Maker education and anthropocene: Brazilian and Colombian ecologization

Educação Maker e antropoceno: ecologização no intercâmbio Brasil-Colômbia

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ABSTRACT
The use of natural resources on our planet must be addressed on the environmental agendas of all governments. In this period known as Anthropocene, global warming is critical to the 21st century environmental agenda, affecting biogeochemical cycles and planetary biodiversity. Education is a key factor in scientific information and debate on the ecological crisis. Maker education is used in greening approach with renewable materials. This case study presents initiatives from the Brazilian Professional and Technological Education. The results are analyzed in cooperation with Colombian researchers, amplifying initiatives for greening approach in educational institutions in both countries.

Keywords: anthropocene, maker education, greening initiatives, professional and technological education, Brazil-Colombia.

RESUMO
O uso dos recursos naturais em nosso planeta deve ser tratado nas agendas ambientais de todos os governos. Neste período conhecido como Antropoceno, o aquecimento global é crítico para a agenda ambiental no século XXI, afetando os ciclos biogeoquímicos e biodiversidade planetária. A educação é fator primordial na disseminação de informações científicas e debate sobre crise ecológica. A educação Maker é utilizada na ecologização com materiais renováveis. Este estudo de caso apresenta iniciativas da Educação Profissional e Tecnológica no Brasil. Os resultados são analisados numa cooperação com pesquisadores colombianos, ampliando iniciativas para ecologização nas instituições de ensino nestes países.

Palavras-chave: antropoceno, educação maker, ecologização, educação profissional e tecnológica, Brasil-Colômbia.

1 INTRODUCTION

In the Anthropocene, it is necessary to recognize both the problem integrating dimension (aggregated impact of human action has become a geological force) and the differentiated dimension of real human life (Pádua, 2017). For Léna & Issberner (2018) the term “Anthropocene” better represents the description of history, in which human

species (*Homo sapiens*) generated impacts on nature equivalent to a geological force capable of modifying the planet's biophysical parameters, which diffuses rapidly, in addition to its behavior.

Overconsumption is amplified by commercialization of lifestyle and feed a little more the frenzy of desires that are increasingly transformed into needs that until then did not exist (Lipovetsky, 2007), causing an increase in solid waste. Thus, the accumulation of solid waste in landfills is one of the causes that contribute to global warming due to the generation of greenhouse gases such as carbon dioxide. This comes from the decomposition of various materials arranged there. This accumulation occurs as a consequence of the indiscriminate production, consumption and disposal of products at the end of their useful life (Montoya, Martinez, 2013).

The “sustainability debate has already been established in an unsustainable society” (Lima, 1997, 2011). Some researchers (Jacobi, 2003; Layrargues, 2012; Jacobi et al., 2016; Rodrigues, Loureiro, 2017) believe that educational institutions have great potential for generating multipliers for environmental sustainability.

Another aspect that must be considered is the fact that revolutionary changes happen when sectors are taken out of companies, governments and other institutions exclusive domain and become accessible to ordinary people. Thus, global supply chains have become 'immune to scale', capable of serving both small and large enterprises: today's public controls the means of production. Therefore, the 'artisanal' movement and mass-scale handicrafts generated widespread demand for these specialized goods (Anderson, 2013).

A model that has been presented as an alternative to reduce environmental impacts and use natural resources in a more viable way is circular economy, which is concerned with a more efficient generation of products and which includes waste as a productive input (Gansky, 2011; Maruyama et al, 2016; Lopes et al, 2019). Many concepts and behaviors of green lifestyle are evident in today’s STEM schools, including recycling, school gardens, composting, energy audits, and environmental-awareness campaigns (Jorgensen, 2014).

Considering the aforementioned issues this research presents a set of initiatives in Environmental Education (Maruyama et al, 2021), promoted by researchers who adopted a project-based teaching approach, considering a 'learning by doing' perspective, contemplating public institutions in Brazil and private institutions in Colombia.

2 ECOLOGICAL CRISIS AND ANTHROPOCENE

Even considering the fact there are millions of people still without access to essential services to a dignified life, we already consume 50% more than the planet is capable of replacing and we need to reduce greenhouse gas emissions by up to 40% so that the planet's temperature does not rise by more than 2ºC, a limit indicated by scientists to avoid major climatic catastrophes (IPCC, 2014).

The planetary limits model by Steffen *et al*. (2015) is based on an assessment of the human interference level that could jeopardize the stability of this geological era on Earth. At least four out of the nine frontiers identified in this work have already been overcome: (*i*) climate; (*ii*) integrity of the biosphere; (*iii*) exhaustion in land use through deforestation; (*iv*) biogeochemical flows (carbon).

Although the planetary limits highlighted by Rockström et al. (2009) are described in terms of individual quantities and separate processes, these limits are closely related. There is no intention to concentrate efforts on any one of them separately, since, if one limit is breached, the other limits will also be subject to serious risks. For instance, significant changes in land use in the Amazon region (basically related to deforestation) could influence water resources as far away as in Tibet.

Thus, for scientists like Rockström et al. (2009), Steffen et al. (2015), Artaxo Neto (2017), climate change depends on staying safely in adequate levels of fresh water, land, aerosol, nitrogen-phosphorus, ocean and stratospheres. The breach of nitrogen-phosphorus limit can impair the resilience of some marine ecosystems, potentially reducing their CO2 absorption capacity and affecting the climatic limit (Lenton et al., 2008; Houghton, 2012; Irabien et al., 2015).

In their study *Sea-level rise from the late 19th to the early 21st century*, Church and White (2011) observed that in the period from 1860 to 2009, the ocean average level rose 23 centimeters. NSDIC NASA reports (2018) also show changes in ice level concentrations in the Arctic: so far, oceans are undergoing unprecedented transformations in up to 300 million years: 1°C warmer; 26% more acids; 2% less dissolved oxygen. Warming the ocean could be the greatest hidden challenge of our generation. In addition to the implications for a coral reef, ocean warming has many other consequences for the ocean and its biodiversity (Goldman et al., 2013).

In this way, Anthropocene was proposed as ‘a new and distinct time in Earth's history’ (Crutzen, Stoermer, 2000), a period of ecological imbalances of such magnitude that threaten life on Earth. Once the advancement of global warming, ecosystems and

climate are increasingly affected: rising animal and plants extinction rate, whose consequences and risks are still unpredictable (PECI *et al*., 2017).

2.1. CONSUMERISM, DEGRADATION AND ENVIRONMENTAL JUSTICE

Enrique Leff (2003) argues that economic-ecological globalization policies have failed to solve problems caused by western population lifestyle in particular. The sustainable growth discourse raises a smokescreen that hides the real causes of the ecological crisis.

Anyone in this current consumer society is considered markedly different from any other consumer society known so far, as advocated by Lipovetsky (2007), introduces the term '*Homo consumericus'*, a maladjusted, unstable and flexible turbo-consumer, largely free from ancient class cultures, unpredictable in one's tastes and shopping.

When talking about *Parasitic Capitalism*, Bauman (2010), recalls that it was forgotten that the nature of human suffering is determined by their lifestyle. Henceforth, the ability to last is no longer in favor of things. Objects are only required to serve for short-term and they can be destroyed or discarded in some way when become obsolete. Today's consumerism is not about accumulating objects, but about providing disposable enjoyment.

Consumer society mainly involves 'forgetting', not learning or engagement. How do living beings inhabit a particular place? How do you recognize its patterns? Using ethology - animal behaviors science - Michel Serres (2011), considers that human beings, as well as other mammals, need to 'mark their territories', by consumption and pollution, developing ways of appropriating nature and exercising power over other animals.

Distributional conflict introduces into political economy of the survival and production ecological conditions, as well as social conflict emerges from dominant forms of nature appropriation and environmental contamination. Ecological distribution designates social, spatial, temporal asymmetries or inequalities in environmental resources and services usage, whether commercialized or not. Consequently, natural resources decrease, including the loss of biodiversity (Martinez Alier, 1997).

Faced with strategies of economic and symbolic appropriation in nature and culture, environmental ethics proposes life revaluation of human and non-human beings. Guatarri (2012) reveals that political formations and executive bodies seem unable to grasp this problem in a broader sense. Descola (2016) argues that at first glance, we could think that there is no difficulty in distinguishing 'what concerns nature' from 'what

concerns culture', but that this distinction is not always so simple, since most of the objects that surround us, including ourselves, are in this intermediate situation: they are natural and cultural at the same time.

In the face of a crisis, Stengers (2015) identifies profiles such as: (*i*) those who know that it would be necessary to 'do something', but are paralyzed by the disproportion feeling between what 'they can and what they need to do'; (*ii*) those who are tempted to think that 'it is too late', there is nothing left to do; (*iii*) those who prefer to believe that everything will end up settling down, even if 'they cannot imagine how'.

Veiga (2010) warns that it is common for sociologists and economists not to even realize that their methodological options are deeply rooted in any of Philosophy 'great families', citing a renowned example from two key fields: (*i*) Giddens on his misuse of the term 'sustainable development' (even disagreeing with it) forgetting to mention the contributions of ecological economics, ignoring that serious socio-environmental problems of this century could be analyzed without addressing previous and abstract questions about the way in which human species deals with the rest of nature; (*ii*) Jeffrey Sachs, saying that 'climate control is not a moral game, but a practical and solvable technological challenge'.

For Latour (2015) in "Telling Friends from Foes at the Time of the Anthropocene", the shift from science versus politics to science with politics is certainly not without danger. At first glance, climate denialists will be amused by claiming that their opponents have finally confessed what they, denialists, have always said: climate science is just politics.

On the one hand, it must be considered that there is no conflict between science and politics, but, above all, there is a conflict between two radically opposed political epistemologies, each with its own definition of what science and politics become, and how both could collaborate with each other. In this sense, there would certainly be a war for the definition and control of the Earth: a war that pits against each other - to be a little dramatic - humans who live in the Holocene (science financed by the market) and the Terrans who live in the Anthropocene (focus of the IPCC scientists).

3 KNOWLEDGE & INTERDISCIPLINARY LEARNING

'Human capital' is the most important input for innovation and knowledge-based activities. As consequence, a high level of human capital allows for a more efficient transformation of pre-existing information into new forms of knowledge (Zhang, 2010).

For a technological development strategy to be successful, it is very important to invest in scientists, managers and researchers training and integration, investigating new technologies, the relationship with universities, research centers and other players, maintaining intellectual property management. Therefore, the innovation process is “an interactive process, carried out with many economic and social agents contribution with different types of information and knowledge” (Lastres, Albagli, 1999).

Interdisciplinarity is more than just an 'integration among areas of knowledge': today it proposes synergy between knowledge of different natures. According to Fazenda (1991), in an interdisciplinary field, research means the collective construction of new knowledge.

Piaget (1972) gave depth and importance to interdisciplinarity concept, considering that it ceases to be ‘a luxury or a product of occasion’ to become ‘the very condition for the progress of research’. In this way, science cannot unfold in a single plane and must include different levels of structuring and concepts.

Nevertheless, CAPES (2012) states that interdisciplinarity, unlike multidisciplinarity, and, in a more complex way than pluridisciplinarity, understands an entirely new format of progress in the knowledge process. Thus, it imposes exchanges of theory and methods, new concepts and greater intersubjectivity among researchers, supporting natural phenomena of extreme complexity.

Interdisciplinarity is an important factor in instigating our education system to “produce an education that teaches how to think, and to think about what has already been thought, ‘learning to learn’; an education that [...] recovers the values associated with knowledge, collaborating with citizens and professional formation” (Luzzi, Philippe Jr, 2011).

3.1 PEDAGOGICAL APPROACH AND ASSESSMENT

Formal or informal education presents itself as a subject and object of concern for education professionals, government agencies and society, arguing about the foundation of teaching praxis. Thus, teaching and learning process has been seen in an integrated way with culture-society its dominant beliefs and values at a given time, which means that theories which support this process have changed over time (Santos, 2005).

Considering authors who analyze and compare teaching and learning process approach, the works of Libâneo (1982), Bordenave (1984), Saviani (1984) and Mizukami

(1986) stand out, who classify and group theoretical currents, according to different criteria based on their different motivations.

Due to a variety of criteria and differences related to the main components that explain the educational process, Mizukami (1986) perspective was considered, focusing on concrete teaching-learning situations, by formal agent, school, involving routine activities between teachers and students presented in detail in Chart 1, below:

Pedagogical Approach	General features	Authors	Teaching-Learning process	Student-Teacher relationship	Assessment
Traditional	Great importance to knowledge; Transmitter-receiver duality.	Émile Chartier, Snyders	Instruction (isolated process); restricted to school actions; unilateral transmission; ignores individual differences and learning styles.	Top-down; transmission of predetermined knowledge.	Expositive, passive, standardized. Evaluation with content reproduction. Difficulty in meeting the individual needs of the student.
Bahaviorial	Emphasis on the object and knowledge; man is considered to be a 'product of the environment'; the student is conceived as a container of information; instructional strategies based on educational technology.	Skinner	Focus on technology; Cooperation between students is not emphasized; cultural transmission.	Structured and objective; well-defined roles; teacher as a link; through techniques.	Educational technology and reinforcement strategies. Assessment at the student's pace, in small steps, without error; follow-up.
Humanist	Emphasis on the student-centered subject; subjective, emphasis on interpersonal relationships; principles of learning and student assistance; man as a permanent and unfinished project; "learn to learn"	Carl Rogers, Alexander Neill	Person-centered; non-directive method; own style; promoter of change and learning. Education based on self-discovery and self-determination.	Personalist approach; individual character of the student-teacher; 'Rapport'; facilitating teacher.	It does not emphasize technique or method. Self-assessment, rejection of standardization.
Cognitivist	Emphasis on cognitive processes and scientific research; the student's ability to integrate information and process it; cognitive and affective development are interdependent; new knowledge integrates with existing structures by modifying them; continuous construction "learning by doing"	Jean Piaget	Trial and error; Problem solution; progressive teaching; openness and new inquiries. Theory of development and knowledge.	Teacher creates situations; student with active role; observe, experiment, argue.	Intelligence is built from the exchange of the organism as a means; the action of the individual is the center of the process. Fluid assessment, multiple criteria.
Sociocultural	Interactionist; focus on the subject as a creator and creator of knowledge; cognitive development is the conversion of social relationships into mental functions; activity-based psychology; 'Middle intervention'; man is the subject of education.	Vygotsky, Paulo Freire	Broad meaning, there are no restrictions on formal and informal situations; Problem-solving, awareness-raising education.	Horizontal; 'Educator-educating and educating-educator'; concern for each student individually and with the process; exchange of meanings.	Active Methodology; creation of own pragmatic content; emphasizes critical dialogue. Assessment: understanding and practice of assessment as an instrument for assessing what to do with critical subjects at work (problematizing situations).

Chart 1 – Pedagogical Approach and Assessment
Source: Adapted from Mizukami (2011)

According to Mizukami (2011), the educational phenomenon is not a ‘finished reality that can be known in a unique and precise way in its multiple aspects’. Consequently, it presents itself as a human, historical and multidimensional phenomenon, with its multiple implications and relationships.

3.1 STEAM & MAKER EDUCATION

STEAM Education seeds promoting Maker culture are not recent going back to Socratic maieutics, to Rousseaunian perspective where ‘education should allow students to freely return to nature’, to Froebel's approach that 'in kindergarten students should not be in classrooms, but in game labs', to Peirce's ‘problem-solving’ and Dewey's ‘reflective thinking’, to Piagetian stance that school integrates discovery in its daily life, to Papert's proposal that students should produce content and not just be passive in their computing classes (CEFOR, 2021).

Collaborating, creating, researching and sharing are skills that have become increasingly part of the teaching-learning process. Pedagogical mediation has a new focus, spaces for competences development, where research, ideas exchange and collaborative experiences will be the bases of knowledge. In this context, active learning places the student at the center of this process and encourage them to transform content into knowledge, in an autonomous and participatory manner.

According to Cavicchi et al (2009), bringing about a classroom where even everyday things can be seen as curious and worthy of questioning means letting the packaging unravel, tolerating spontaneity in what students notice, wonder about, and discuss, and finding grounds in those responses for further activities and study. Doing this, compounds the risk that teacher and students experience. Not only do they, like artists and scientists, use commonplace things in provoking contemplative and investigative acts that may reveal failings in everyday knowledge, but also disrupt structures of human relationships that become ingrained in people through conventional schooling.

The politics of STEAM (Science, Technology, Engineering, Arts and Mathematics) education incorporates knowledge society concepts related to learning and governance, including the “network” and the “partnership.” These concepts are used to suggest how the educational sector of society might adapt to social, environmental, and economic uncertainties (Jorgenson, 2014). Arguing that educational researchers have paid little attention to the shift from an industrial economy to a knowledge economy, Sawyer (2006) suggests that schools turn their attention to knowledge creation.

One outcome of improving achievement in STEAM education in many countries is preparing a workforce that will improve national economies and sustain leadership within the constantly shifting and expanding globalized economy (Kelley, Knowles, 2016). As Popkewitz (2013) notes, when integrated into educational reform movements, the partnership carries particular implications for both teachers and students: an active, self-reflexive problem-solver and lifelong learner.

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Chart 1 – Pedagogical Approach and Assessment
Source: Adapted from Mizukami (2011)

Features	Traditional Lab	Critical Exploration/Maker Space
Student's perspective	Executor, users of applications suggested by the teacher	Protagonist of his learning making decisions and leading the choice of projects
Professor's perspective	Supervision, mediation, monitoring of activities	Facilitator of student trajectories, mediator and co-author
Team work	Restricted to pairs or trios from the same course or area of expertise.	Interdisciplinary / Transdisciplinary Team
Learning	Restricted to curriculum content, content defined by the teacher.	Diversified from the creation and socialization among the members
Error meaning	Avoided: corresponds to a student's failure. It must be eliminated.	Part of the process: a problem that must be considered in the next version
Creative potential	Restricted to resources: equipment and software made available.	Open, dynamic, unrestricted
Technology role	Provide information and activities (end)	Provide conditions for the construction of objects and artifacts (means)

Chart 2 - Pedagogical aspects of Teaching-Learning spaces
Source – Adapted from Passos (2014)

Introduced by Duckworth (2006) 'Critical exploration methodology' from the research that Jean Piaget (1960) and Bärbel Inhelder (1974) evolved while investigating how children come to new understandings and capacities in relation with the world (Cavicchi, 2006). This approach focuses on experiences in teaching and learning which a teacher conducts so as to engage learners in a subject matter that is real and may be physically present in the classroom. With its fullness of detail, the reality of such a subject accommodates plenty of leeway across which learners may exercise curiosity, actions, observations, conjectures and thought. By their own agency on and with the subject, learners develop in their awareness and understanding of it, and in their capacity for action (Cavicchi et al, 2009).

In this context, the Maker Movement proposed by Hatch (2013) emerges as a philosophy of life, which should be practiced, considering the following principles: *Make* (create, build, express yourself); *Share* (share not only your product, but your knowledge); *Give* (is a rewarding act); *Learn* (journey to master craftsmanship, lifelong path); *Tool up* (the right tools for each project); *Play* (enjoy this experience); *Participate* (join the Maker Movement in society); *Support* (we are responsible for making a better future); *Change* (embrace the change that will naturally occur throughout the process).

When analyzing this process, it is realized that innovation cannot be taught, which means, 'no one teaches another person to be innovative'. However, this does not prevent creating the conditions for innovation to be learned: when facing challenges and thinking about them looking for possible solutions, every individual is able to develop competencies related to innovation (Braga, 2021).

4 ECOLOGIZATION EDUCATION

Misinformation contributes to build informational competence, dealing with issues such as: resistance to change consumption habits, resistance to change production, resistance to change in public policies and regulatory frameworks and even the resistance to presenting the problem as a system, constituting the same planetary order. In this context, how to understand these issues in the higher education institutions (HEI) with issues brought up by the Anthropocene?

For Mészáros (2008) it is necessary to break with the logic of capital if we are to contemplate the creation of a significantly different educational alternative. Souza (2002), based on Paulo Freire studies, understands that in the teaching-learning processes the

confrontation between scientific culture, mass culture and popular culture must be established, to build new knowledge, institutions, subjectivities and new societies.

Thus, when thinking about ‘necessary knowledge for educative practice’ (Freire, 2011), it seems impossible to build ‘sustainable development’ without considering education for sustainable development, which should have as a basic premise: be economically viable, ecologically appropriate, culturally equitable, socially fair and inclusive.

The relationship between environment and education takes on an increasingly challenging role, demanding the “emergence of new knowledge to apprehend risen complex social processes and intensifying environmental risks” (Jacobi, 2005). In view of environmental problems that involve different social actors’ accountability, knowledge articulation and empowerment is fundamental for education for sustainability, valuing above all education professionals (Ravetz, 2004; Sulaiman et al., 2014).

Environmental education history in Brazil witnessed, throughout its development, moments of dispute and conflicts between behavioralist and political pedagogical conceptions understood as antagonistic ways of perceiving and reacting to socio-environmental problems (Lima, Layrargues, 2014). In this sense, Jacobi et al. (2009) argue that environmentally sustainable educational practices point to pedagogical proposals centered on emancipation, changing behavior and attitudes, to social organization and collective participation. In this proposal of "reflective and engaged education, centered on knowledge and practices built with ‘teachers’ and 'learners', environmental education differs substantially from environmental information".

Reigota (1998) defends the idea that environmental education points to pedagogical proposals centered on awareness, behavior change, skills development, assessment capacity and student participation. The relationship between environment and education for citizenship takes on an increasingly challenging role, demanding the emergence of new knowledge to apprehend complex social processes and intensify environmental risks. Sustainability as a new basic and integrating criterion in education needs to permanently stimulate ethical responsibilities, knowledge dissemination, change of values and skills improvement, as basic conditions to stimulate greater integration of individuals with the environment (Pádua, Tabanez, 1998; Reigota , 1998; Jacobi, 2003).

In the environmental management field, 'social learning' is supported by growing understanding that the diversity of opinions of different actors and different sources of knowledge (scientific research, indigenous peoples, landowners, etc.) can support

decision making with greater quality and social validity. According to Jacobi (2003), environmental education must seek, above all, solidarity, equality and respect for difference through democratic forms of action based on interactive and dialogical practices.

4.1 SUSTAINABLE DEVELOPMENT AND SOLID WASTE POLICY IN BRAZIL-COLOMBIA

As observed in the Sustainable Development Goals (SDGs), Public Administration appears as a key actor for articulation amongst other actors (Silva et al, 2020). Thus, Decree nº 8,892, of October 27, 2016, deserves to be highlighted, by which National Commission for Sustainable Development Goals (CNODS) was established, with the primary purpose to "internalize, disseminate and give transparency to the implementation process. of the 2030 Agenda for Sustainable Development of the United Nations, subscribed by the Federative Republic of Brazil" (Art. 1). CNODS does not only count on political representative participation from Municipal, State, and Federal Governments, but also includes members of productive sector, Academy, Third Sector and involves private organizations with public utility in civil society such as NGOs.

Since 2010, Brazilian National Solid Waste Policy (PNRS) seeks to organize the way public and private sectors should treat waste. For instance, Law 12.305/2010 indicates the responsibility for reverse logistics of some electronic products, batteries and batteries should rest with manufacturers, importers, traders and distributors. On the other hand, this whole process only begins with consumers effective participation, who must dispose their products in suitable locations so that they are properly collected and recycled.

According to the publication "Panorama of Solid Waste in Brazil", the amount of solid urban waste generated in the country in 2019 was almost 79.1 million tons where 72.7 million were collected (ABRELPE, 2020). This document makes it possible to assess that, compared to previous years, there was a reduction in the per capita amount of waste produced by the Brazilian population, although not very significant in view of the lack of infrastructure for access to garbage collection or its environmentally appropriate final destination, much less the significant development of socio-environmental initiatives (Azevedo et al, 2020).

Another aspect that must be taken into account is that the current consumption pattern has led to the intensification of the disposal of electronic waste (WEEE). In a short

time, the materials move from innovation to obsolete equipment and, as soon as, technological scrap. Waste from electronic devices is made up of different materials and chemical elements that are harmful to health and, because of that, they must have an appropriate and harmonious destination with the environment (Ferreira et al, 2020).

In Colombia there is a solid waste policy, which determines that the problem of waste is associated with the following aspects: (*i*) consumption patterns that determine unsustainable waste production patterns; (*ii*) lack of citizen awareness about solid waste management; (*iii*) potential for the use of waste is lost since it is mixed at the source; (*iv*) lack of support of product market, which is limited to some sectors; (*v*) waste management is focused on final disposal, such as landfills, without considering other alternatives; (*vi*) other phases involving waste management (Salcedo, 2004). Currently in Colombia the processes of Comprehensive Solid Waste Management do not contemplate the minimization of solid waste production as a strategy, which is why the accumulation of solid waste in sanitary landfills prevails, and its production is increasing, given population growth (Montoya, Martinez, 2013).

It is perceived that universities or, in general, higher education institutions (HEIs) have their role as transforming actors in projects implementation aiming to put into practice methods that not only disseminate SDGs, but also reach them within 2030 Agenda deadline. These HEIs, in addition to seeking to achieve these goals, should serve as a stage for articulation and dialogue between scientists and researchers with government representatives, third sector and ordinary citizens of society (Silva, 2020).

Similarly Bochnia et al. (2013) argue that educational institutions have a significant role regarding the importance of preserving environment encouraging sustainable practices centered on social and environmental responsibility. In addition, HEIs can be compared to small urban centers, which involve various teaching, research, extension and activities related to their operation, through restaurants, canteens, among others. Therefore, it is essential that these organizations begin to incorporate sustainability principles and practices to make fundamental decisions about planning, training, operations or common activities.

5 METHODOLOGY

A literature review was carried out considering the following themes: Anthropocene, Pedagogical Approaches, Maker Education and Ecologization in

Educational Institutions. In order to support the empirical research on HEI commitment to environmental issues, by documentary research and compared study.

Based on Scientific Methodology literature (Gil, 2008; Flick, 2009; Ludke, André, 2012), this research is: (*i*) regarding the approach: qualitative (descriptive); (*ii*) regarding the qualitative research paradigm: symbolic interactionism; (*iii*) as to nature: applied, interactions among social actors relating to environmental education; (*iv*) regarding the objectives: exploratory; (*v*) as to the method: case study; (*vi*) regarding the procedures: bibliographic research, documentary research and comparative study.

Based on data consolidation and pedagogical elements association, the Environmental Agenda based on Education in the Anthropocene is discussed to bring Best Practices that can be used in both educational institutions in Brazil and Colombia.

6 RESULTS

Life cycle analysis (LCA) refers to activities in product's life from manufacture, use, maintenance and final disposal (IBICT, 2018). LCA process is an approach composed of four key components, which are: (*i*) definition of objectives and scope; (*ii*) inventory analysis; (*iii*) impact analysis and (*iv*) interpretation of results (ISO 14040:2001).

For example, in Colombia, created by Conceptos Plásticos bricks were made of plastic waste, allowing low-cost popular houses building. In this way, plastics life cycle was extended by its transformation into bricks (Braga, 2021). In Brazil, a brick made of clay composition with cement and water, undergoes a manual manufacturing process with 40% cost reduction of popular house building. This initiative was developed by Professional and Technological Education students of Vila Vitória community in Imperatriz-MA, northeast Brazil, by Federal Institute of Professional Scientific and Technological Education of Maranhão - IFMA (Varão Silva, 2018).

6.1 MAKER EDUCATION BASICS: BUILDING A WIND-POWERED CAR

Building a ‘wind powered car’ is one of the first dynamics developed in workshops focused on Maker Culture in Education that does not require complex knowledge of technologies and that can be applied to a wide variety of audiences, from basic education to postgraduation. For instance, to develop such activity, the following materials are required: (1) milk/juice recycled cardboard; (1) 10cm x 15cm piece of

construction paper; (3) recycled wooden skewers; (2) plastic straws; (4) plastic bottle caps; complementary devices such as tape, scissors, hobby-knife and fan.

Starting from MOOC Educador Maker course organized by Federal Institute of Espírito Santo - IFES, with the creation of a ‘sustainable version’ using recycled materials. In order to build your own ‘wind powered car’ you should apply the following procedures: 1- tape the straws to the recycled cardboard; 2- make sure the straws are parallel; 3- cut off ends of the straws; 4- carefully poke a + shaped hole in the center of each bottle cap; 5- push a wooden skewer through one of the bottle caps; 6- thread the skewer through one of the straws; 7- push a bottle cap onto the Other endo f the skewer; 8- cut off the endo f the skewer, making na axle; 9- repeat the process to make a second axle; 10- make sure the axles spin and the car rolls without getting stuck; 11- poke a hole in the Middle of the cardboard; 12- insert a wooden skewer to make a mast; 13- secure the mast with tape; 14- cut out a shape from construction paper (approximately 10cm x 15cm) to make a sail; 15- poke the wooden skewer through the sail on both ends; 16- turno n the fan and watch your car go! Figure 1 shows a sample:

Figure 1 – Maker Education: sustainable wind powered car

Source: Author’s data collection.

At the time of construction of the wind-powered car, an observation process begins that leads to reflection: if any material is modified, could it improve its performance? The use of recyclable materials feeds into the 'product life cycle' within the concept of circular economy, which can be studied in the reuse of other types of recycled materials.

6.2 ECODESIGN IN COLOMBIA

Universidad El Bosque has established significant learning, proposed by Dr. Fink (2003), as a pedagogical model in this Institution, proposing that class activities be a significant learning experience for the student.

For this reason, ecodesign product analysis in Bogotá local market, with the purpose that students understand the environmental problem. By this perspective, understanding how it could affect the planet due to the lack of responsibility in production and consumption, with the purpose to propose better design alternatives mitigating its impact. For this study development, Life Cycle Analysis (LCA) tools were used, to later apply ecodesign strategies (Maruyama et al, 2016; Lopes et al, 2019; Maruyama et al, 2019).

Ecodesign is focused on the creation and manufacture of products minimizing environmental impact generated by the same mechanisms during its life cycle: raw materials extraction, manufacture, product distribution (transportation), use, and final disposition (UNEP, 1997; Lidia Isaac, 2008). Life Cycle Analysis (LCA) is a technique that allows evaluating a product environmental loads during its life cycle, with the objective of proposing environmental improvements from the selection of low impact materials, non-toxic, to enhance material management systems (Rodríguez, Iris, 2012).

The selected products are: (*i*) a package of five chewing gum units that is on the market (Martinez, Montoya, 2012); (*ii*) toothpaste cardboard box + container where the toothpaste is packed (Montoya et al, 2014). Through LCA application methodology, it was evidenced that chewing gums packaging generated an environmental impact of 92.2% in the use of non-renewable raw materials, fossil and mineral origin (plastic and aluminum), which also made difficult the separation and recovery in recycling, reuse or biodegradation processes, ending the lifecycle in the sanitary landfill.

By ecodesign strategies such as monomateriality (Figure 2), biodegradability, recycling, reuse, and design for waste minimization, it is possible to reduce the environmental impact (gum packaging) by more than 90% compared to its original product. This decrease is due to the use of cardboard as raw material instead of three (plastic, paper and aluminum). This change promotes a product-service approach, that is, a packaging which promotes gum recharge and prolongs its useful life while maintaining customer loyalty (Martinez, Montoya, 2012).

Figure 2 – Bubble gum wrap and toothpaste ecodesign

Source: Adapted from Martinez, Montoya (2012) and Montoya et al (2014).

In order to prepare the proposal to redesign the toothpaste container, environmental requirements mentioned above were taken into account, as well as other reference objects features such as: elongated cylindrical tube potato chip container shape with a flat circular bottom and internal sweeping mechanism of a deodorant, allowing the toothpaste to be completely washed away using the product.

By life toothpaste lifecycle analysis, it was possible to show that aluminum generates 59.9% in the extraction process, in addition to the difficult separation of these materials. Using ecodesign strategies it was possible to eliminate the use of several materials until reaching a single material, which is polypropylene: allowing a longer useful life, facilitating its recharging by implemented design. In addition, this new feature makes the product reducing environmental impact up to 58% compared to the previous container, because its long-term production would be shortened due to recharging. Besides, thanks to new toothpaste packaging characteristics, this product mass distribution is facilitated, due to its material rigidity, decreasing secondary cardboard packaging (Martinez, Montoya, 2012; Montoya et al., 2014).

6.3 SUSTAINABLE EDUCATION PORTFOLIO IN BRAZIL

Cefet-RJ community awareness process involves carrying out activities that seek to draw attention to important socioenvironmental issues, which are increasingly noticeable by environmental problems affecting citizenship (Zeitoune et al, 2019). Another aspect of sensitization process is values and attitudes development promoting environment friendly behavior (Trigo et al, 2017). “Less Plastic is More” project professors Valéria Pereira and Giselle Correa da Silva as advisors from Cefet-RJ

Maracanã Chemistry Coordination. This project is developed since 2018, with the following objectives as guidelines (Pereira et al, 2019):

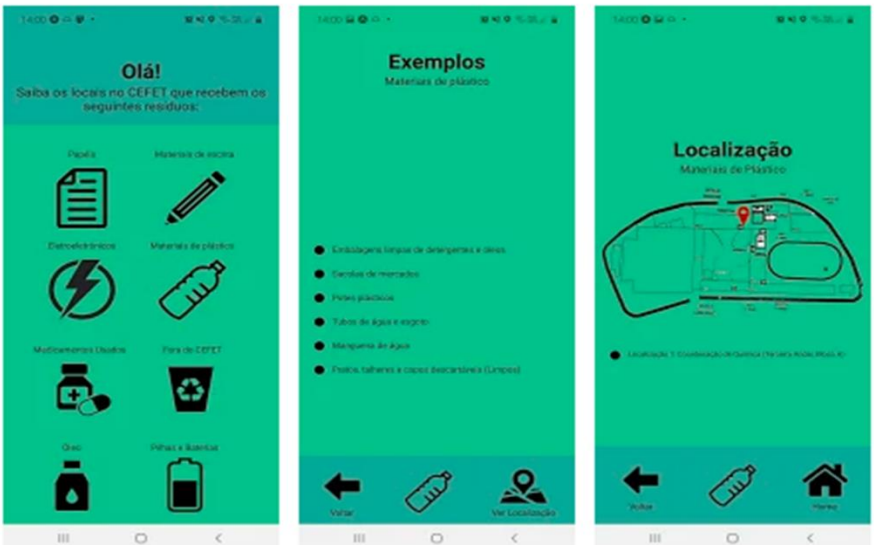
- Make students and the community aware of the environmental impacts, misuse of plastics and consequences of improper disposal;
- Dedicate a cleaning day on Rio de Janeiro city beaches;
- Identify different types of plastics and create a research collection database;
- Research on the various alternative materials that can replace these plastic materials.

Since its creation, as part of its strategy to raise awareness in the community, several visits were scheduled to Rio de Janeiro beaches such as: Ipanema, Flamengo, São Conrado and Praia da Bica. By crushed plastic compound, another phase had started: material resistance tests for its use as an additive in civil construction. Figure 3 shows examples of 'Less Plastic is More' Project (a, b) and 'Solmar Project' (c).

Figure 3 – 'Less Plastic is More' (a,b) and Solmar (c) Projects

Source: Author's data collection.

Figure 4 – Reciclaqui App



Source: Authors.

The purpose of SOLMAR Project, coordinated by Professor Sidney Teylor in Mechanics Technical Education at Cefet-RJ, is to demonstrate that technological education students can apply their knowledge in a practical way to develop equipment using solar energy for various activities. When carrying out the buoyancy test, moving a sustainable vessel prototype - the equipment maintains itself without causing significant environmental damage. Due to its characteristics, the equipment has as main benefits: (*i*) generation of clean electric energy (solar energy); (*ii*) low cost; (*iii*) incentive to selective collection with reuse of materials that would be discarded (recycling).

Another initiative to encourage responsibility for electronics products reverse logistics, Reciclaqui app was created in 2020 (Figure 4), available for download at https://play.google.com/store/apps/details?id=com.cefetsust.tejedor aims to help students and employees of Cefet-RJ Maracanã campus to dispose waste such as plastics, paper and writing materials (Moura et al, 2020).

Considering that Electrical and Electronic Equipment (EEE), at the end of its useful life, is classified as Waste Electrical and Electronic Equipment (WEEE), must be properly disposed, since electrical/electronic waste has hazardous potential, it is necessary to have a high level of safety in segregation and subsequent treatment process (Trigo et al, 2017; Moura et al, 2020).

7 FINAL CONSIDERATIONS

In Anthropocene times, there is no single answer, there is no single responsible - even if this is the capitalist system itself - just as there is no single solution. And just like 'Ariadne's Thread', all efforts, if not properly considered and articulated, could represent a 'Pyrrhic victory' to someone's eyes.

During this research, it was observed that actions carried out by both Brazilian public institutions and private Colombian institutions, have pedagogical approaches which challenge students through active methodology approach projects and encouraging them to develop entrepreneurial skills to create their own more innovative sustainable products.

On the other hand, there is still a long way to adequate environmental management in higher education institutions, because although there are educational initiatives aiming at environment awareness, investments to promote an environmental agenda is still incipient in most institutions. However, it is noteworthy that each teacher, each discipline, each project can contribute within their areas of knowledge to a 'learning by doing'

culture by integrating knowledge from different areas and organizing efforts towards a common purpose: a more environmentally sustainable society for future generations.

Finally, it is expected that these initiatives examples represents the first step towards reflection for gathering efforts in consolidating an Environmental Agenda for Latin America, considering UN Sustainable Development Goals (SDGs), capable of promoting HEI interactions with the purpose to build an Education in the Anthropocene committed to environmental sustainability in a socially fair and transparent way.

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