/brasil/2017/08/22/economia/1503370922_013669.html (accessed Jan 26, 2020).

¹⁶ Moradigna. <https://moradigna.com.br/> (accessed Jan 26, 2020).

¹⁷ See footnote 15.

social innovation by “*linking with multi-layered ‘narratives of change’ in both mainstream and grassroots movements*” (Avelino et al., 2019, 199). In this line thought, the engaged engineering program of the Laboratory for Citizenship and Social Technologies (Lab-CTS) of the Aeronautics Technological Institute (ITA), which is located close to São Paulo, has been working with vulnerable communities, cooperatives and civil society organizations.¹⁸ Lab-CTS has also supported Enactus/ITA’s social entrepreneurship in co-constructing with a local community of river dwellers clean energy solutions generating income and capacity building (Kleba and Vidal, 2018).

Indeed, the non-aligned stream also bears risks. One may advocate a pragmatic stand (engineers are compassionate, talented builders and developers), at the same time ignoring how technology and innovation are linked to cultural and value-based options. In allowing an excessive eclecticism, core values may be neglected, taken for granted, or not sufficiently reflected upon. Concerned engineers may ask whether co-creation, social justice (Nieusma and Riley, 2010), nonviolence, empowerment, decolonial, and post-colonial critique are effectively considered in designing and implementation peace engineering projects.

No matter in which stream of peace engineering, proactive initiatives working in favelas, in urban or rural areas, with gender issues and affirmative actions, or with cultural minorities and threatened indigenous peoples, are always a touchstone in changing a culture of violence present in the geographical and cultural landscapes of Latin America.

Considering the policy dimension, much can be done to advance the context in which peace engineering initiatives may take action. In Brazil, an opportunity for deepening engaged projects within university programs has been set up recently by Brazilian Law 13.005/2014, which commands universities, including engineering schools, to: “ensure, at least, 10% (ten percent) of the total curricular credits required for graduation in service-learning programs and projects, guiding its implementation, primarily, in areas of great social relevance” (BRASIL, 2014, Art. 12.7). This law has been further specified by Resolution Nº 7/2018 and must be implemented in universities with the deadline of December 2021 (BRASIL, 2018). Engaged service learning in engineering schools is an essential tool to train and alert engineering students towards peace engineering challenges (Crocco et al., 2019).

¹⁸ Citizenship and Social Technologies Lab - ITA. <https://www.labcts.org/> (accessed Aug 14, 2020).

6. Conclusion: A collective future for peace engineering

What can engineers, engineering organizations and engineering schools do to foster peace engineering? We hypothesize that peace engineering relies on the foundational insight that development depends on peace, and vice versa. So, building peace results from overcoming the interconnected forms of structural, cultural and direct violence. Further, peace is not merely the absence of conflict but also a general framework that enables and encourages peace attitudes. Peace attitudes are more assertive when based on shared values of social cooperation, which must be actively cultivated in society. Comparative research has shown that countries combining a high level of welfare, equality and democracy tend to be ones with the highest positive peace levels (Institute for Economics & Peace, 2020; EIU, 2020).

Development is a contested concept, and much effort has been made to rethink development on a new basis. In the last twenty years, many initiatives have arisen with the purpose of redefining the role of engineering formation and practice with a critical view on development. Such engineering initiatives engaged in ethical and transformative ST&I practices with communities and organizations are also clearly peace engineering initiatives, as they act against structural and cultural violence. The sound design of socio-technical projects must be bring together high standards in ST&I and strong principles of social justice. Awareness about the critique of development can help us to avoid failures of past development approaches. .

Rethinking development leads to revisiting the role of ST&I. It must work for people and ecosystems, intertwined with the spaces of proactive mobilization, in which organizations, social movements and local communities are pursuing the creation of a new social order based on social inclusion and social justice. The empirical cases have shown the value of these innovative processes situated in the territories, creating engaged technologies and services within communities to foster positive peace. Peace engineering practices can be shared under diverse regions and organizations, centered in local communities and generating sustainable opportunities, towards engineering for social transformation (Reina-Rozo, 2020).

Looking at Latin American critical views on development, we will find common issues with other regions and particularities. Latin American liberation movements underline how economic welfare must go hand in hand with the pursuit of a society built upon equality, liberation pedagogy, and solidarity. From the economic perspective, any development concept centered solely on economic growth, will fail to put human values at its core. Latin American countries' central challenge has been to reduce

their dependency and economic vulnerability in the global order. So, the design of socio-technical projects in such a context shall take a post-extractivist approach, adding value to the supply chain, reinforcing local consumption, and protecting the territories and cultures of indigenous peoples and local communities. In this sense, concepts such as solidarity economics and Latin American political ecology provide insights into alternative developments.

To rethink the role of ST&I, the critical debates in Latin America have provided powerful concepts. The notion of 'epistemologies of the South' invites engineers, educators and activists to become aware of non-Western cultures' richness. Sound socio-technical solutions require a deep cultural understanding of indigenous and local communities' livelihoods and ways of life. It also demands dialogue between science and other systems of knowledge. Further, ST&I policies for peace engineering must carefully consider forms of exclusion by promoting practices such as co-design, social technologies, knowledge dialogue and Buen Vivir ontology.

The analysis of empirical cases sheds light on how peace engineering can take action in real situations. Looking at the initiatives in post-conflict Colombia, we learn that peace engineering can foster ST&I focused on people's needs, integrating socio-technical projects in cultural processes fostering peace attitudes and social cohesion. By contrast, the Brazilian analysis disclosures that peace engineering may intervene in many possible ways, along the dimensions of the civil society, the social economy, and public policies. Social transformation towards peace attitudes and development centered in human values requires experimentation and active engagement.

Peace engineering may learn lessons from a variety of engaged engineering practices. Grassroots engineering aims at participatory methodologies, contributing to popular education and solidarity economy and building resilience in local communities. Links to social businesses may be a thriving concept to work with the youth in urban slums. Finally, peace engineering ought to experiment more with forms of activist engineering (Karwat et al., 2014).

To advance in the field of peace engineering, further research is needed. We envisage the following questions: How to understand better the dimensions of cultural and structural violence in the agency of peace engineering projects? How can we reach a better comprehension of the complexity and creativity of non-Western cultures in participatory processes of technology development and social innovation? In which ways can we align the search for solutions of ST&I policies with critique of development when working in postconflict situations and conflict prevention?

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