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DISRUPTIVE ENVIRONMENTAL INNOVATIONS WITH HIGH-POPULATION IMPACT AIMED AT THE DISPOSAL OF RECYCLABLE MATERIALS IN MAJOR EVENTS

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ABSTRACT

Technology has been occupying more and more space in the daily lives of people in big cities, which ends up raising the current discussions about sustainability. Thus, this article sought to make a theoretical review in the literature on the beginning of discussions and development of the first "green" technologies and on their patents, as well as on Brazilian inventions aimed at the processing of solid waste. At the same time, it addresses concepts of information innovation and disruptive technologies for commercial purposes, presenting two technological tools with high educational content and great capacity to change people's way of thinking and consumption habits. Finally, it emphasizes the importance of studies focused on the behavior of technologies in the face of contemporary issues such as sustainability and environmental preservation. We bet that these instruments, more than operating a technological production related to recycling, can deconstruct old paradigms and establish new ones.

Keywords: Disruptive technology. Green patent. Smart Recycle Bin. Recycling Scoreboard.

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INTRODUCTION

Technology has been gaining more and more space in everyone's lives over the years, especially in large metropolises. Few people do not use apps or features of their smartphone for some activity of the day, whether in order to order food, call a car, or even quantify the mileage and time of that morning run.

On the institutional side, it is possible to say that companies have also become dependent on technology, with their integrated databases of high scalability and interoperability, stored on VPS servers or in the cloud, making it necessary for any service to use the stored information. In short, this database ends up being the company's most precious asset because without it, it is not possible to access revenue and profits, which is why the servers are protected by several firewalls, fixed ips, and backup routines in order to preserve such information.

Thus, the rise of capitalism and exaggerated industrialization, the increase in consumption, including technologies, combined with the deliberate low durability of this type of product, generates a large amount of waste, which ends up raising all the current discussions about sustainable development.

"Sustainability", or "Sustainable Development", is basically the balance between attitudes aimed at social and economic development with actions to preserve the environment. It radically alters the decision-making process on the part of governments, entrepreneurs, consumers, and workers who, for a long time, took into account only economic criteria. However, currently, these subjects also need to observe social and environmental aspects.

So, the topic of sustainability It began to be considered relevant for business in recent years, when it began to think about a fluidity of the production process, without obstacles, from the raw material to the final consumer, including the reverse movement of this process, which encompasses the return of what is left over from the post-consumption stage (BALLOU, 2007, p. 45).

With this, it is important to build a historical context regarding the theme, being highlighted from the concepts of sustainability and environmental preservation in the Capitalist System. Thus, initially, an approach will be made regarding the point at which the discussions begin and the first technologies aimed at a more "green" perspective are developed, bringing some examples of technologies, based on what Cardozo and Murarolli (2015) present in their text "Green Information Technology": Technological Sustainability"

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and "The Advancement of Technology about the Environment: Technology and Sustainability".

Subsequently, how technologies are applied as "green patents" will be dealt with", instruments that allow industries to insert in their production processes more appropriate and, in a way, alternative methods, while less polluting, mitigating environmental degradation and bringing competitive advantages to these companies. Specifically at this moment, the dialogue is established with Santos et al. (2017), with the text "a model of management information system: competitive advantage in the reverse logistics process of cooking oil", which deals with the application of a Management Information System (GIS), as an information technology instrument for the reverse logistics of residual vegetable oil of industries, using as a case study a franchise of a fast food chain in São Paulo – SP.

Finally, the third text will bring an approach to invention and use patents produced in Brazil directly linked to alternatives for disposal, reuse, and/or recycling of products for non-environmental degradation. The case study by Silva et al. (2016) exposes the Brazilian civil construction sector, which concentrates more garbage discarded per inhabitant per year than domestic waste, as argued by the authors in the text entitled "Mapping technologies associated with the reuse of solid waste and recycling of materials used in the Brazilian civil construction sector", which, in addition, brings numbers that help to understand what moment we are in as technological measures to be used in companies directly linked to the recycling and reuse of solid waste industry.

In the second chapter, according to Christensen's (2006) thinking, the concept of disruptive technologies will be addressed, which can be considered innovations in products, services, or processes that seek to be alternatives to what is in force and are also aimed at another type of consumer. In short, for the author, disruptive innovation is intended to cause changes in social practices and in the ways of living, working, and relating, causing a rupture in the standard models related to the field of consumption and business.

Also, two technological tools that can be considered disruptive will be presented due to their high educational content and their great ability to modify the thinking and consumption habits of those who enjoy them. It can be said that these tools cause an imaginary disruption of high popular impact since they are aimed at the masses and can cause permanent changes in the consumer's subconscious.

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With that in mind, why not use technology as an ally of more sustainable practices? This is what we seek to reflect in this work, which sought to understand the role of technologies today and how they can contribute to changing society's thoughts and habits.

MATERIALS AND METHODS

The methodology used for the discussions of this research is qualitative, as it "works with a universe of meanings, motives, aspirations, beliefs, values and attitudes, which corresponds to a deeper space of relationships, processes and phenomena that cannot be operationalized by variables" (MINAYO, 2001, p. 21-22).

In addition, it presents as a basis a theoretical review of articles found from a survey carried out on the Google Scholar platform between March 20 and 21, 2020, with the combination of the following keywords: Information Technology and Recycling (1) and Disruptive Technology and Recycling (2). The survey was carried out with the aim of searching for the most appropriate texts to the researched theme, published in the Brazilian and international scientific academic scope, in journals and other means of dissemination, such as annals of events.

The main works found on Information Technology were: that of Cardozo and Murarolli (2015), which deals with green information technologies and cites as a representation of this type of innovation the Cloud Computing and Virtualization tools; that of Santos et al. (2017), which proposes a discussion on the discharge of effluents into water resources; that of Silva et al. (2016), which addresses green patents and its main aspects.

Still on innovations and disruptive technologies, Theis's works were found; Schreiber (2015), Gilioli (2014), Carvalho; Pear tree; Assis (2018), among others, which are based on the ideas advocated by Christensen (2006), the main researcher on the subject of "disruptive technologies".

Finally, a case study of two green patent technologies was also carried out: the smart trash can and the recycling scoreboard. Regarding the methodology of the recycling scoreboard, it was used the programming language php, database *MySQL* and video, already edited, rendered and containing the information. The recycle bin involved development in C++ on the printed electronic circuit board, *PHP*, *HTML*, *Java Scripts*, and database *MySQL*. Regarding the server environment, it used *Java servlet* (UDP), fixed IP, VPS virtualization environment, and database insertion *MySQL*.

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GREEN INFORMATION TECHNOLOGY AND ENVIRONMENTAL CONCERN: REUSE OF MATERIALS AND RECYCLING IN INDUSTRY

According to Cardozo and Murarolli (2015), in the 1980s, a commission to develop measures on development and the environment was established in the 1980s for all countries in the world; it was created at a UN conference (1983). There, issues related to the impacts on the environment generated by the excessive exploitation of resources and measures to mitigate these impacts, such as the reduction of consumption, environmental preservation, and recycling.

From 1987 onwards, the Our Common Future Report, also called the Brundtland Report, was instituted, bringing the need to print a real change that would support global progress (sustainable development). Also, according to the authors, the document brought a criticism of the measures adopted by capitalist countries, which, in the eyes of this report, were unlikely to be applied in countries with peripheral capitalism.

In 2005, the term "Green Information Technology" was implemented," which, according to Cardozo and Murarolli (2015), is quite recent but has gained great space for discussion and implementation with alternatives such as virtual storage (*clouds*, for example). Also, according to the authors, companies realized the importance of their virtual assets, thus expanding investment in Information Technologies.

Since then, it has been a market that has been strengthening since globalization is intrinsic to the development of information technologies, and the transmission of information in a continuous and permanent way is indispensable. Some technologies that have been developed are directly linked to Green IT, namely, *Cloud Computing* and Virtualization.

The "*cloud computing*" instrument consists of a virtual storage space (in clouds, or "*cloud*") in order to eliminate the use of physical storage memories. Cardozo and Murarolli (2015) argue that this method has been adopted by several companies that want to save time and costs in equipment maintenance. However, at first, it generated some distrust, as the notion that storage could be lost, deleted, or invaded, no longer remaining in the sole possession of the company, was an idea to be clarified.

Therefore, companies currently hire servers with known security certificates, and there are 4 possible types of Cloud Computing: public cloud, community cloud, hybrid cloud, and private cloud (CARDOZO; MURAROLLI, 2015).

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Public clouds, according to the authors, are a standard model of "*cloud computing*", offered for free or pay-per-usage. Community clouds, on the other hand, are accessed by a specific group with common interests. Hybrid clouds are two or more clouds that offer the benefits of other clouds in a single one. Finally, private clouds are storage services aimed only at a specific organization or company.

In dialogue with Dámaso (2013), Cardozo and Murarolli (2015) state that it is possible to exemplify companies that work with this storage method today, such as *Google Drive*, *Dropbox*, *SkyDrive,* and *iCloud*. All these companies offer storage options, obviously with specific differentials, according to the interests of their customers. Also, cloud computing is an alternative for reducing CO2 emissions, consumption energy, and waste generation, which is why they are considered a "green" technological alternative.

In order to understand the concept of "virtualization", imbricated in this notion of "clouds", it is necessary to distinguish the real, as palpable, the material and that which simulates what is real, in this case, the virtual. According to Cardozo and Murarolli (2015), virtualization is a "virtual environment that seeks to imitate a real environment, thus being able to use all systems and programs, without them being installed in the virtual environment" (CARDOZO; MURAROLLI, 2015, p. 154). In other words, the purpose of "virtualization" is to optimize the use of physical equipment as much as possible. Thus, there are three angles to look at virtualization: hardware virtualization, presentation virtualization, and application virtualization.

The first of them, hardware virtualization, is defined by the use of several operating systems on a single machine, with the data of its components being "copied" through software to be read and used by the different operating systems. The second is presentation virtualization, and it consists of accessing a computing environment without the need for physical contact with it.

In this way, it is similar to "remote access"; however, it can be accessed by several users at the same time. Its advantage is the possibility of access from any location, using the operating system's tools, without having to install them on a physical computer.

Finally, application virtualization is an important tool to prevent software incompatibility on certain operating systems. Thus, by installing an application on a desktop remote, the user can access it from any location and from any operating system.

According to Cardozo and Murarolli (2015), this form of technology is important in terms of the economy of consumption of energy, as well as of physical space, not

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generating waste due to equipment purchased and used in excess. The standards by which green IT is regulated are defined by ISO (*International Organization for Standardization*14000, Environmental Management System. The authors also argue that this ISO is defined by the Environmental Management System (EMS), by auditing, by environmental labeling, and by the product life cycle.

In dialogue with Almeida and Real (2012), the aforementioned ISO is defined by several documents that, in general, can be defined by: EMS (ISO 14001 and ISO 14004), Environmental Audits (ISO 19011), Ecolabel (ISO 14020, 14021, 14024, 14025), Environmental Performance Assessment (ISO 14031 and 14032), Product Life Cycle (ISO 14040, 14041, 14042, 14043) and Terms and Definitions (ISO 14050).

However, it is valid to state that ISO 14000 is optional, despite the documents that support it. The argument for the optional mandatory applicability of this regulatory rule is the investment that companies would have to make to adapt their productions and products as "green". This issue contributes to the non-alignment with the ideal of "sustainability".

In addition, there is still discussion about the legislation in Brazil that has a direct action on the sustainability proposal. It is worth highlighting Law No. 12,305 of August 2010 (BRASIL, 2010), which, based on the text, provides guidelines for the handling and disposal of solid waste, the preservation of the environment, and the improvement of the quality of public health. According to Cardozo and Murarolli (2015):

> For Green Information Technology, specifically, article 33 of this law deals with garbage, where it is the responsibility of the companies themselves to correctly dispose of the materials in order to reduce the impact produced directly by them on the environment and in men's health. This Law describes in great detail the correct way to deal with solid waste, thus making it essential nowadays (CARDOZO; MURAROLLI, 2015, p. 157).

Dialoguing with Smaal (2009), Cardozo and Murarolli (2015) state that "electronic waste" does not refer to "spam" sent to e-mail boxes, but rather to waste produced from the obsolescence of electronic products. According to the authors, from the beginning of production to the disposal of the product, there is a great environmental impact. Thus, it is necessary to implement a project to reduce the production of these pollutants, whose environmental damage is immeasurable.

Also, according to the authors, there is a virtual government platform that began through an initiative of the São Paulo State Department of the Environment (2008), in which the zip code can be entered and the nearest place for proper garbage disposal can

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be verified electronically. The address is "www.e-lixo.org", a website maintained through a cross-check of data with *Google Maps*. The authors also emphasize the importance of having the correct disposal of this waste since it contains heavy metals, which can easily contaminate the soil and water, causing diseases to humans.

Cardozo and Murarolli (2015) argue that environmental management policies and garbage relocation actions giving the correct disposal, recycling what is possible and reinserting it into the chain of production what would only be thrown into the environment, signifies a new and important step in environmental conservation and the concept of sustainability. According to the authors, in dialogue with Baio (2008), it is estimated that 5% of the garbage generated by humans on the planet is electronic, which confers about 50 million tons per year. Giving an adequate end to the disposal of this waste is also collaborating to reduce this number.

In another way, but contemplating the theme of the section and the proposals that argue about the need for the correct disposal of solid waste, the text by Santos et al. (2017) is found, pointing out alternatives to enable the correct disposal of this waste. Beyond the garbage mentioned by the authors so far, one of the major concerns when talking about pollution focuses on the discharge of effluents into water resources.

According to Santos et al. (2017), the main cities responsible for the disposal of debris in water resources and, in turn, for the pollution of these resources are large cities. Archela et al. (2003) state that there are two types of discarded effluents, differentiated by their origin: domestic and industrial. From this, within the group of domestic waste, there is cooking oil, an organic compound with a high rate of contamination of water resources when disposed of incorrectly. Santos et al. (2017) argue that, according to the Environmental Management Program of the Federal Public Prosecutor's Office, 1 liter of cooking oil is enough to contaminate about 1 million liters of water, enough to be consumed by one person for 14 years.

The authors say that there is still no exact data on the oil reused by industries, the one that returns to the production cycle. However, they say that there is work being carried out to raise awareness of the population for correct disposal since it does not require a large investment, only the change of customs.

Regarding the disposal of industrial waste, Santos et al. (2017) state that, in the State of São Paulo, control and inspection are rigorous, supported by Law 997/76, in which, through environmental licensing and inspection of activities, companies are

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analyzed by the Environmental Company of the State of São Paulo (CETESB), a delegated body of the state government.

On a national scale, there is CONAMA federal resolution No. 430 of 2011, responsible for the classification of water bodies and environmental guidelines, establishing standards for effluent discharge. According to Santos et al. (2017), for vegetable oils, there is a limit of 50mg/L of the compounds in effluents.

Thus, based on these data, the authors are still concerned with the definition of the concept of Reverse Logistics, which is an important tool for controlling the flow and return of products and inputs to the means of production. Carvalho (2002) argues that logistics is the "management of a chain supply properly structured and planned, involving the storage, transportation and control of materials or products" (SANTOS et al., 2017, p. 67).

He also argues that logistics also acts to improve efficiency in relation to the substantial gains of a company, since the flow of production occurs from the correct and necessary amount for the sale and return of the product.

Leite (2009) points out four characteristics related to logistics: supply logistics, manufacturing support logistics, distribution logistics, and, finally, reverse logistics. Each of these characteristics has its importance in the production cycle: the first of which is necessary for the supply of inputs and materials so that the company can produce; the second for the planning, storage and control of the company's internal flows; the third for the distribution of products; and, the last, for the return of these post-sale and post-consumer products.

The discussion by Santos et al. (2017) focuses on this fourth characteristic: Reverse Logistics. From this, after-sales reverse logistics is characterized by the return of products that had problems with the quality and/or quantity of the product distributed. Post-consumption is characterized by the return of the product after it has been consumed by the customer so that, in some way, it can be reused, through reuse, manufacture, or recycling.

Cooking oil is an example of a product returned to the industry through post-consumer reverse logistics. Its uses are varied, such as for saponification, composition of paints, production of putty, production of flour for animal feed, burning in boilers and production of biodiesel, generation of glycerin as a final product, among others, according to Santos et al. (2017) apud Reis, Ellwanger and Fleck (2007).

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Thus, to discuss the advantages of using Information Technology in the production process as a competitive differential, Santos et al. (2017) conceptualize "Information Systems (IS)":

> Interacting and interdependent parts of a set that form an organized whole and have the purpose of generating accurate knowledge and assisting in decision-making, analysis, and transformation of information, generating value through the data presented in a meaningful and useful way (SANTOS et al., 2017, p. 73).

From this, the use of IS within companies directly involves information technologies for the development of services, products, and capabilities so that companies develop competitiveness among other companies and on the scale of global capital.

An example cited of the use of Information Technology applied internally in the production process of a company is GIS (management information systems), which collaborate in the organization of a sparse volume of potentially problematic data, when it comes to controlling the flow and return of production in logistical terms, as in the case of Reverse Logistics of Cooking Oil. These GIS are implemented as instrumental technologies in Business *Intelligence (BI),* collaborating in the company's competitive advantage over others when it comes to process optimization.

To exemplify the use of GIS in companies as a technology of competitive advantage in the market, Santos et al. (2017) cite the example of a Database (DB) structured to contain information collected of vegetable oil used (post-consumer) and return to the production process – regardless of its subsequent use.

To this end, the architecture of the system produced for this purpose initially consisted of a form filled out by the organizations that collect the residual oil from other companies, whether NGOs or other collection points and this form is later transformed and supplies a database where they are archived in a *Data Mart* specifically for this context. Finally, this DB produced is used to design reports that will be instruments of *marketing* in order to structure the company's image as environmentally responsible.

Thus, the initial form used by the initiatives organized through collection points of vegetable oil is filled through a standardized interface, linked to a web portal, being a transactional database. In this, important information is stored and used in a mapping of the entire reverse logistics process of this oil.

From this, with the primary characteristics that structure this GIS, after feeding the initial form, the information is sorted by an Extraction, Transformation, and Loading system

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(*Extract*, *Transform, and Load – ETL*). In dialogue with Kimball (2013), Santos et al. (2017) argue that this system consists of three stages: "[...] a work area, instantiated data structures, and a set of processes. This system deals with the systematization of the treatment and cleaning of data from various organizational systems for insertion in a *Data Mart*." (SANTOS et al., 2017, p. 77).

With some metrics inserted from this system, it is possible to develop cartograms, for example, which will illustrate the company's ability to return the residual oil and transform it into other products which, as mentioned earlier, is an instrument to increase the company's green marketing, which also creates a "healthy" sphere of competition between companies and, Of course, it highlights the value of the reverse logistics of this oil.

Based on the GIS used as an example, Santos et al. (2017) affirm the importance of this method, not only for the company's Green Marketing but also for socio-environmental responsibility. To this end, one of the franchises in São Paulo – SP, of the McDonald's fast food chain, which applies a GIS regarding the reverse logistics of cooking oil, is used as an example.

The company mentioned demonstrates, through the results generated from the Database regarding the collection of and oil transformation that, during one year, collected about 6 million liters of oil, thus preserving 150 billion liters of water. This means, according to the company's data, a number close to 12 billion m^3 of CO^2 avoided, which is equivalent to about 70 thousand trees planted. In addition, with the return of this post-consumer cooking oil, almost 6 million liters of biodiesel can be produced.

With the case study pointed out, the use of Information Technology applied in GIS, in the control of reverse logistics, proves to be an important instrument, not only in the competitive advantage between companies, but also in the partnership between these institutions, when the common interest is the preservation of the environment and financial savings in the production process.

OLID WASTE AND GREEN PATENTS

This section deals specifically with the problem of solid waste in the Brazilian civil construction sector, from the perspective of the text authored by Silva et al. (2016). The justification for the presence of this discussion at this time is the fact that more garbage is

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produced per inhabitant, per day, in Brazil, from civil construction, in relation to garbage as the authors argue.

According to his text, based on data from the Brazilian Association of Public Cleaning and Special Waste Companies (ABRELPE), the number of solid waste generated in 2014 through civil construction was greater than the waste from garbage domestic. For each Brazilian, it was estimated 1.062kg of domestic waste per day. In relation to civil construction waste, it was estimated that 1.5 to 2.5 kg per day was estimated. Thus, the authors point out that solid waste from civil construction is divided into 63% mortar, 29% concrete and blocks, 7% other components and 1% organic waste.

Silva et al (2016) argue, based on a dialogue with Magalhães (2007), that innovation consists of any evolutionary or disruptive change that aims to extend the life of organizations. From this, they state that the civil construction sector in Brazil has a great capacity to innovate and stimulate the economy, through technological innovations linked to recycling, which, however, still lacks a long-term plan.

The authors also state that green patents These are technologies that focus their objectives on positively interfering with the environment, in order to preserve it and stop climate change and environmental degradation. The authors argue that, in Brazil, the Brazilian Patent and Trademark Office (BPTO) prioritizes the evaluation and approval of patents related to this purpose. Also, according to the INPI (2013), in the words of the authors:

> Within the scope of the innovation that Green Patents can provide, the targeting of technologies for the promotion of renewable energies, energy conservation, pollution control, reforestation techniques, soil improvement, waste disposal, waste treatment and waste management stands out (SILVA et al., 2016, p. 51).

Green Patents in the country occupy 5% of the total volume of patents filed, being linked to the "efficient processing of materials, composition and process to obtain products that have less impact on the environment and waste recycling processes" (SILVA et al., 2016, p. 51).

Between 1991 and 2015, according to Silva et al. (2016), 182 patents were registered for technologies related to the reuse of solid waste linked to the civil construction sector in Brazil, to the recycling of these materials and to systems and processes oriented to sustainable practices, with 168 invention patents and 14 utility models. Also, according to the authors, the periods that most represented a considerable increase in the

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registration of green patents in Brazil they are from 2002 to 2005, jumping from 2 records to 12 and, later, from 2006 to 2009, jumping from 9 to 21 records.

Regarding the profile of applicants responsible for registering patents, the authors point out that 74% are individuals and 26% are legal entities, of which 21 registrations are from Educational Institutions and/or Research Institutes, 20 registrations comprise private companies and 7 registrations are the result of public-private partnerships. The other 134 registrations are those that comprise patents registered by individuals. Most of the patents registered by educational institutions and/or research centers, as well as by private companies and public-private partnerships, are found in the South and Southeast regions, with only one coming from the Northeast region of the country.

According to Silva et al. (2016), patent applications made to the BPTO are classified according to the technological area to which they belong. The authors argue that, of the 182 patents found, 99 comprise 3 classifications: C04B (74 patents), E04C (14 patents) and B09B (11 patents), with the other patents being distributed among other classifications.

The first patent, C04B, comprises materials such as lime, magnesia, slag, cements; their compositions (mortar, concrete or building materials). The second, E04C, comprises structural elements – construction materials. Finally, the B09B classification comprises solid waste disposal. In the authors' analysis, of all green patents registered, 56% are concentrated in these three classifications.

The three texts that served as the basis for the theoretical revision of this section point to the deficiency of the correct disposal of solid waste and, in addition, the counterpoint based on case studies, as referred to in the second text with which we established dialogue, demonstrating that the applicability of "green" technologies in industries and other sectors of the economy results in mitigating and environmental preservation measures.

Another point that can be highlighted is the advent of information technology and disruptive technology as methods, so that the recycling, reuse and correct disposal of solid waste becomes feasible so as not to harm the environment and, in addition, to present itself as a possibility of savings and better management of costs in production processes.

DISRUPTIVE TECHNOLOGIES

Before specifically addressing disruptive technologies and their behavior today, it is necessary to understand how they emerged and what they are based on. To do so, it is first

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necessary to understand the concept of innovation, which, in the view of Schumpeter (1982) apud Theis and Schreiber (2015) is everything that expands, causing a change in the circumstances of economic equilibrium. Also according to the author, it is possible to cite as an example the discovery of new ways of producing and marketing or the creation of new products, services and technologies.

Drucker (1986, p. 39), agreeing with Schumpeter, points out that innovation is the main tool to awaken the entrepreneurial soul, with which one discovers usefulness in any element found in nature that is capable of generating wealth. Thus, innovation is made, creating solutions for consumption, transforming any and all changes into a great business opportunity (THEIS; SCHREIBER, 2015).

Therefore, it is worth saying that applying a technology or scientific knowledge to improve processes and products can be considered a great factor of competitiveness between companies, since they are important aspects in the consumer decision-making process (THEIS; SCHREIBER, 2015).

The Oslo Manual, which is an important international document of guidelines on innovative activities in industry, exposes four types of innovation, namely: product, which is the creation of a new technological product or service modified by technology; process, which alters and benefits the production process, even if there is not necessarily a change in the final result of the product or service; marketing, which relates to those changes made at the time a new product is launched on the market; and the organizational, which are the changes in the conduct of processes in a company, provided that their results can be proven through the improvement in productivity, sales or profits, for example (OECD, 2005 apud THEIS; SCHREIBER, 2015).

In this sense, from these concepts of innovation, the idea of disruptive innovation was also outlined, which, according to the main researcher on the subject, Christensen (2006), is the process in which a product or service enters the lower part of a given market and moves to its upper part, until it occupies a position that reduces or completely eliminates the competition (CHRISTENSEN, 2006 apud GILIOLI, 2014).

For Christensen (2006, p. 3) disruptive innovation fits "situations in which new companies can create relatively simple, convenient and low-cost innovations to promote growth and beat industry leaders". It is a model that ensures greater accessibility for the population that previously did not have access to this market, and this is a characteristic that makes developing countries the best niches for launching this type of innovation.

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This is due to the business model of these countries and the low-income population, following a logic that it is better to enter a market where there is no competition, because there is no consumption, to enter directly into global markets where there is already a habit of consuming this type of product/service. It is a system that ends up benefiting the population with lower purchasing power and has great potential to generate growth (CHRISTENSEN; HART, 2002 apud BENCKE; GILIOLI; ROYER, 2018).

Therefore, it is concluded that a disruption occurs in the market when the innovation or technology replaces the product commonly appreciated by the market, even with a lower performance of its attributes, also reaching a portion of consumers who are more sensitive to price (CARVALHO; PEAR TREE; ASSIS, 2018).

However, it is also essential to demonstrate how some technologies considerably influence biopolitical aspects, being able to foster increased consumption, through the information stored in the databases of large companies. Through artificial intelligence techniques and algorithms, it is possible to recreate a consumption structure and make advertising campaigns more precise according to the audience you want to reach (LEAL; BIOEN, 2019).

For this reason, one cannot fail to notice the direct relationship that exists between consumerism and disruptive technologies that feed it, also contributing to the intensification of calamity situations in the current ecological scenario (LEAL; BIOEN, 2019).

Christensen (2006) considers that disruptive innovation is all technological changes used to transform labor, materials, capital and information into products and services with possibilities to add value (GILIOLI, 2014). However, it is possible to perceive this principle of disruptive innovation in several spheres, and not only in the institutional sphere of generating profits and economic advantages. In other words, disruptive technologies they do not need to be practiced only for commercial purposes (LEAL; BIOEN, 2019).

Theis and Schreiber (2015) point out that, currently, most environmental innovations are reactive and motivated by environmental regulations and laws, and are not sustained by the simple fact that they are not genuinely honest with the ecological principle. They simply seek to survive the market, respecting the impositions of the government or society.

In view of this, the possibility of creating disruptive technologies is questioned with educational and awareness-raising objectives, with a great capacity to modify thinking and consumption habits of those who enjoy them.

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It can be said that these tools could cause an imaginary disruption of high popular impact, since they would be aimed at the masses, causing permanent changes in the consumer's subconscious. This is the case of the tools that will be analyzed below, which were created with the objective of quantifying the natural resources saved in the act of recycling solid waste from consumption, thus making this reality more palpable in the consumer's subconscious.

SMART RECYCLE BIN[3]

According to Christensen (2006), disruptive technologies are the ones that provide different values from the main technologies, such as, for example, the smart trash can, which aims to educate consumers about the amount of natural resources saved when waste is disposed of for recycling.

It is a green patent, taking up Silva et al. (2016), as it aims to bring about positive changes for the environment through the awareness of the population and improvements in solid waste recycling processes.

The Smart Recycle Bin4 uses advanced technology to identify, collect, and process data on various types of recyclable materials. The machine has programming developed in C++ and recorded in a PIC16F877A-I/P microcontroller to recognize which waste is being inserted, storing it in compartments ready for selective transport. When the consumer disposes of it in the trash can, he receives a coupon, informing about the amounts of natural resources preserved by recycling that material.

The system is basically composed of 5 main blocks. First, the insertion of an object is detected, then the type of material inserted (PET bottle or aluminum can) is identified, and then the anti-fraud test is carried out. If the object does not pass the test, it is rejected, otherwise it is compressed and then detached. The machine, according to its programming and its5 volumetric capacity sensor, identifies its occupancy from 20% to 20%, and, when it reaches 100%, a communication is sent to the server that triggers a siren through the Web

[3] Patent: Innovation Privilege. Registration number: MU00251302795267, title: "Lixo Inteligente", Registration institution: INPI - National Institute of Industrial Property. Deposited: 17/04/2013

[4]More information about the Smart Recycle Bin can be found at the following email address https://www.youtube.com/watch?v=PzXHWIt6Dnw.

[5] To measure the percentage of garbage volume that occupies the trash can, the use of the ultrasonic distance sensor was chosen, which measures the distance, according to the sound response time. The sensor used was the XL-MaxSonar-AE, attached.

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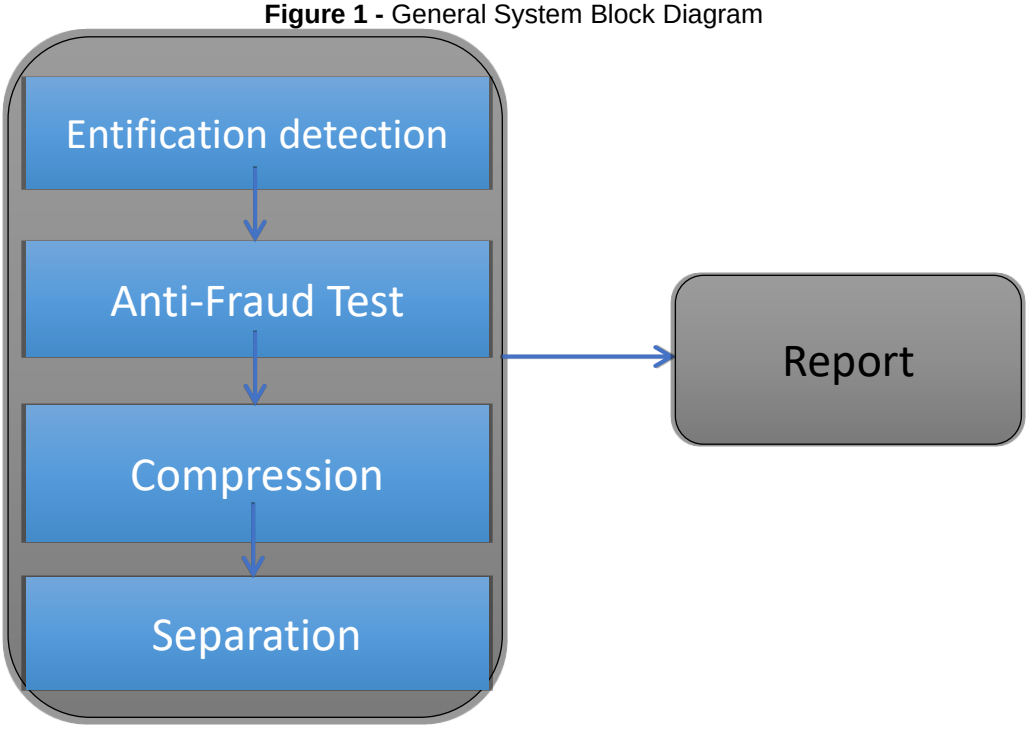
system developed with the following words: Trash can with 20%, 40%, 60%, 80% and 100% (trash can full) attached and (Figure 1).

When the trash can is full, a team is activated to empty it and send the materials for recycling, in a reverse logistics process that, according to Santos et al. (2017), is the return to the production line of what is left of a product, in this case, through recycling.

It is worth mentioning that, for each material discarded in the smart trash can, the identified data are sent to the server, through the GSM/GPRS communication protocol, that is, apn of cell phone connection coupled to the electronic circuit of the attached trash can. When sending to the server's fixed IP, the *socket Java Servlet* receives the data and is inserted into the database *MySQL*. Thus, the treatment of spatial information is shown in the reports developed in the programming language *PHP*, which are generated from each recycle bin. Returning to the idea of virtualization, defended by Cardozo and Murarolli (2015).

The reports display the following information: amount stored by type of recyclable material, idle capacity of the machine, natural resources saved generated by each consumer or general, geographic location of the machine (increasing the safety of the equipment), any information is obtained in real time, when the system allocated in the www.lixeirainteligente.com.br domain is accessed.

Figure 1 - General System Block Diagram



Source: Prepared by the authors (2020).

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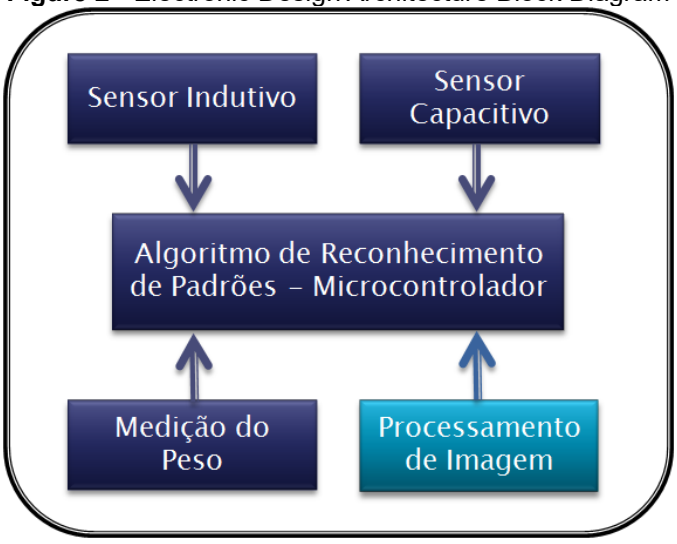
The electronic system is shown in Figure 6, in which the interference of the magnetic field is measured to identify the object, if it is made of aluminum. It is also a stage of the anti-fraud test. If the inserted object is a plastic bottle, it will be recognized through a capacitive sensor. Weight is measured to determine if the bottle/can was placed empty, as well as being a variable for the classification algorithm, in which, in the calibration process, we will carry out several tests, interconnecting the information collected to determine patterns.

Figure 2 - Electronic Design Architecture Block Diagram



Source: Prepared by the authors (2020).

As a classification method, the "decision tree" is used, available in the annex, which is an artificial intelligence system that has a pattern recognition algorithm. In this algorithm, the classes are found, which, in this case, are the different types of materials.[6]

An Excel spreadsheet was also created that serves to calculate the amount of resources saved from what is collected/recycled. By feeding the spreadsheet, placing the number of material collected in tons (aluminum, metal, paper, plastic, glass), the amounts of resources saved are already calculated, which are shown by another spreadsheet and by graphs, as shown in Figure 6.

[6] A decision tree is a multi-stage decision system in which classes are sequentially rejected, until an accepted class is finally found. In the end, the trait space is divided into regions that correspond to the classes. The decision sequence is applied to individual traits, and it is tested whether a given trait is above or below a certain threshold. Each decision node contains a test on an attribute, each descending branch corresponds to a possible value of this attribute, each leaf (represented by the rectangle) is associated with a class, and each path in the tree (from root to leaf) corresponds to a classification rule.

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However, the most interesting thing to observe is how the public relates to this disruptive technology. At first, people deposit their residue with a certain suspicion or without understanding the real dimension that that information has in their lives, in their daily lives. So, when they observe the coupon and realize, for example, the amount of energy saved with the recycling of that particular material, the situation takes shape in their imagination and, even if the person never uses that trash can again, every time they deposit waste in any trash can, they will remember, again, the experience of the smart trash can. It is as if what you learn from that information is permanently impregnated in your subconscious, thus causing a rupture, which occurs from this change in thinking and attitude towards garbage/residue.

The discussion about this type of disruptive technology, with a green patent and with educational and non-profit objectives, is different from the common discussion in academia, which observes disruptive technologies From the point of view of the precariousness of work, such as, for example, in the case of mobility app drivers or food app delivery workers.

What is intended to be addressed, through these innovations, is the change in the way we look at information, it is the ability to disseminate awareness-raising information, through very low-cost tools that can even generate a policy that seeks to include everyone in discussions about ecology and educate about the preservation of the environment.

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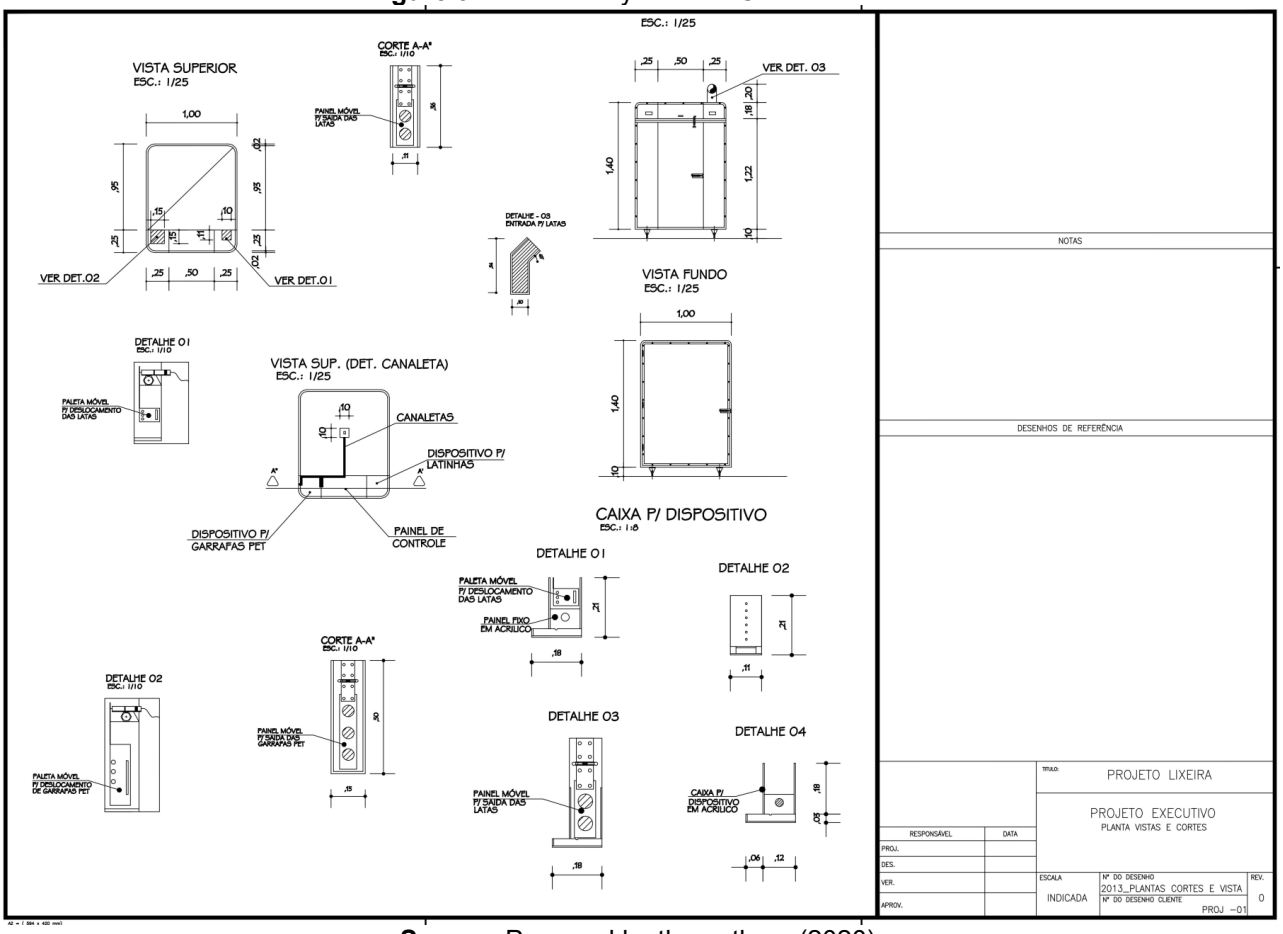
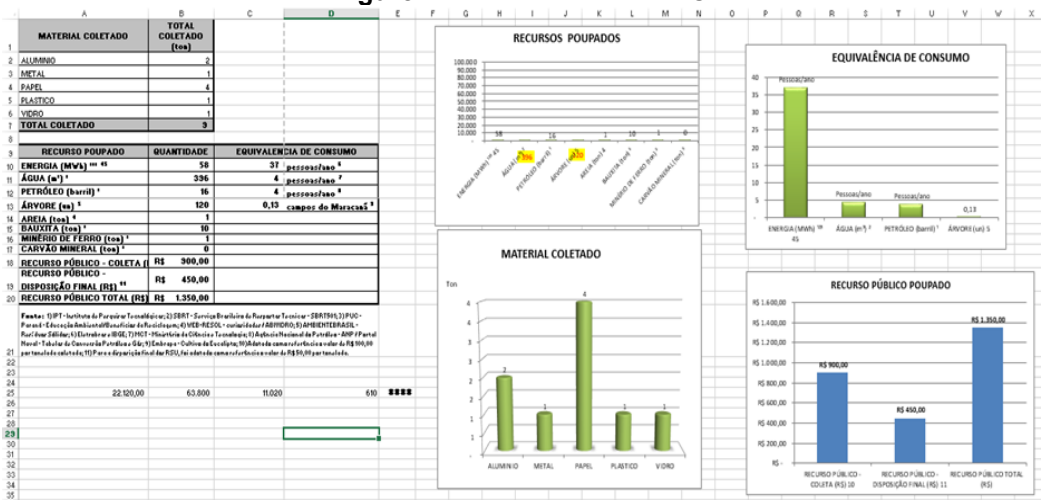
Figure 3 - Smart Recycle Bin - Cut and Views



Source: Prepared by the authors (2020)

Figure 4 - Natural Resources Calculator[7]



[7] Source: 1) IPT - Institute of Technological Research; 2) SBRT - Brazilian Technical Response Service - SBRT501; 3) PUC - Paraná - Environmental Education/Benefits of Recycling; 4) WEB-RESOL - curiosities / ABIVIDRO; 5) AMBIENTEBRASIL - Solid Waste; 6) Eletrobrás and IBGE; 7) MCT - Ministry of Science and Technology; 8) National Petroleum Agency - ANP / Naval Portal - Oil and Gas Conversion Tables; 9) Embrapa - Eucalyptus Cultivation; 10) For the final disposal of the MSW, the value of R$ 38.00 per ton was adopted as a reference. The calculations used by the author for the construction of the Smart Trash System and the Recycling Scoreboard are based on this source.

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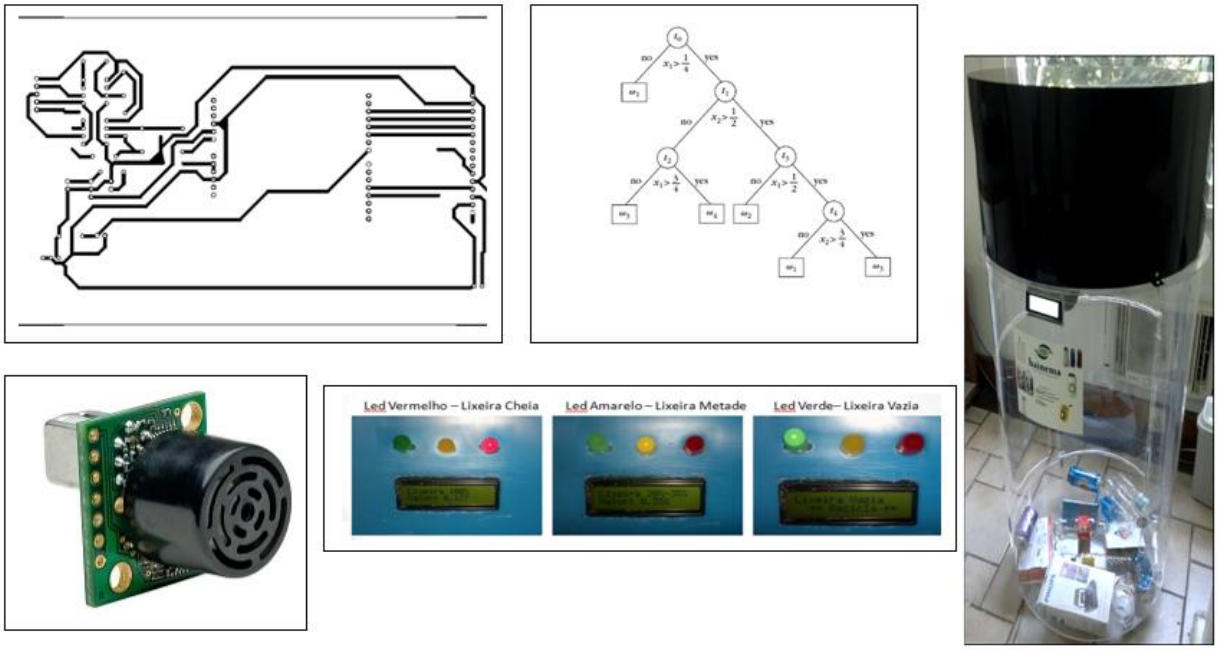
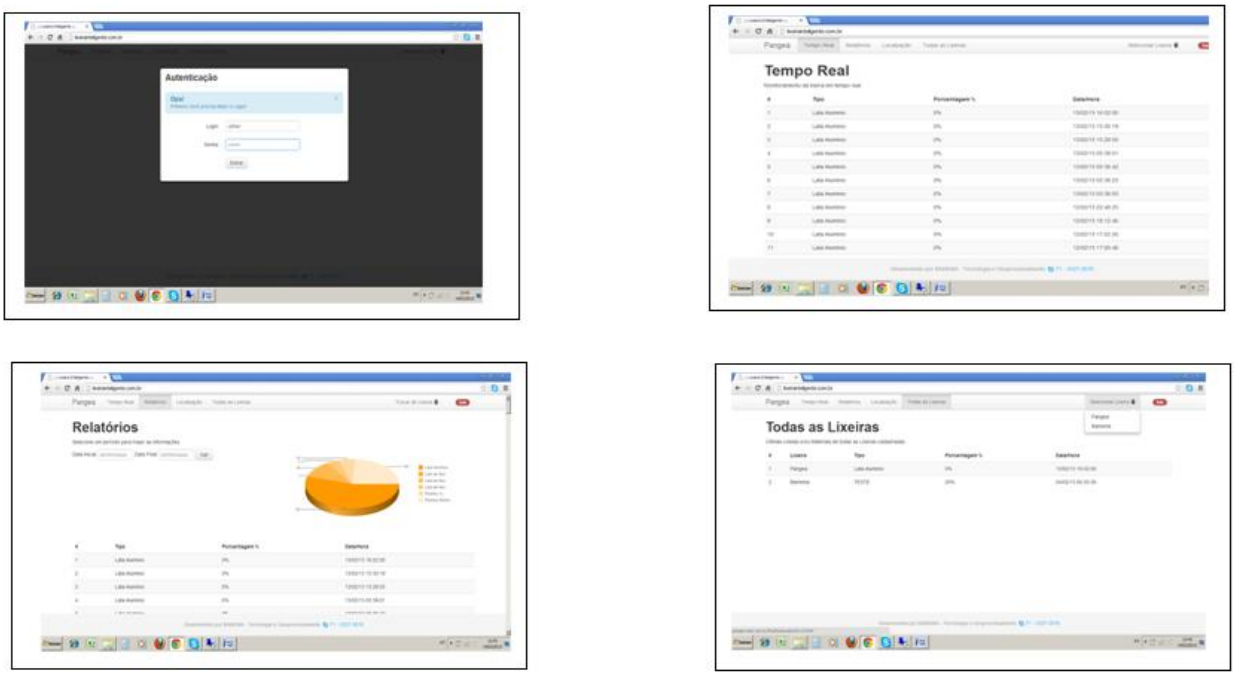
Source: Prepared by the authors (2020)

Figure 5 - Smart Trash Bin - Printed Electronic Circuit Board, 128x64 Graphic LCD Display, 40KHz Ultrasound Sensor (RX & TX Pair), Decision Tree



Source: Prepared by the authors (2020)

Figure 6 - Web System – Smart Recycle Bin



Source: Prepared by the authors (2020)

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RECYCLING SCOREBOARD[8]

The Recycling Scoreboard9 was created to record all recyclable materials collected during the 2020 Carnival held in the cities of São Paulo and Recife. With it, the public learned about the types of materials collected and their quantity, as well as the volume of natural resources saved with the proper final destination of these materials. Its operation is similar to that of the Smart Recycle Bin, as it uses online management reports and the Natural Resources Calculator. It also takes up the concept of virtualization, by Cardozo and Murarolli (2015), insofar as the virtual environment represents reality. The difference is that the Recycling Scoreboard seeks to reach a larger audience in less time, as they are visualized in major events, such as Carnival, Soccer Games, World Cup, and Olympics, and can thus be considered a disruptive technology tool for environmental awareness with a high population impact.

The main objective is to create awareness among revelers and, consequently, reach the other layers of civil society. The process goes through the following steps: the collection carried out by waste pickers of recyclable materials at events goes to weighing; Immediately, the scale makes a connection via communication protocol and inserts the data into the bank *MySQL*. Finally, the dynamic data is shown at each weighing and in real time on a screen 4 meters high and 3 meters wide, as shown in Figure 7, which displays data related to environmental preservation associated with the population's day-to-day tasks, as shown in the table below.

Table 1 – Materials and equivalences of resources saved

Collected Material	Quantities	Resources Saved
Aluminum cans	648.769	Energy Consumed by 71. 169 people
Glass	2	Saves sand in the construction of 0 (m2) of popular houses.[10]
PET - Plastic	3.099	It saves gas to run 4,927 km.
Paper	1.503	Saves 67,635 liters of water
Total collected	13 tons of waste	It is equivalent to 181,030 liters of water, consequently, it saves an average of 302 hours of bathing.

Source: Prepared by the authors (2020).

[8] Computer Program. Registration number: BR512013000238-9, registration date: 06/20/2012 - Registration institution: INPI - National Institute of Industrial Property.

[9]More information about the Recycling Leaderboardat the following email addresses: https://www.youtube.com/watch?v=fVE81fJAknY,https://youtu.be/MXHruRHK0As, https://youtu.be/sRqTJ55qss0,https://youtu.be/YWjdbEWlwp8, http://porumcarnavalsustentavel.com.br/, http://domeulixocuidoeu.com.br/carnaval/index.php and to access the dynamic video that plays on the screen for public viewing http://recado.eco.br/recife/meulixo/video.php?infodados=0

[10] The amount of glass collected in this event was not able to earn value on the Recycling Leaderboard due to the low amount collected.

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Figure 7 - Image of the Recycling Scoreboard screen

Source: Prepared by the authors (2020).

The Recycling Scoreboard – in the perspective of meeting the precepts of the legislation combined with socio-environmentally correct initiatives – reached about 80 thousand people in Recife, at Galo da Madrugada, a show that concentrates about one hundred thousand people per night of the parade, which makes the production of waste significant.

It also reached 120 thousand people in São Paulo directly. Indirectly, it reached an incalculable amount of people through mass media, such as TV reports (Globo, Record, SBT, etc.) and news that came out on various online portals.

In the carnival of the city of Recife, in particular, there was a differentiated action, promoted through the partnership established between the companies Ball and Novelis which, through the incentive and support in compliance with what is determined in the National Solid Waste Policy – Law 12.305/2010 – PNRS, in its articles:

> Art. 7 The objectives of the National Solid Waste Policy are:
> XII – integration of waste pickers' reusable and recyclable materials in actions that involve shared responsibility for the life cycle of products;
> Article 8 The instruments of the National Solid Waste Policy are, among others: solid waste plans;

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> III - the collection Selective, reverse logistics systems and other tools related to the implementation of shared responsibility for the life cycle of products;
> IV – the incentive to the creation and development of cooperatives or other forms of waste pickers' association of reusable and recyclable materials (BRASIL, 2010, p. 2).

Allied to the provisions of the Sectoral Agreement, it favored the participation of waste pickers and recyclable material collectors in the collection process Selective, both in technical rehearsals and on the days of Samba Schools parades, ensuring, in addition to environmentally correct actions in the disposal of waste, the opening of jobs from the perspective of socio-productive inclusion for a significant number of waste pickers.

It is worth mentioning that disruptive technologies presented in this research are linked to the capitalist model of "environmentally sustainable" marketing, being, in this sense, aimed at the public that attends events with high population impact. The business modus operandi, which imaginarily suggests that the well-dressed waste picker, with personal protective equipment and with high rates of daily allowances, can "rejoice" during the exercise of the profession, hides and silences the daily reality of these workers in cooperatives, streets, and garbage dumps. It is, therefore, at the service of a media that "aggregates values, representations, ideas and orientations at the service of social reproduction, based on a competent ecological discourse devoted to teaching everyone a 'single' ecologically correct worldview". Del Gaudio et al. (2015).

The waste picker, in these major events, escapes from his dull and precarious daily life. This is because these events always take place in places belonging to the bourgeois ruling class, as is the case with the Olympics, the World Cup, Carnival, the *Rock in Rio*, Lollapalooza, etc. The recycling scoreboard, in this regard, emerges to inform and change society's imagination in relation to conventional trash cans. However, in a critical analysis, disruptive technologies shown in this research fulfill the function of "a lot is announced and silenced by those who made the decisions, made the choices, the discursive construction of this silencing through a lot of saying, to silence a lot". Del Gaudio et al. (2015). Here, there is a clear attempt to show the environmental payment for the services provided at that time to society and to hide, historically, what was not paid in the day-to-day life of the Brazilian recycling network, in which a strategy of domination is fulfilled that generates a very efficient "ideological smokescreen", as the mainstream media is in charge of disseminating it on its websites and open/closed channels.

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Finally, it is concluded that the Recycling Score can also be considered a disruptive technology, just like the Smart Recycle Bin, for its ability to provoke and establish changes (ruptures) in thinking, creating a new look at the everyday actions of consumers. It is also a green patent because it aims to preserve the environment through innovation (SILVA et al., 2016).

In addition, one cannot fail to mention the social issue that is reflected in a paradigm shift in the lives of waste pickers and in the way people see them, realizing how important and valuable their work is for society and the environment.

CONCLUSION

It is undeniable how much technologies have occupied, in recent decades, a considerable space in people's lives. They are the result of large-scale industrialization caused by capitalism, which, consequently, increased consumption and the amount of waste, provoking routine discussions about ecology and sustainability. Inevitably, one thing leads to another.

So, why not think of technology as an ally of the practice of sustainable development? How can it facilitate and improve people's lives and take care of the environment at the same time? These are fundamental discussions nowadays, since along with the advantages of technologies and globalization, there are also the disadvantages due to the excess or misuse of natural resources.

Thus, in this work, it was observed that sustainability is the balance between society, the economy, and the environment. That is why Green Information Technologies are such a promising market, as they allow companies to combine innovations, financial interests, and ecological interests. An example of this is the storage of database information on VPS servers or "clouds", making almost all transactions and processes virtual.

An approach was also made to the resolutions and patents related to the disposal of industrial waste and solid waste from the civil construction sector.

In addition, it was possible to understand the concept coined by Christensen (2006) of Disruptive Innovations, considered by him as all those technological changes/ruptures that aim to transform products, services, information, etc. However, this idea of disruptive innovation can be seen in several spheres, or rather, it does not need to be practiced only for commercial purposes.

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Then, two tools were presented - the Smart Trash Can and the Recycling Scoreboard - that could cause an imaginary disruption of high popular impact since they would be aimed at the masses, causing permanent changes in the consumer's subconscious. They were created to quantify the natural resources saved in the act of recycling solid waste from consumption, making this reality more tangible for the consumer.

Finally, given this, it is concluded that information technologies have the potential to contribute, in a considerable way, to the fight in favor of the environment. Whether through modifications and disruptions in the ways companies operate in the market, even if these changes are made in search of financial returns, or through applications or systems with educational and awareness-raising functions.

Thus, the importance of studies focused on the behavior of technologies in the face of contemporary issues such as sustainability and environmental preservation is highlighted. It is essential to continue attributing to technology the role of facilitator in the process of overcoming and solving problems that are often also the result of modernity and globalization.

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