Analysis of Social Technologies in Brazil from the perspective of The Theory of Inventive Problem Solving (TRIZ)

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Abstract. The 2030 Agenda defines 17 Sustainable Development Goals (SDGs) that countries must achieve by 2030, and the achievement of these goals involves the collaboration of civil society and the scientific and academic communities. In this scenario, Social Technologies (STs) can generate positive impacts regarding achieving the goals; however, because they are implemented locally, most of the STs are not disseminated to the population, and patenting is a way to change this scenario. Thus, this study aims to analyze the STs present in the Social Technologies Platform of the Banco do Brasil Foundation based on The Theory of Inventive Problem Solving (TRIZ) to define the inventive principles of the prioritized technologies. After surveying the platform, two analysis groups were defined, one of the technologies that generated patents and another that did not generate patents. A contradiction matrix was used to obtain the inventive principles of each analyzed group, resulting in the STs that generated patents having almost three times more inventive principles than the STs that were not patented. Furthermore, the STs of the patented group address more general problems than those of the group without patents, which mainly address problems that presented characteristics such as cost reduction without perceived improvements, use of knowledge already accessible to the public, and application of knowledge in an obvious way.

Keywords: Sustainable Development Goals, Social Technologies, The Theory of Inventive Problem Solving.

1 Introduction

The 2030 Agenda, drawn up by the United Nations (UN) in 2015, determined 17 Sustainable Development Goals (SDGs) be achieved by all countries in the world by the year 2030, comprising not only the participation of government and local authorities but also the cooperation of civil society and scientific and academic communities.

In this scenario, Social Technologies (ST) emerge as fundamental tools for the proper achievement of the established goals [1], allowing the 17 SDGs to be areas that can be explored in terms of ST development. STs can be of different formats, such as procedures, techniques, methodologies, or services, and aim at solving a local social problem [2,3]. When adopted by the whole society, STs can generate a Social Innovation (SI) [4].

In Brazil, the Transforma platform, managed by the Banco do Brasil Foundation, catalogs the technologies related to the impacted SDGs. However, due to their local application in communities, many of these technologies are not widely disseminated to

society. Nonetheless the patenting of these technologies with social purpose allows wide dissemination to the whole society, locally, and to all interested [5].

In this scenario, an analysis of the ST based on the Problem Solving Theory (TRIZ) sought to categorize inventive patterns present in the ST with patent records and identify the inventive criteria that could contribute to other STs reaching the level of patentability.

The TRIZ is composed of a set of tools that, besides helping to identify problems, also assists in the proposition of inventive solutions [6]. It is worth mentioning that, despite being applied in more than 35 countries worldwide [7], no TRIZ studies were found focused on the subject of social technologies.

Thus, this study aims to analyze the STs present in the Transforma platform based on TRIZ to define the priority inventive principles present in these registered technologies. Therefore, this study was divided into the following sections: literature review, methodology, discussion of results, and final considerations.

2 Literature review

2.1 Social Innovation (SI)

Even though there are several definitions, no widely accepted concept defines what Social Innovations (SI) are [8,9,10]. For Mulgan (2006) [11], SI is defined as innovative activities and services motivated by meeting a social need. According to Nicholls and Dees (2015) [12] IS have the potential to offer simple solutions to problems that affect several or even all nations.

Even though there are several definitions, no widely accepted concept defines what Social Innovations (SI) are [8,9,10]. According to Caramizaru and Uihlein (2020) [12], SI have the potential to offer simple solutions to problems that affect small or large enterprises.

The study by Amanatidou *et al*. (2018) [13] claims that SI development is possible with little or no widespread involvement. Moreover, that is a type of innovation that increasingly offers solutions to localized problems and more systemic and structural issues [14].

According to Robby *et al*. (2024) [15], social innovation emerges as a response to the marginalization of the surrounding environment, as well as to different common points of view. The changes become social movements with cultural representation based on the depth of the dilemmas faced by the community. For such conditions to be overcome, resources must be mobilized within the community through organizational and institutional dynamics.

According to Howaldt *et al*. (2018) [16], the four actors most engaged in social innovations are: non-governmental and/or non-profit organizations (46.4%), public agencies (45.5%), private companies (37.1%), and research and education institutes (15.2%). It is worth noting that more than one agent can participate in the development and diffusion of an SI.

Regarding the characteristics of SI developed worldwide, according to Unceta *et al*. (2016) [17], more developed countries get involved with issues related to population aging, climate change, new forms of locomotion, immigration crises, among others. On the other hand, underdeveloped countries are usually involved with SI related to issues that the government often neglects, such as access to basic sanitation, education, and reduction of social inequalities, among other issues.

2.2 Social innovation versus social technologies

According to Instituto de Tecnologia Social (2019) [2] and Fundação Banco do Brasil (2018) [18], STs comprise tools (products, services, or processes) that are developed and implemented from the interaction with the community aiming to solve a local problem. In Brazil, STs are being developed by: civil associations, local communities, public authorities, companies, and educational institutions, among others.

According to Duque and Valadão (2017) [19] there are two aspects of STs: this type of technology arises from widespread knowledge rather than scientific knowledge; secondly, from scientific knowledge and constitutes tools or artifacts that are introduced into a community to improve the quality of life of users.

The definition of Social Technology refers to an innovative development proposal, considering a constructivist approach in collective participation in the process of organization, development and implementation, associating popular knowledge, social organization and technical-scientific knowledge [20].

It is possible to notice that the double vision is the closest to the definitions given by [2, 18]. From this perspective, the main characteristics of social technologies are their adaptability and ease of reapplication to achieve social transformation [2,18].

Studies that discuss the relationship between ST and SI have a common point, social technology being a step for social innovation to happen or a tool used for the same purpose [4, 21, 22].

2.3 The Theory of Inventive Problem Solving: TRIZ

TRIZ started to be developed in the 1940s by Genrich Altshuller and collaborators. Over the years, they analyzed thousands of patents from different areas to identify inventive patterns among them and thus developed a problem-solving method [7].

The significant differential of TRIZ is the composition of several tools that help identify problems and propose solutions [6,7]. According to Chechurin and Borgianni (2016) [23] the most straightforward TRIZ tools are the most frequently used. Their application promotes unique benefits such as a new approach to problems, generating solution hints, and valuable ideas. The speed of idea generation is also a highlighted point, as it allows problems to be quickly identified, making it possible to focus on the essentials.

TRIZ is a methodology applied to the creative resolution of problems, in a systemic way using imagination based on knowledge, with the sources of resolution coming from the sciences for problem solving. Therefore, scientific knowledge regarding the problem to be solved is necessary. The method starts from a specific problem using tools

for analyzing the situation, obtaining a generic problem. Subsequently, there is a bottleneck to arrive at a generic solution. Finally, the generic solution is individualized, to focus on a specific solution [24].

The TRIZ developers discovered that experts from different fields were solving similar problems during the patent analysis, even if this was not initially apparent. Thus, to develop the problem-solving method, the researchers extracted the inventive principles and recurring parameters in the analyzed patents and developed a generic framework for identifying and solving problems [25]. Thus, the problem-solving process is initiated using the TRIZ tools to transform the specific concrete problem into a generic one.

TRIZ began to be applied not only to inventive problems in engineering but also to several other segments in the industry, being used in products and services [26]. Socioeconomic circumstances differentiate useful and harmful functions that underlie the TRIZ methodology and guide it to humans [27].

Therefore, the use of TRIZ tools can contribute to the proposition of solutions in various areas, including Social Technologies, the main objective of this study.

3 Methodology

The study analyzed the STs registered in the Transforma Platform of the Banco do Brasil Foundation, since this is the only Brazilian platform for ST registration. The following steps were followed to carry out the study:

a) Survey of the STs on the FBB platform, carried out in the period from December 17, 2019, to December 22, 2019;
b) Checking of the STs that generated any patent and those that did not carried out in the Brazilian patent bank (National Institute of Industrial Property), in the period from January 06, 2020 to February 27, 2020, made by searching the name of the applicant and/or name of the inventor, and the names searched were registered in the Social Technologies Platform is responsible for the technology. In other cases, the name of the company responsible for developing the social technology was also searched;
c) Definition of the groups for analysis according to the following criteria:
Group 1 (STs with patent registration with the National Institute of Industrial Property) and Group 2 (STs without patent registration at the National Institute of Industrial Property);
d) Definition of the engineering parameters related to the characteristics of the STs in each group;
e) Development of the contradiction matrix for each technology, between the parameters to be improved and the undesired parameters, to generate the inventive principles;
f) Analysis of the inventive principles that were most repeated in each contradiction matrix to elaborate the inventive patterns for each group;
g) Analyze the results obtained to present the differences perceived between the two groups and explain how the inventive patterns found can facilitate the development of new STs.

4 Discussion of the results

4.1 ST registered on the Brazilian platform

The Transforma platform registered, in the period in which the survey was conducted 597 ST registered, among procedures, techniques, methodologies, services, and products, among others. The survey obtained as a result of 60 ST. The criterion used to perform the selection was to account only for the ST with the primary purpose of product development.

4.2 Analysis of ST with patent registrations with the National Institute of Industrial Property

After surveying the ST registered on the Transforma platform, research was carried out with the National Institute of Industrial Property to check that the ST generated a patent. The analysis was performed by searching the name of the applicant, and however, as no results were found, the search was performed using the name of the inventor.

One of the technologies presented by the Transforma platform is the "PVC hydraulic ram", which is the creation of a homemade hydraulic pump that replaces the need for an electric motor to pump water from a lower region to a higher region without using electricity or fossil fuel. Anyone can assemble and install it. This technology is linked to the UN's goals: SDGs number 6, clean water and sanitation, and 13, climate action.

After researching the FBB platform, the National Institute of Industrial Property pa- tent database was consulted between 01/06/2020 and 02/27/2020 to categorize the 60 STs. The information found in the National Institute of Industrial Property database allowed the categorization into two analysis groups: Group 1 (formed by 11 ST with patent registration at the National Institute of Industrial Property); Group 2 (formed by 49 ST without patent registration at the National Institute of Industrial Property).

4.3 Definition of the engineering parameters for each ST

The engineering parameters were determined based on the information registered in the Transforma platform, considering that the summary, objective, solved problem, description, required resources, and achieved technology results should be registered. It is worth noting that the platform also had a field to attach relevant documents related to the technology. In this way, the attached documentation was also analyzed during the definition of the parameters, if present. In the case of Group 1 technologies, the document with the patent description obtained from the National Institute of Industrial Property patent bank was also analyzed.

It is worth noting that during the analysis of four social technologies belonging to Group 2, it was not possible to define the engineering parameters due to the lack of relevant information existing in the Transforma Platform.

4.4 Construction of the contradiction matrices

The study's next step was to assemble the contradiction matrices for each social technology. Some STs in Group 2 had similar goals or SDGs, but they were united in a single matrix. After merging similar STs, the number of matrices built for Group 2 was reduced to 26, while those for Group 1 remained at 11. The Figure 1 and 2 below present the contradictions of the ST of Groups 1 and 2, along with the justifications for the choices of a ST's engineering parameters ("Mobile flour mill") found to illustrate the activity performed at this stage.

			Parameters that are impaired
			38
			Scope of Automation
Parameters to be improved	01	Weight of the moving object	26, 35, 18, 19
	05	Area of the moving object	14, 30, 28, 23
	07	Volume of the moving object	35, 34, 16, 24
	13	Stability of the components of an object	1, 8, 35
	25	Waste of time	24, 28, 35, 30
	27	Reliability	11, 13, 27
	32	Ease of manufacturing	8, 28, 1
	35	Adaptability or versatility	27, 34, 35

Fig. 1. Contradiction matrix of the ST "Mobile flour mill" - Group 1
Source: Elaborated by the authors (2022)

Mobile flour mill		
Characteristics of Social Technology	**Engineering Parameters**	
Groups several functions and process steps in a single piece of equipment	01	Weight of the moving object
	05	Area of the moving object
	07	Volume of the moving object
	13	Stability of the components
Reduced assembly time	25	Waste of time
High safety standard	27	Reliability
Reduced assembly time	32	Ease of manufacturing
Ease of transportation	35	Adaptability or versatility
Activities are performed manually	38	Scope of Automation

Fig. 2. characteristics of the ST "Mobile flour mill" vs engineering parameters
Source: Elaborated by the authors (2022)

From the construction of all matrices of the two groups, the classification of the inventive principles that were most repeated for each social technology was performed. It is worth mentioning that the objective of this step was to determine the inventive principles that most appeared in each group; however, initially, the analysis was performed by matrix, considering that the number of matrices in each group is not equivalent, Group 1 resulted in 11 matrices while Group 2 resulted in 26.

Based on the results obtained, the amounts of repetition of the inventive principles in all the matrices obtained were analyzed (Figure 3). It was observed that the principles were more repeated in the ST of Group 1 (with patent registration at National Institute of Industrial Property), since the matrices are, in general, larger because they have more engineering parameters involved. Based on the analysis performed, a minimum cut-off score of eight repetitions per principle was established for each matrix; that is, principles that appeared less than eight times in each matrix were disregarded. It is worth noting that a principle might not have had eight repetitions in one matrix but another, making it present in the group's overall classification of inventive patterns. Thus, all principles repeated at least eight times in a matrix were considered for the entire group.

Social Technologies	Inventive principles	Total repetitions
Low-cost solar heater	1 – Segmentation	6
	2 – Extraction	5
	4 – Asymmetry	5
	7 – Nesting	5
	11 – Pre-damping	5
Biciclotrem	**1 – Segmentation**	**9**
	15 – Dynamization	5
	2 - Extraction	4
	12 - Equipotentiality	4
	32 - Change the color	4
Dessalinizador solar	**15 - Dynamization**	**8**
	28 - Mechanical replacement	**8**
	1 - Segmentation	7
	16 - Partial Action	7
	18 - Mechanical vibration	7

Fig. 3. Selection of inventive principles
Source: Prepared by the authors (2022)

From the analysis of the number of repetitions of the inventive principles in each social technology (Figure 4), it was possible to notice that only principles 1, 15, and 28

met the number of 8 repetitions. It is noteworthy that, although principle 15 presented only 5 repetitions in the matrix of the "*Biciclotrem*" technology, it presented 8 repetitions in the "*Dessalinizador solar*" social technology. Figure 7 presents the Inventive Principles that reached the criterion of 8 repetitions after analyzing all the ST for each group.

ST Group	Inventive principles
1	1 – Segmentation
	2 – Extraction
	3 – Local Quality
	4 – Asymmetry
	8 – Counterweight
	10 - Prior Action
	11 - Pre-damping
	13 – Inversion
	15 – Dynamization
	18 - Mechanical vibration
	25 – Self Service
	27 - Use and Disposal
	28 - Mechanical replacement
	29 - Pneumatics and hydraulics
	34 - Disposal and recovery
	35 - Changing parameters and properties
2	1 – Segmentation
	2 – Extraction
	10 - Prior Action
	15 – Dynamization
	28 - Mechanical replacement
	35 - Changing parameters and properties

Fig. 4. Inventive Principles by ST Groups
Source: Prepared by the authors (2022)

It was possible to notice that Group 1 (Figure 4) presented more inventive principles than Group 2. In this scenario, Group 1 (with patent registration at the National Institute of Industrial Property) presented patentability requirements defined by the Industrial Property Law, identifying innovative features crucial for patent registration. Some

examples are the possibility of a product to fit several situations and the elimination of the need for extra elements composing the product, present in the ST "PVC hydraulic ram" and "mobile flour house".

The lower amount of inventive principles present in Group 2 points out that the technologies presented characteristics such as cost reduction without perceived improvements, use of knowledge already accessible to the public and application of commonsense knowledge, i.e., that do not fit patentability criteria, as defined by the Industrial Property Law in Brazil.

For Group 2, the inventive principles highlighted in Figure 4 present how the related inventive principles could have contributed to a more significant number of patentability criteria and a possible patent registration, which is necessary to improve the invention and disseminate knowledge to society.

It is worth noting that the principles present in Group 1 also appear among the highlighted principles of Group 2, presenting their inventive importance. However, despite generating the same inventive principles, there is a significant difference in the ST of Groups 1 and 2. On the one hand, the ST of Group 1 covers globally complicated topics, such as the ST "Mathematics for the visually impaired through multiplane" and "Solar water disinfection". This analysis agrees with what has been defined by Caramizaru and Uihlein (2020) [12], that SIs can propose simple solutions to problems that affect several or even all nations.

On the other hand, when analyzing the ST of Group 2, it is possible to realize that most of them aim to solve local problems, as already shown in the results of Howaldt *et al*. (2018) [16], where in Brazil the development of social innovations occurs mainly to supply basic needs that are not met by the government, one of these needs being basic sanitation.

The STs that make up Group 1, besides having a higher number of inventive steps, also meet the other patentability criteria, i.e., being novel and having an industrial application, considering that they have already been patented. On the other hand, the STs in Group 2 did not meet the other patentability criteria, so only the application of the inventive principles does not guarantee a patent.

The STs in Group 1 presented patents registered in the International Patent Classification related to the SDGs impacted by the technology. The classification also presents the areas explored by the invention. Thus, it is worth noting that the patenting of the technology allows its dissemination to society, even allowing other countries to have access to it.

In this context, TRIZ can contribute to the fast generation of ideas [28] by thinking unconventionally [29] and with the construction of innovative products that make users' lives easier [30], characteristics that match the development of new social technologies.

5 Final Considerations

The development of Social Technologies with correct dissemination in the form of patents can create a favorable environment for social innovation, thus generating social transformation and the country's technological development. In this context, the use of

TRIZ, even though no studies related to STs were found, proved to be feasible in identifying inventive principles that, if used, can contribute to the development of new transformative STs.

Thus, the results found in this research can serve as guidelines in developing social technologies with greater inventive rigor to reach solutions for the community and/or region. However, it should be noted that the analysis of the ST characteristics is not absolute or unique, and the interpretation of the functionality of each inventive principle or engineering parameter can vary from the interpretation of the ST analysis or more specific knowledge about the technology.

However, only the application of inventive principles is not a guarantee of innovation, given that the technology must meet the criteria of novelty and application, i.e., it must be developed at some level of interaction with the community.

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