# Assessing Grassroots Engineering Applications in Brazil

**Dr. Cristiano Cordeiro Cruz, Aeronautics Technological Institute**

I currently develop a post-doctorate research at the Aeronautics Technological Institute (ITA) with a scholarship from FAPESP (#2018/20563-3). I hold a PhD degree in Philosophy (University of São Paulo, 2017), a bachelor degree in Philosophy (Jesuit Faculty of Philosophy and Theology, 2008), a master degree in Electrical Engineering (University of Campinas, 2002), and a bachelor degree in Electrical Engineering (University of Campinas, 1999). My research area encompasses philosophy of technology and of engineering and engineering education. I am now studying grassroots engineering (GE) and social/solidarity technology (ST), as well as engineering education, focusing, on one hand, on the ethical-political, aesthetics, and epistemic aspects that both characterize and make GE and ST possible, and, on the other hand, on the challenges the engineering education must face in order to train/develop the capabilities or skills engineers must possess so to be able of doing GE and producing ST. The work I currently develop at ITA is related to the conception and institutionalization of a minor in engaged engineering.

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In Brazil, service learning or community service is an integral part of every university's fundamental duties, along with teaching and researching. The type of learning or service to be provided, however, depends on the hermeneutics applied, which can either lead to group empowerment and socio-technical change or to mere paternalism.

In the early 2000s, during the two terms of Lula as president of Brazil, many community service/ service-learning teams were established and institutionalized, linked to engineering courses and faculty members. From the conjugation of social technology and solidarity economy movements, some of these teams developed a form of engineering practice that is now called *grassroots engineering*.

In this manuscript, along with a brief recall of the most important facts concerning the emergence of Brazilian grassroots engineering (GE), I will: 1) present three of the GE's current leading teams; 2) discuss some of the theoretical and methodological basis of GE; 3) analyze some of the impacts of GE on the supported group; 4) highlight the main aspects of the formation process and evaluative tools provided to students; and 5) discuss some potentialities and limitations of GE.

In doing so, I will draw on different GE teams' publications, interviews with some leading grassroots engineers, and my perception as a member of the GE network, Repos.

## Introduction

According to Brazilian law, higher education must articulate teaching, research, and extension [1]. Extension means a wide variety of activities, "ranging from community engagement to junior company; from cultural production to juridical assistance to the poor; from university hospitals to extension courses destined to present academic knowledge and research to non-specialized audience" [1]. The aim of extension is to create "A process that promotes a transformative interaction between higher education institutions and other sectors of society, through the production and application of knowledge, in permanent articulation with teaching and research" [2].

One important type of extension is performed by extension centers, institutionalized groups of teachers, students, and administrative staff, that develop community engagement activities. In this manuscript, one specific type of extension center that practices *grassroots engineering* (GE) is analyzed.

In so doing, I seek to address two complementary research questions: what are the specificities, both methodological and theoretical, of GE as a community engagement activity? What are the benefits of GE to the groups being assisted and the students that take part in these initiatives?

This paper is divided into five main parts: the next section presents a brief overview of GE's development since it first emerged in the early 2000s, concluding with a presentation of three extension centers that are home to some Brazilian leading GE teams; then, I present part of the

methodological and theoretical basis of such teams' work; section three analyzes some of the GE's impacts on the supported groups; section four briefly present the way these extension centers manage to prepare their students to perform GE and to evaluate them; finally, the closing remarks return to the two research questions, summarizing the answers offered throughout the paper.

The method used in this work entails collecting data from chapters, papers, books, and official websites of universities as well as from interviews I conducted with some grassroots engineers and my perception as a member of the GE network since 2016.

Throughout the paper, I am using verbs like "assist" and "support" in such expressions as "supported/assisted group." This use is not meant to suggest any asymmetric relationship between engineers and grassroots groups. Indeed, in grassroots engineering, both parts are equally responsible for the technical design and implementation, as well as for the popular education process that is undertaken. From their (GE engineers' and grassroots group's/ people's) own and different experiences, knowledge, training, values, worldviews, they have something to teach to one another and to learn from each other. If this exchange does not happen, it will not be grassroots engineering. So, "assisted/supported group" is used due to my ignorance of a better expression.

**Brazilian Grassroots Engineering**

Based on Fraga, Alvear, and Cruz [3], it can be said that the process that eventually produced grassroots engineering emerges right after the ending of the Brazilian civil-military dictatorship (1984-85) when a forum of extension deans is created. This forum changes the way university extension is practiced, it is no longer mostly centralized by the Federal Government and performed in remote areas of the country. The local universities begin to manage it, working mainly in the surroundings of their campuses [3], [4].

In addition to that, and as a consequence of this same forum of Extension Deans' articulations, it is created a *Program of University Extension*. Such a program, during the administrations of the Workers' Party (2003-16), will allow university extension to become public policy. This means that funding lines will be granted, plus the possibility of strategically associating some extension programs with many ministries' action plans. In this sense, it can be said that, during the Workers' Party's administrations, university extension becomes a space for the articulation between the State and society [3], [4].

Also, in the early 1990s, the solidarity economy movement gains momentum nationwide. That is mainly caused by the increasing rates of poverty and unemployment, which are some of the consequences of the implementation of neoliberal politics in the country. In response to that, many social initiatives are tried, from collecting food destined to feed the millions who were facing starvation, to actions that sought job creation. In 2001, with the first edition of the World Social Forum, the multiple actors behind such poverty mitigation/overcoming initiatives found a place to gather and talk. This proved fundamental for the strengthening and unification of the Brazilian solidarity economy movement [3].

Solidarity economy encompasses collective economic enterprises (i.e., cooperatives, associations, and informal groups) that have as guiding ideals: self-management, cooperation, and solidarity. In 2003, Lula da Silva's administration creates the National Secretariat of Solidarity Economy, aimed at fostering such productive enterprises. Also, in 2003, a national program of university incubators of solidarity economy initiatives is resumed. This program encouraged the creation of many university extension centers nationwide that practice this new type of extension that emerged after 1985, have the solidarity economy ideal as one of their non-negotiable principles, and can find support or strategic association with the new Secretariat of Solidarity Economy [3].

Along with this new kind of university extension and the solidarity economy ideal, a third and final main ingredient to the construction of grassroots engineering is social technology (ST) (also known as *solidarity technology* [5]). As such, ST is a latter offspring of the appropriate technology movement, which emerged with Gandhi's traditional spinning wheel (Charkha), in the 1920s; it achieves its climax in the 1970s and early 1980s. The movement is then abandoned almost everywhere as a consequence of the hegemonic imposition of the neoliberalism credo in the mid-1980s [3], [6], [7].

The Workers' Party's federal administrations promoted ST through the Secretariat of Science and Technology for Social Inclusion, created in 2003, and through the continuation of an annual award of ST best solutions and a cataloging effort of ST initiatives countrywide by Banco do Brasil (Brazil's second-biggest bank, which is a federal public company), something that started in 2001. On top of that, ST was also promoted by some civil society organizations, such as the Social Technology Network and the Social Technology Institute [3].

Formally, ST can be defined as: "a set of transformative techniques and methodologies, developed and/or applied in interaction with [grassroots] people and appropriated by them, which are solutions for social inclusion and the improvement of living conditions" [8]. Like appropriate technology (AT), social technology seeks to address poor people's urgencies and problems in a way that does not (or should not) cause any type of dependency of the assisted group on technical or economic help from outside the group [3], [6], [7]. Unlike some AT initiatives, ST building process is committed to the empowerment of the assisted group and to the valorization of the group's knowledge and its incorporation into the technical solution being co-designed and co-constructed [3], [6].

From the above, it can be stated that grassroots engineering is mostly shaped by these three streams: university extension, solidarity economy, and social technology (or solidarity technology). Indeed, despite some specificities and some additional commonalities, the main aim of most GE practices is to produce social technology in support of some socio-technical challenge of a solidarity economy enterprise, and this is usually performed by GE teams linked to a university extension center [3]. Some minor but existent variations in this GE's threefold description are: GE teams not linked to a university, such as [9] and [10]; socio-technical solutions not associated with a productive challenge, such as the Brazilian semi-arid cisterns [7].

*Engineering and Social Development Meetings & Grassroots Engineering Network*

A fundamental arena for GE's constitution and advancement was the national and regional annual Engineering and Social Development Meeting. It was at these meetings, which started in 2004, that extensionists (that is, practitioners of university extension) committed to social technology and/or solidarity economy in non-rural areas found a place where they could share their experiences, debate their ideas, and also attract and provide some initial formation to new students [3].

It was at these meetings that the option to privilege the assistance of (and association with) social movements over isolated grassroots enterprises started to spread widely through the GE teams [3]. The rationale behind this, which is not a unanimity, even though more and more GE teams acknowledge it as something important, is that social movements are bigger and stronger than GE teams or isolated grassroots enterprises to force or bring about the political-economic transformations necessary for the construction of this "other possible world" that is sought. Moreover, assisting social movements reinforces the supporting role of GE teams. This means, on the one hand, that grassroots engineers are not – and cannot be – saviors or leaders of the poor but can be their partners [12]. On the other hand, such proximity does also allow the movements to contact GE teams and propose demands for technical assistance (instead of waiting for such teams to contact them and offer their support), presenting to these teams problems/ challenges for their research and extensionist action.

These national and regional meetings did also lead to the constitution of a grassroots engineering network in 2014 called Repos (an acronym for Oswaldo Sevá Grassroots Engineering Network). Repos' intended proposals are: to technically support social movements across the country; provide formative experiences for those interested in GE practices; and reflect on Brazilian engineering syllabuses so as to be able to lobby for an engineering education compatible with the formation of grassroots engineers, and assist universities and/or governments in the implementation of such formation processes [3], [13].

From within Repos, it has been consolidated an understanding – or definition – of what grassroots engineering is. That is, "a practice that, through university extension, develops social technology along with solidarity enterprises, based on participatory methodologies [...]" [3]; a practice that intends to be a Freirian popular education process, an activity that contributes to engineers' and local people's enlarging consciousness and, as result of this, that leads to conceiving and implementing (or trying) utopias, other possible socio-technical realities. It is mostly such commitment to the construction of an alternative – and counter-hegemonic – reality, from and along with grassroots groups, the poor(est), that not only brands this type of engaged engineering but also distinguishes it from other engaged practices.

The Engineering and Social Development Meetings keep on attracting students. For example, 262 participants attended the 2018 national edition, the last one for which there are consolidated data available. Besides, Repos, which is also responsible for supporting the local organizers of these meetings, seems to be growing stronger, perhaps at a slower pace than many would like, but steadily. These two aspects seem to play an important role in the shared perception of many GE practitioners, in which, despite the highly adverse Brazilian political scene since the removal

of Dilma Rousseff from office (2016) and, mainly, after far-right Jair Bolsonaro's presidency inauguration (2019), GE teams not only survive (in many cases, however, with much less money and undergraduate students (as scholarship holders)) but are also being created nationwide.

*Leading Grassroots Engineering Teams*

Many groups, linked or not to university extension centers, identify their ideals with some or all of GE's. Examples of such groups are Engineers without Border, in São Paulo city, Natal, and other Brazilian places. This also holds for self-organized undergraduate students' teams at many public universities and some extension centers. Repos, the grassroots engineering network, does not consider it legitimate to accredit a role for itself, whereby it would be entitled to grant the "grassroots engineering" mark.

However, there are some teams that, for most or all of Repos' participants, are very good exemplars of what GE means (or can mean). These teams, however, are not taken as perfect, nor are they considered as models to be copied. Instead, they are seen as inspiring examples that might provide some general guidelines on how to perform GE and/or on how to form students capable of practicing GE.

I identify four of these groups, all of them formal university extension centers: Soltec, at Federal University of Rio de Janeiro (UFRJ); ITCP, at State University of Campinas (Unicamp); Pegadas, at Federal University of Rio Grande do Norte (UFRN); Alter-Nativas, at Federal University of Minas Gerais (UFMG). In what follows, there is a brief presentation of each group, highlighting some of their main characteristics. The methodological and theoretical basis of their practice is discussed in the next section.

Soltec, an acronym for "Technical Solidarity," is the most consolidated grassroots engineering team. It was created in 2003, linked to the course of Industrial Engineering of the UFRJ's Engineering School at Rio de Janeiro [14], [15]. Its history blends with that of GE, at least in the first years of grassroots engineering. Indeed, for instance, the Engineering and Social Development Meetings, the arena that made GE's emersion and polishing possible, is created by Soltec, which also hosted its first four editions [3].

Currently, Soltec develops six different GE projects:

- PAPESCA: offering a community that makes its living from artisanal fishing support related to management, solidarity economy, empowerment, environmental sustainability, etc. [16];
- TIFS: providing technical support on software engineering to social movements, building with them apps, programs, websites, etc. [17];
- OTA: supporting companies recovered by workers and a few other solidarity economy initiatives with challenges linked to self-management, production, etc. [18];
- CACI: building, along with some Movement of Rural Landless Workers' (MST's) leaders, courses on agroecological management and cooperation, offering these courses to farmers from the movement and other related initiatives [19];

- RIPER: supporting cooperatives of waste pickers by strengthening these cooperatives' network, fighting for the implementation of the selective collection according to what legislation preconizes, and diffusing and implementing the solidarity economy ideals [20];
- ETNO: providing support on solidarity economy to traditional groups (i.e., native communities and quilombolas [21]), aiming at strengthening them culturally and economically [22].

As permanent staff, Soltec reckons with a team of six fulltime collaborators (two teachers, four technical-administrative officers (two of them, Ph.D. holders, authorized to teach and do research), and one graduate student) with background on Engineering (4), Law (1), and Psychology and Journalism (1). They are in charge of both managing the center's activities and infrastructure, and leading most of Soltec's research/action projects. Also, there are six part-time volunteer collaborators (five of them teachers at UFRJ or other federal universities), all with a background in engineering, who support or coordinate some of Soltec's projects. Each project has about six undergraduate/ graduate students. Students' courses/ backgrounds vary, including Production Engineering, Electronic and Computer Engineering, Environmental Engineering, Sociology, Social Service, and Architecture and Urbanism.

ITCP is an acronym for "Technological Incubator of Grassroots Cooperatives." There are more than a hundred of such incubators across the country, each one an extension center linked to a university, supporting a great variety of productive enterprises [23], [4]. For grassroots engineering, however, the particularly relevant one is that of Unicamp.

ITCP/Unicamp was founded in 2001, linked to the Office of the Vice-President for Extension and Outreach [24]. In 2013, a second ITCP was founded at another of Unicamp's campuses. The ideals and methodologies of both ITCPs are quite the same, and their teams overlap in a significant way [25]. That is why their numbers, which are not separated on their single official website, will be presented together.

Since 2001, 31 grassroots groups have been assisted, directly affecting about 850 people. Two hundred students have been ITCP/Unicamp members as extensionists (as scholarship holders), along with 700 additional ones who had more punctual contact and action. Currently, the ITCP/Unicamp's team is formed by one teacher (with a background in both Engineering and STS) and 16 students (from different graduation courses) [26]. They assist two groups: a cooperative of waste pickers (providing technical assistance and support on solidarity economy challenges); a rural pre-settlement of 100 familiar farmers (helping them sell their produce) [27].

Pegadas, an acronym for "Engineering and Managerial Projects Applied to Environmental and Social Development," was created in 2010 linked to the Department of Production Engineering of UFRN's Engineering School at Natal. Its focus is on solidarity economy enterprises (either cooperatives, associations, or informal groups), cultural organizations, productive networks, and supply chains. Pegadas aims to support and strengthen such initiatives, helping them with their economic, social, technical, environmental, cultural and/or political viability. They do so through assistance and formation on management, innovation, and social technology [28].

Currently, Pegadas has two teams. One of them works with solidarity economy enterprises in general; the other focuses specifically on companies recovered by workers [28]. On average, about ten undergraduate students have participated as Pegadas' members every year. Their courses vary, encompassing Engineering, History, Pedagogy, Psychology, Public Policies, and Communication. The founder and only permanent member of Pegadas is a teacher with a background in Production Engineering.

Alter-Nativas (Alter-Natives), at UFMG, is the fourth inspiring GE team. All its members are graduate students that have on their extensionist practice their research problem. Most of these actions/researches take place at cooperatives of waste pickers or companies recovered by workers. Yet, there is no formal extension center. What binds all these works together is these students' supervisor, a Production Engineering full professor named Francisco Antunes Lima. These engineers' actions/reflections are highly valued among grassroots engineers, and their theoretical and methodological approach to GE is a unique one. Nevertheless, Alter-Nativas completely lacks consolidated data about its history and its deeds. That is why I could not accurately present it in this section.

Table 1 summarizes part of the information presented in this section.

| | **Creation** | **University** | **# Teachers (2019)** | **# Students (2019)** | **Assisted Initiatives (2019)** |
|---|---|---|---|---|---|
| **Soltec** | 2003 | UFRJ | 9 | +/- 30 | Solidarity economy initiatives, Social movements, Agroecology, Coop. of waste pickers, Traditional/Native communities. |
| **ITCP/ Unicamp** | 2001 | Unicamp | 1 | 16 | Coop. of waste pickers & Rural pre-settlement |
| **Pegadas** | 2010 | UFRN | 1 | +/- 10 | Mostly, solidarity economy initiatives |
| **Alter-Nativas** | ? | UFMG | 1+ | 5+ | Coop. of waste pickers & Comp. recovered by workers |

*Table 1 – GE Teams' General Aspects*

**Methodological and Theoretical Basis of Grassroots Engineering**

The methods and theoretical basis of grassroots engineering became a research object just recently. Professors Lais Fraga (State University of Campinas) and Bruna Vasconcellos (Federal University of ABC), along with myself, are about to start an analysis of GE's specificities and commonalities. Yet, some of GE's general traits, as well as some GE teams' particularities, are clear enough to be singled out. Four of such elements are presented here: popular education; non-neutrality of technology; action research methodology; and ergonomic activity analysis.

Generally, as stated earlier, GE is always committed to solidarity economy, social technology, and thinking of and implementing other possible socio-technical realities (or utopias). The

questions that remain to be answered are: how do GE teams proceed in assisting grassroots enterprises? And on what theoretical basis do they do so? Let us start with the latter.

*GE's theoretical basis*

Among the multiple and diverse theoretical references grassroots engineers make use of when substantiating their research/action, one is undisputable and unanimous: Paulo Freire's popular education [29]. Roughly stated, Freire's theory considers education's most important result to be human – or the oppressed – liberation. Liberation from oppression and a less fulfilled life. This other possible world – of freedom and "being more" – is not given, nor can it be built individually or theoretically. Instead, it can only bring about as the result of a collective effort of mutual liberation and mutual education, necessarily mediated by the social reality we live in. That is, from reflecting about the world, collectively trying to change it, and reflecting about the results of our actions, we learn more about society and ourselves (mutual education; enlarging our consciousness), and we become more capable of dreaming other possible worlds and of making this dream come true (mutual liberation).

In this sense, GE's ultimate proposal is to help grassroots groups conquer an enlarged consciousness and cultivate their ability to dream and fight for the construction of "the other possible world." On the other hand, as a result of this same educative and liberating process, GE practitioners do also get an enlarged consciousness and associate themselves with the supported group on this effort of conceiving and implementing this other desired socio-technical reality. That is why, in a way or another, grassroots engineers must also be popular educators [24], [28]. Thus, as stated elsewhere [1], in close dialogue with some of Freire's main works [12], [29], an engineer capable of GE must be an *educator engineer*, someone with empathy and critical sense, capable of dialoguing, and opened (and able) to learn with non-schooled people and from non-academic knowledge.

Why exactly does GE demand an educator engineer? This leads to the second unanimity among GE teams: the non-neutrality of technology. To address this point, we must acknowledge that, as presented elsewhere [1]: a) every technical challenge can usually be addressed through different technical solutions; b) each technical solution *necessarily* favors or emulates some (set of) ethical-political values over others; c) because of "a" and "b," society and technology shape one another in a way that d) technical development and engineering production are things to be democratized, to be disputed, in the case of GE, by grassroots' needs and (critically taken) values and worldviews.

This means that technical knowledge (not to mention science [31]) can be enlarged, allowing for the democratization of technical development and, with that, for the construction of this other possible socio-technical world that the 90% might dream about. Changing our social reality is not only a matter of political fight for institutional transformations. If we do not also change the society's (socio-)technical substrate, from material devices and systems to technical procedures and technical codes, this other socio-technical world will not be realized. This is so because, as stated earlier, society (with politics, institutions, ethical-political values, worldviews, etc.) and technology (produced by engineers and other technical professionals) shape one another [32]-[34].

Grassroots engineers must then be able to both criticize the available (hegemonic) knowledge (that they themselves possess) and to co-construct that enlarged technical knowledge (for example, in the form of social technologies) in line with grassroots people's own knowledge, ethical-political values, and worldviews. Yet, since the oppressed (or colonized) do not usually want to break free, but instead want to become the oppressor (or colonizer) [29], GE, in its "popular educator role," must also create room to allow the grassroots people to critically think about their values, demands, and/or worldviews.

Only someone with empathy, critical sense, ability to engage in a dialogue, and open do learn ("even" with uneducated people), plus being "technically well-formed," can do all this. So, only an *engineer educator* can perform grassroots engineering.

In GE teams' typical practice, both the critique of possessed knowledge and/or values, worldviews, etc., and the enlargement of knowledge, consciousness, values… are developed together and organically (i.e., as an integral and non-artificial part of the support provided) with the phases of the assistance process. In many cooperatives assisted, for instance, the very solution of the technical problem to be addressed (of management or production, for example) requires that the engineers' (academic/technocratic) knowledge be changed or enlarged (so to fit the specificities of that particular group) and that some of the cooperative members' values/worldviews (not too cooperative, not too open to dialogue, prejudiced and/or…) to be modified. Thus, throughout the assistance, some or many of the (group) conversations to be undertaken will have elements like "lack of cooperation" or "misogyny" as their theme, and talking about it will be a way of becoming more critical/reflexive and of perhaps changing values/worldviews or, at least, of modifying habits. On the same token, knowing what is non-negotiable to the group (say, the reduction of workplaces or the increasing of work hours) forces grassroots engineers to go beyond what they learned at school (the latest understanding of mainstream production engineering) so to be able to help the group with their socio-technical demands properly.

As already unraveled above, grassroots engineers are supposed to be personally implicated in this supporting process. They are not expected only to provide technical help but also to take part in the very struggle for survival and political acknowledgment that the assisted group is facing. On the one hand, trying to be in the supported group's shoes is fundamental for the sort of technical design/construction that GE is committed to, as only such experience can unveil some of the group's needs, values, conditions, and worldviews, and can allow for a real dialogue of knowledge. On the other hand, standing side by side with the oppressed that one is trying to serve is a natural and necessary attitude since GE is consciously and explicitly committed to transforming the oppressing and violent reality that GE groups, together with the rest of the 90%, live in.

That is why the third unanimity among GE practitioners is the adoption of action research methodological approach. As Thiollent, a scholar that is influential in the GE field, states it, "[...] action research is a kind of social research with empirical basis that is conceived and undertaken in close association with an action or the solution of a collective problem. A research in which

researchers and the representative participants of the situation or problem are involved in a cooperative or participatory way [35].”

In order to be an action research, an investigation/action must observe six conditions: to guarantee a close interaction among researchers and supported people; from this interaction, to rank the problems to be investigated and addressed; have the situation, instead of the supported people who live it, as the research object; have as its main goal the solution or, at least, a better understanding (by researchers and supported people) of the identified problems; assure the supported people a central role in the decisions and actions taken throughout the process; as a result of this process, to enlarge the researchers' knowledge and the supported people's consciousness [35].

As can be seen, action research and popular education have a lot in common. As Comstock states, action research, as a type of critical research, is the broader process or methodology. Popular education, in turn, can be usefully implemented as part of such process, to help the supported people (and also the technical team) to see things differently, to overcome alienation to some degree and, with that, to be able to think of a better reality for themselves [36].

*GE’s methodologies & Ergonomic Activity Analysis*

ITCP/Unicamp reverses Comstock’s order, thinking of its incubating activity as a big popular education process assisted by action research methodology. Roughly put, the incubation they practice has three main phases: 1) creation of affective and trust bonds, investigation of the enterprise’s and grassroots group’s situation, and creation of an incubation plan; 2) execution of the incubation plan (which can be freely adjusted so to face new challenges or emergencies that might emerge during this phase); 3) progressive exit of the ITCP’s team from the supported initiative (dis-incubation). At the end of phase three, what is aimed at is the enterprise’s financial sustainability and political strengthening. ITCP/Unicamp acknowledges, however, that incubation is only part of a bigger process for making solidarity economy thrives; a process that also demands credit granting, proper infrastructure, and public policies [30].

Pegadas has chosen to have a different approach, focusing more on the networks of solidarity economy enterprises than on assisting enterprises individually. Because of that, their leading practice has to do with forming multipliers, creating straightforward material about technical and managerial issues, and offering workshops on these subjects [28].

Soltec, on its many projects, usually does also follow the same three phases of the ITCP’s approach: knowing, connecting, and making an assistance plan; executing (and adjusting) the plan; ending the support [37], [38]. Yet, perhaps because Soltec acts in multiple fronts and in different engineering areas (which is not the case for ITCP/Unicamp or Pegadas, which mostly deal with cooperatives or similar productive enterprises, helping them with production and managerial challenges), it is difficult to identify a more elaborated systematization of Soltec’s approach that could be taken as its official and/or unique guidelines.

As a sign of such openness or richness, some members of Soltec’s expanded team understand that a popular education approach to GE limits the engineer’s technical support. Their point,

along with what other grassroots engineers understand, is that, even though this popular education approach definitely helps the supported group conquer some consciousness and deal with some decision-making problems, it does not offer engineers useful instruments for a more "technical assistance." In this sense, grassroots engineers' practice is sort of equated with providing formation that can help with conflict mediation, improving political consciousness, and managing challenges related to the decision-making process. In this kind of assistance, grassroots engineers concerned with work conditions and the productive process tend to become and act as work sociologists [39] progressively.

I do not know whether every grassroots engineer who takes popular education as his/her primary tool in GE practice agrees that this forces him/her out of engineering. From some of ITCP/Unicamp's and Soltec's technical achievements, this is hardly the case anyway. Notwithstanding, this critique seems to have a different goal. What those who stand for it seem to be claiming is that there could be additional methodologic approaches that could help grassroots engineers do engineering. For this group of "critical" production engineers, indeed, this is the case for the Ergonomic Activity Analysis.

As defined by these grassroots engineers, Ergonomic Activity Analysis (EAA) is a methodological orientation elaborated from the theoretical framework of the activity ergonomics. It is a guideline that can show ways to conceive technologies that allow both self-management and human life's flourishing/ dignity/ cultivation at work [40].

Activity ergonomics understands that the worker's prescribed task is never (and can never be) fully implemented on his/her action. His/her actually performed activity, instead, has to deal with multiple varieties or contingencies that cannot be fully anticipated on the task's prescriptions. The worker's decisions concerning such variabilities thus show a lot of his/her values, understandings, and worldviews. Things s/he is not always aware of. But things that must be acknowledged by both the worker(s) and the supporting grassroots engineers if they are really aiming to do GE. That is, if, on the one hand, they are co-constructing a technical solution that incorporates the worker's knowledge, values, and worldviews. And, on the other hand, if they do so in a way that helps the worker(s) to improve his/her/their consciousness, to think of a better socio-technical order for him/herself/themselves, and to come up with technical solutions that emulate to a certain extent such desired reality [39], [40].

In order to be able to perform an ergonomic activity analysis, grassroots engineers draw on ethnographic and participant research techniques, performing a five-step process of: analysis of demand; analysis of the enterprise's global functioning; analysis of the chosen task; systematic observation of the correspondent activity; recommendations (and assistance in their implementation). Since grassroots engineers seek not only to understand the workers' activities better and improve their lives but also to help to realize this new socio-technical order, action research is taken as fundamental to this GE practice too [40].

This approach to grassroots engineering is being developed by engineers from different GE teams (such as Soltec's) that work together in the assistance of some companies recovered by workers [39], [40]. Yet, EAA is more deeply studied and practiced at all Alter-Nativas' researches/assistances [41].

As such, EAA is a theoretical and methodologic element that is unique to some grassroots engineers' practice. For these, despite their critique of a "popular-education-type assistance," they do not abandon Paulo Freire's orientations but seem to incorporate them into EAA phases and activities.

The main aspects of what was presented in this section can be summarized like this:

| | Engineering Areas | Type of Support Provided | Supporting Phases | Methods Adopted |
|---|---|---|---|---|
| **Soltec** | Various (among which, Production, Computer, and Civil Engineering) | Direct Technical Assistance | Knowing; Executing co-constructed plan; Ending. | Pop. Education, Action Research & Ergonomic Activity Analysis |
| **ITCP/ Unicamp** | Mostly, Production Engineering | Direct Technical Assistance | Knowing; Executing co-constructed plan; Ending. | Pop. Education & Action Research |
| **Pegadas** | Mostly, Production Engineering | Forming Multipliers | Knowing & Executing | Pop. Education |
| **Alter-Nativas** | Mostly, Production Engineering | Direct Technical Assistance | Knowing; Executing co-constructed plan; Ending. | Ergonomic Activity Analysis & Action Research |

*Table 2 – GE Teams' Approaches*

**Impacts on Assisted Groups**

When asked about the main impacts of their grassroots engineering practices, all the three extension centers described in this work (Soltec, ITCP/Unicamp, Pegadas, and Alter-Nativas) agree that students' formation is (much) better served than the supported groups themselves. This usually does not mean that there was no impact or change on the assisted groups' reality. Instead, it seems to indicate that what might last longer to these groups or their members are not the (socio-)technical solutions co-constructed, but things like the abilities they developed throughout the supporting process.

Actually, it is not unusual for a GE team to support an enterprise, either a waste picker cooperative, a company recovered by workers or a Landless Rural Worker affiliated settlement, that end up going bankrupted or being displaced/ closed by the public power. In such situations, it might seem as though all the effort invested in the supporting process was wasted and that, as presented before, without things such as public policies and funding lines, no solidarity economy enterprise can truly thrive, regardless of the assistance that grassroots engineers can offer.

Yet, when taken in perspective, even from these "evident failures," "smaller" (?) gains or victories can usually be seen. Indeed, it is not uncommon that community leaderships, more critical and self-confident workers, and/or more careful, tolerant, conscious, combative, etc. individuals or groups emerge out of these apparent total defeats.

Such frustrating outcomes haunt engaged engineers/technicians since at least 1969 when Paulo Freire wrote *Extension or Communication?* [12]. According to Freire, however, this which many

GE practitioners may think of as only minor "consolation prizes" are, rather, the ultimate results to be sought, for it is only with "liberated people" that a world without oppression and violence can eventually be built [12].

So, who is right, Freire or grassroots engineers? I think that none and both of them. On the one hand, agreeing with Freire, it is undeniable that this "other possible world" that GE is fighting for can only be achieved if there are "liberated people" constructing it. On the other hand, agreeing with grassroots engineers, if we do not build different technical solutions (such as enduring social technologies), democratized ones, and do not scale this process up, no liberated people will be able to implement the world they dream about. Freire does not and could not incorporate to his rationale this understanding about the mutual conformation of technology and society that was thematized only more than a decade after *Extension or Communication?* came into light. Grassroots engineers, on their turn, underplay an outcome that is by no means irrelevant to the struggle they are committed to.

Either way, as far as I can see, GE teams seem to somewhat fail in both assessing this "liberation progress" and coming up with (better) instruments for such evaluations. When we talk to them and/or we read some of their papers, books or reports [24], [28], [37], [39], [40], these elements are usually somehow considered, but only rarely substantiated in a broader or less subjective or random way.

On the other hand, even when only the "technical realm" is considered, there has been an increase in both grassroots engineers' expertise and social technologies produced. Moreover, despite remaining largely marginal, such movement has been somewhat magnified by the slow but steady growth on the number of GE groups nationwide and by some fruitful and strategic connections that it has been established with other Latin American similar initiatives and networks.

**Formative Process and Evaluative Tools Provided to Students**

When it comes to the formation provided to students by the GE teams, what is usually taken as horizon to be sought is the educator engineer ideal presented earlier: a person that, in addition to the technical knowledge and skills conventionally taught/trained at the engineering schools, is also empathic, has critical sense, and is capable of dialoguing and of learning with non-schooled people and from non-academic knowledge.

In order to form such type of engineer, the one who is best suited to perform grassroots engineering, Pegadas, ITCP/Unicamp, and Soltec rely on different formative processes, but not so different evaluative tools.

At Pegadas, the formative process is developed in four different and complementary ways: 1) formation seminars: a monthly activity destined to discuss texts that the students should have studied beforehand. These texts are chosen according to the study themes the whole group defines together each year and that are related to the assistance they are providing and/or difficulties linked to GE general practice that they are facing; 2) material and workshop: elaboration of both the straightforward material about the issues they are trying to address with

the supported initiatives and the workshops they will offer to the multipliers (that is, those who will present and work that material within the enterprises they belong to); 3) Pegadas' management: learning and taking part in Pegadas' self-managed operation; 4) visits: visiting local enterprises to conduct workshops. In all these activities, the teacher in charge of Pegadas tries to foster the students' better understanding of all the relevant elements involved, making them more open, empathic, and aware of the supported people's/ enterprises' singularity, challenges, and accumulated knowledge/ experience.

At ITCP/Unicamp, the students' formation is expected to take place in their study groups, the incubation process provided to the assisted groups, and the ITCP self-management process [24]. Concerning the first two formative spaces,

> All ITCP's educators take part in one incubation team, where s/he exercises his/her [GE's] practice, and in one study group, where s/he learns/discusses theoretic-methodological references. So, we have disciplinary study groups [i.e., production and technology, gender relations, worker's health, human relations' dynamic, communication and arts, pedagogic processes, economic planning] that are articulated in an interdisciplinary way during the incubation offered to Solidarity Economy Enterprises, constituting the incubation teams. This leads us to a practice that is registered, reflected, and transformed by theory; and to a theory "nurtured" and redesigned by practice [30].

ITCP has been home to many graduate and undergraduate researches, which resulted in monographs, master's degree dissertations, and Ph.D. thesis, not to mention academic papers, chapters, and books.

At Soltec, students' formation is provided at three different and non-hierarchical levels [42]:

1. At GE practice teams: each one of these teams is in charge of one of Soltec's current projects (presented above). At this level, formation happens: on the team's monthly or biweekly studying sessions; on general formations provided to all Soltec's teams; on the immersive supporting practice; on individual or group feedbacks;

2. At elective undergraduate disciplines – "Participatory Management" and "Solidarity Technology": they are four-weekly-hour and fifteen-week-long disciplines that conjugate theory with some practice, reserving a fifteen-hour load for the students' interaction with some economically deprived group's reality [43];

3. At the master course in "Technology for Social Development:" it is an up to two-year-long master (with dissertation) program that is mostly organized and provided by Soltec's researchers and collaborators. "Its first selective process took place in 2016, with 20 vacancies. From 2018 on, this number became 22. Up to now, there was not a year when vacancies outnumbered admitted students." [42], [44].

On top of that, as it happens with ITCP, Soltec is also home to many graduate and undergraduate research works that result in monographs, master degree dissertations (not linked to the "Technology for Social Development" program), and Ph.D. thesis, not to mention many academic papers, chapters, and books.

The assessing situation here seems a little similar to what happens when evaluating the impacts of GE's assistance on the supported groups. This does not mean that there are no instruments or processes already in place for that. To the contrary, all of these means can be found on virtually every GE extension center: (final) reports (especially to scholarship holders and to formal courses related initiatives); monograph, dissertation, and thesis (for those whose formal researches are associated with a GE practice); individual and collective feedbacks from teachers and colleagues. But from the interviews I did and the way such aspect appears (or does not appear) on GE's academic papers and official websites, it seems that evaluation should be considered in a (still) more consistent and perhaps integrated way. This seems mostly necessary for those students who are not scholarship holders, nor will produce a monograph, thesis, or academic work based on what they did and learned at the extension center.

Summarizing the formative process and evaluative tools these GE teams provide to their students leads us to something like this:

| | | **Pegadas** | **ITCP/Unicamp** | **Soltec** |
|---|---|---|---|---|
| **Formative Process** | For doing GE | Seminars + Preparing Workshops + Visiting and Giving Workshop | Study Group + Incubation Group | Seminars + General Formation + Immersive Supporting Practice |
| | Helping to manage the team | Yes | Yes | ? |
| | Formal Classes | No | No | Two elective undergrad disciplines & Master Program |
| **Evaluative Tools** | Individual/Group Feedbacks | Yes | Yes | Yes |
| | Extension Scholarship Final Report | Yes | Yes | Yes |
| | Undergrad monograph & Grad Thesis | Only undergrad | Yes | Yes |
| | Papers, Chapters, Posters etc. | Yes | Yes | Yes |

*Table 3 – Formative Process and Evaluative Tools Provided to Students*

**Closing Remarks**

This manuscript aims to answer two research questions: 1) what are the specificities, both methodological and theoretical, of GE as a community engagement activity? 2) What are the actual benefits of GE to the assisted groups and the students that take part in these initiatives?

Both of them have been answered in this work. That can be summarized as follows:

1. What is specific to grassroots engineering as a form of community engagement is: its commitment to solidarity economy and social/solidarity technology; its theoretical and methodological basis derived from popular education, the understanding that society and technology shape one another, and action research; its occasional adoption of ergonomic activity analysis' methodological orientation. Besides, and as a consequence of its popular education roots, GE is committed to dreaming about and socio-technically implementing/trying utopias, other possible worlds.

   As stated elsewhere [1], GE is an engineering practice that chooses to ally to the poor and fights, along with them, for the socio-technical order, for this "other possible world." GE, moreover, does so in a unique way, very attached to some global South's important perspectives (such as de-colonialism and bem viver/ buen vivir/ good living), which clearly distinguishes itself from other community engagement initiatives. It is certainly a way that needs to be improved and more precisely evaluated, but it is still a relevant and promising way.

2. The intended GE's impact on the group it supports is liberation and the materialization of this other socio-technical possible order. GE's actual results fall a lot shorter than this, but mostly because GE assistance is only a part of the conditions that seem necessary to be satisfied for such a result to be achieved (which would also need public policies, funding lines, and proper infrastructure). Alongside the successful and lasting (socio-)technical results obtained, positive impacts on the group can also be found on its members' enlarged consciousness, strengthened self-esteem, empowerment, etc. But GE seems to lack (better) evaluative tools and processes to both measure such impacts and, considering these data, improve the assistance provided.

   Concerning the students' formation, the intended goal is to form educator engineers. This has been the case in all the three extension centers analyzed (Soltec, ITCP/Unicamp, and Pegadas). One additional evidence in favor of this is that some of today's leading grassroots engineers were formed there. Still, some improvements seem to be needed in part of the evaluative process provided.

That something like GE is urgent to the construction of a better world, in accordance with the poor's perspective, is self-evident. Brazilian today's political situation – that encourages or directly produces increasing violence, intolerance, environmental destruction, contempt to traditional knowledge, etc. – does only make such urgency bigger. In such an adverse situation to engaged engineering, which is also materialized by funding cuts and discontinuing favorable public policies, witnessing GE's survival and sort of strengthening proves not only to the GE's robustness and potentiality but also to the need of not giving up hope in engineering students' sensibility to and attractiveness for social causes.

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