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CIRCULAR ECONOMY IN HIGHER EDUCATION INSTITUTIONS: LESSONS LEARNED FROM BRAZIL-COLOMBIA NETWORK

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ABSTRACT

Goal: this paper goal is presenting sustainability experiences using Life Cycle Assessment perspective in two Latin America higher education institutions (HEI). What similarities do these HEI have in common regarding sustainability? What are the major challenges they face? In which way is Circular Economy effective on university campuses? Since universities face challenges posed by a changing and competitive environment, there ought to be sustainable management that is more appropriate to higher education institutions' real environment, which is characterized by complexity, paradoxes, ambiguities, and conflicts.
Methodology/Approach: Multiple Case Study. A resilience threshold of global ecosystem should be considered. Ecosystem dynamics require effort in mapping its functions.
Results: the results considered that the difference between environmental approach failure and success lies in knowing how to realign their strategic plans.
Limitations of the investigation: comparing private and public HEI and different levels of education (technical, undergraduate and graduate courses).
Practical implication: the practical implication leads to an understanding that Circular Economy in HEI can be perceived as a guideline to innovation towards a more sustainable economy.
Originality/value: the originality/value of this work is the ability of enabling scientists to empathize with both Brazıl and Colombia's LCA perspectives in HEI.

Keywords: Circular Economy; Environmental Management; Higher Education İnstitutions; Research Group; Sustainability.

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1. INTRODUCTION

The advent of a new economy and culture of consumption, post-Fordist system is accompanied by profound changes in demand stimulation, sales formulas, behaviors, and consumer imaginaries. Industries and services employ a variety of choice logic, product, and price customization strategies (Enríquez, 2010). Large distribution is committed to presenting policies of differentiation and segmentation, but all these changes only increase the commodification of life style and feed frenzy desires increasingly transformed into previously non-existent needs, leading to hyperconsumption (Lıpovetsky, 2007).

On the other hand, global discussion about environmental sustainability has been gaining undeniable strength in recent years. The establishment of a rational and ecologically sustainable use of nature for the benefit of local populations, leading them to incorporate concern for biodiversity conservation, should be a development strategy component (Sachs, 2009). Industrial capitalism, which is based on continuous and cumulative development of new products and services, has generated diverse environmental effects. Consequently, the planet's ability to provide resources and absorb waste is rapidly reaching a critical and irreversible level (Wagner et al., 2013, Léna et al., 2012). There is no doubt that the 'disposal economy' contributes significantly to climate change.

Despite progress, the dilemma of expanding economic activities equitably while attempting to stabilize the rate of resource use and reduce environmental impacts poses an unprecedented opportunity and challenge to society (UNEP, 2011). Environmental management perceives driving of a new thought that needs to be accompanied changes in perceptions and new practices: from expansion to conservation, quantity for quality, domination for partnership, from reactive to proactive management (Trigo et al., 2017).

The establishment of a rational and ecologically sustainable use of nature for local populations benefits, leading them to incorporate concern for biodiversity conservation to their own interests, should be a component of a development strategy. Decoupling environmental pressure from economic growth occurs by abandoning the perception of economy as being isolated from nature and adopting a broader view, considering economy as part of a living and dynamic ecosystem.

Regulatory and market pressures contribute to industries learning more about their impact on the environment and improving their environmental strategy (Berkhout, 1996; Yadong et al., 2013). As a result, some organizations have created an environmental management department that promotes learning and structures actions concerning this issue.

Moreover, the use of Life Cycle Assessment (LCA) as a generator of relevant environmental information for decision makers became more evident in the last decades (Motta et al., 2018). When this debate is broadened, the relationship with social issues is verified, since several actors are involved such as: public sector, companies, society as the generator of this waste. Thus, it is considered one's perspective whether the people who formally work in processes collection, treatment and final disposal of waste, as well as those in situations of social vulnerability, such as informal workers who live from the collection of recyclable waste and other related activities, or even people who are in a situation because they live in regions where waste is disposed of without adequate treatment (Gobira et al., 2017).

Henceforth, Circular Economy has been presented as an alternative to reduce environmental impacts and use natural resources in a viable way. It is concerned with both a more efficient generation of products and the inclusion of waste/disposal material as productive input (Gansky, 2011). However, the model used in the production system generally works in a linear fashion. Replacing this model requires changes in the forms of production as well as in the training of professionals who deal with these processes.

One question which might arise is how should the concept of Circular Economy be used in the training of engineers? One possibility is the utilization of the knowledge of production engineering in product design and development, especially through the ecodesign of the analysis of generated environmental impact and the trade-offs pertinent to the life cycle assessment (LCA). That knowledge, together with production, can offer elements of convergence with the concept of Circular Economy for teaching in production engineering.

In natural systems, waste is never truly wasted, since the residue of one system becomes food for another. Circular Economy (CE), or restorative economy by nature, is a concept generated in the 1970s that presupposes the rupture of linear economic model (extract, transform, and discard). It is currently applied by most companies for the implantation of a model in which all types of materials are designed to circulate efficiently and be relocated in production without loss of quality.

Thus, Circular Economy divides materials into two groups: (i) biological, which are designed for reinsertion in nature and (ii) technical, which require investment in innovation to be dismantled and recovered. Furthermore, Circular Economy has most often been considered only as an approach to more appropriate waste management, but it seems to be a very limited point of view when its opportunities and potentialities are considered.

Brazilian Journal of Operations & Production Management
Volume 16, Número 1, 2019, pp. 88-95
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Sustainability co-creation is defined as "a role where the university collaborates with diverse social actors to create societal transformations with the goal of materializing sustainable development in a specific location, region or societal subsector" (Trencher et al., 2014, p. 152). The epistemological shift from knowledge production as a goal in itself (i.e. conventional scholarship) toward the co-production of knowledge and transformative strategies with societal stakeholders is key (Trencher et al., 2016; Van Veen et al., 2013). In this sense, HEI are used as co-creation headquarters to sustainability and technical and social innovation. This paper presents a multiple case study between Brazilian and Colombian HEI, discussing alternatives to develop these concepts in training of future production systems professionals, both in undergraduated technical courses and engineering.

2. CIRCULAR ECONOMY: A NEW PARADIGM

The most widespread concept of sustainable development is that mankind will meet its current needs without compromising the future generations' ability to accomplish the same. Moreover, as presented by Veiga (2015), the development of humanity should not be restricted to what is understood today by 'economic development'; therefore, an ecosystem resilience threshold should be considered. Understanding ecosystems dynamics requires an effort to map its functions, which can be translated into ecosystem services insofar as they benefit human societies (May, 2010).

In natural systems, waste is never truly discarded, once the residue from one system becomes food for another. In this context, one challenge faced by industries is how to revalue all types of waste, since it implies finding valuable products that can be repaired instead of labeled as waste (Gansky, 2011). Thus, one must seek to optimize processes by means of a Circular Economy whose logic considers environment not only in in terms of the resources withdrawn from it, but also its impact reduction.

3. LIFE CYCLE ASSESSMENT AND ECODESIGN

Life Cycle Assessment (LCA) is a key methodology to guide innovation towards a more sustainable economy with reduced use of natural resources. The ACV examines how the product can affect the environment during resource consumption, manufacturing processes, use, and disposal.

The productive process studied during stroke usually involves the following phases: conception; acquisition/extraction of raw materials; manufacturing; use/reuse/ maintenance; recycling; waste disposal. Each step is analyzed and quantified in order to verify the local, regional or global impact that this process, product or service will have on the environment. One of the main advantages of the LCA methodology is the possibility of verifying the transfer of the environmental impact from one stage/category of the cycle to another (Motta et al., 2015).

On the other hand, ecodesign focuses on the development and manufacturing of products that minimize the environmental impact caused during the product life cycle (i.e., raw material extraction, manufacturing, product distribution, use and disposal). Minimizing effects requires considering strategies to reduce the use of energy and raw materials as well as optimizing production processes, thus reducing the amount of packaging material (Unep, 1997; 2011).

Ecodesign presents seven steps: (i) definition of a business strategy; (ii) product selection; (iii) environmental analysis; (iv) development of new concepts to define product improvements; (v) detailed project definition; (vi) action plan - product development and manufacturing; (vii) continuous evaluation (Fundacion Prodıntec, 2005).

In order to detect a product's environmental impact, a life cycle assessment tool defined as a methodology is used to "identify, quantify, and characterize the various potential environmental impacts associated with each phase of a product's life cycle" (Montoya et al, 2014). Several authors (Bhander et al., 2003; Zufia et Arana, 2008; Benetto et al., 2009; Peuportier et al., 2013) have been developing different approaches in scientific reasearch. In this study it was based on Montoya et al. (2014) approach.

4. METHODOLOGY

The primary purpose of this Multiple Case Study, considered as exploratory research is to provide the widest possible range of information about the phenomenon studied (Carrancho, 2005). The procedures were documentary research, investigation of different scientific contributions to sustainability in higher education institutions in Colombia and Brazil.

5. PROPOSALS FOR TEACHING: A BRAZILIAN CASE STUDY

In this section two case studies are presented; concepts of environmental sustainability were applied to both educational activities. Each case occurred in different contexts: one in technological teaching in Brazil and the other in higher education in Colombia.

Brazilian Journal of Operations & Production Management
Volume 16, Número 1, 2019, pp. 88-95
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6. SOLMAR PROJECT: BRAZILIAN INITIATIVE IN TECHNOLOGICAL TEACHING

The recycling sector has been growing rapidly in Brazil and in other emerging countries. According to Brazil's Federal Government website (MMA, 2016), this sector moves R$ 12 billion a year, where only 10% of the whole waste generated in cities is recycled. Considering this scenario, scholars and professionals committed to fostering sustainable development have urged a re-examination of the curriculum and restructuring of research in higher education institution (HEI) towards a more sustainable approach. How can multi- and trans-disciplinary teaching and research coexist in a meaningful way in HEI structures? Does education relevant to sustainable development require its own protected incubating environment to survive, or will it otherwise be gobbled up and marginalized by attempting to instil it throughout the traditional curriculum? (Ashford, 2004).

SolMar Project proposes the association of alternative energy (solar energy) materials with recycling PET bottles. This activity has also been regarded as being able to foster positive behavior in students' future professional life, since environmental opportunities in this sector tend to increase. Moreover, project participants develop awareness about environmental issues when directly involved in project-based learning challenges from its conception and execution.

SolMar Project was inspired by different tournaments around the world, such as: 'Desafio Solar Brasil'; 'Solar Splash'; and 'Victorian Model Solar Challenge'. By benchmarking different competitions, relevant aspects on LCA and clean energy were identified and incorporated into the original idea. This project was developed by students of CEFET/RJ's mechanics technical course at the beginning of 2016, counting on the support of professors from Mechanical Engineering, Metrology, Automation Engineering, and Administration courses.

The purpose of SolMar Project is to demonstrate that students of technological education can apply their knowledge in a practical way to develop equipment using solar energy in various activities. Performing the buoyancy test by moving a sustainable vessel prototype indicates the equipment is capable of being maintained without causing significant environmental damage. Due to its characteristics, the equipment's main benefits: (i) generation of clean electric energy (solar energy); (ii) low cost; (iii) incentive to selective collection with the reutilization of materials that would be discarded. Figure 1 shows the design and assembling of the equipment that uses PET bottles and plates to capture solar energy in a floating form.

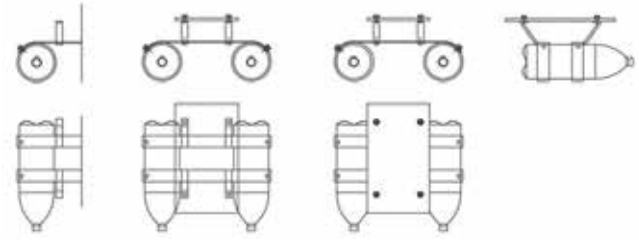

Figure 1. Assembly of equipment with recycled material
Source: Authors.

After equipment designing, the selection of recycled material was made considering the design of the 2-liter PET disposable bottle for better buoyancy performance. Additionally, the plate for capturing solar energy was associated with the use of clean energy.

Figure 2. Students assembling equipment with recycled material
Source: Authors.

Considering that this project was carried out by teenagers from 13 to 16 years old, as part of their technology teaching (see Figure 2), the equipment assembly and final result it seems to be simple (Figure 3), but adequate for developing scientific and entrepreneuship competencies in their education level. For instance, all planning and execution stages, including the pilot test, present possibilities for improvement. It is believed that the partnership amongst students of technology teaching and engineering students throughout this project would be beneficial to both groups. In addition, providing interchange of practical knowledge by different experiences in sustainability, this partnership could allow the development of more complex and sophisticated products that could eventually be used beyond the walls of schools and universities.

Brazilian Journal of Operations & Production Management
Volume 16, Número 1, 2019, pp. 88-95
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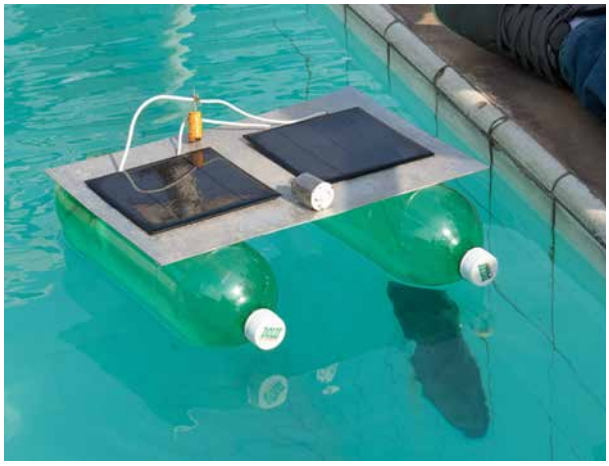

Figure 3. Equipment under test for SolMar Project
Source: Authors.

Figure 4. Map of the university El Bosque and route of materials
Source: Adapted by Montoya and Martinez (2013).

7. COLOMBIAN PROJECT: ENGINEERING AT UNIVERSIDAD EL BOSQUE

Currently in Colombia solid waste management processes do not generate their reduction as a strategy, leading to the accumulation of this waste in landfills, with an increase in their production. In Bogotá, 6,300 tons are accumulated per day at the Doña Juana landfill (El Bosque, 2011). According to Montoya et Martinez (2013) to the extent that waste is still generated and there is no policy applied to reduction, reuse and recycling, [this practice] will continue to require large tracts of land to dispose of waste.

The research developed at the Faculty of Engineering of Universidad El Bosque was conducted in order to identify solid waste within the University, specifically in the production of packaging that is made in the food areas. For data collection, waste management was identified through observation, photographic record, interviews with vendors and College General Service providers. During six-months, stakeholders analysis had been made, as well as waste sources (food areas), and the disposal from 'ecopoints', cans, and certain collection centers.

Nine suppliers were interviewed in order to identify feed areas, products sold and their weekly sales. Subsequently, selected products by each company were characterized, and these results were aggregated to the total sum of all companies: weekly sales, number of units and packaging weight (quantity of waste) were taken into account.

Through these interviews, it was observed that companies that sell products within the University are unaware of the material used to make the packaging and the impact generated by its disposal in the environment (Montoya et Martınez, 2013). The main aspects identified were:

- Lack of interest or sufficient knowledge by university community (suppliers, consumers and waste pickers) to implement appropriate waste management culture.

- Lack of diversity in food packaging market, such as: styrofoam, tetrapack, plastic, blends of polyethylene, polyethylene, cardboard, paper, and glass.

We attempted to quantify and analyze the environmental impact associated with production and distribution of glasses and spoons in El Bosque University food court establishments. The study was conducted from manufacturing these products to distribution phase at end points (sales) in Bogotá. Functional amount considered to this study were 1,000 cup units and 6,000 spoon units. For overall analysis, elements such as: ink for cup printing, spoon color, vanes and napkins were not considered.

Raw materials used to manufacture beakers are PET and paints for product decoration. The glass weighs 1.3 grams and is produced in three phases: (i) extrusion; (ii) thermoforming; (iii) ink printing. A total of 50 cups is packed in a plastic bag arranged in cartons weighing 250 grams. Considering that the carton contains 1,000 cups, 3.9 kg of PET are needed to manufacture this amount of cups.

In order to manufacture the spoons, high-impact raw materials are used: PP pellets and Masterbatch color for printing. The spoon weighs 0.8 grams and is produced through the injection process. A total of 100 spoons is packed in a plastic bag placed in cartons weighing 250 grams. As the carton holds 6,000 tablespoons, 4.8 kg of PP are necessary for the manufacture of this quantity of spoons.

Brazilian Journal of Operations & Production Management
Volume 16, Número 1, 2019, pp. 88-95
DOI: 10.14488/BJOPM.2019.v16.n1.a8

Figure 5. Ecodesign models elaborated at Universidad El Bosque
Source: Adapted by Montoya and Martinez (2013).

Ecodesign was employed to analyze new materials used in both glass and spoon, reducing environmental impact by evaluating these products' life cycle. Regarding the glass material usage, its newly redesigned version (with polyboard material) improving (which means reducing) its environmental impact behavior by 40% when compared to the previous glass.

For harvesting, new material used has been redesigned using corn starch biopolymers to improve its environmental performance. Ecodesign was important not only for choosing new material composition, but also for improving its functionality; the reason is that the new spoon also assumes the role of a straw, thus acquiring two functions in only one product. Finally, environmental improvement of the redesigned spoon, when compared to the previous one, represents a 52% optimization (efficiency index) regarding LCA impact.

8. BRAZIL-COLOMBIA PROJECT RELATIONS

After analyzing both projects, a schematic chart was drawn up considering their main ideas identified, educational contexts observed, as well as its LCA analyzed concepts.

Presenting these projects may help in identifying examples for teaching plans for engineering and related areas. The use of KPI (key performance indicators), should be applied to each element indicated in both projects.

9. FINDINGS

Universidad El Bosque is one among many sources of solid waste, thus contributing to its accumulation in the landfill. Through the identification of the current solid waste management of packages generated in eating places within Universidad El Bosque, a field work was developed in four months; it mapped waste management from its generation until its final disposition. Nine eating zones were subsequently defined to quantify and characterize the waste generated from packages, which was achieved through interviews. Finally, the information obtained was analyzed so Colombian projects could be compared to their Brazilian counterparts. The Colombian scenario showed that nine eating zones combined produce 375Kg of packages per week, mainly glass, paper, cardboard, and plastic, which amount to 15 tons of recoverable materials (Montoya et Martinez, 2013).

Another initiative from the Colombian University deploys the result of a research work of scientific initiation of Industrial Engineering students from El Bosque University, in which toothpaste packaging through was analyzed LCA methodology. The study goal is to minimize the product environmental impact making use of ecodesign strategies. The study case presented is a toothpaste packaging compound by a cardboard package and the direct toothpaste container. The application in the redesign not only of the monomateriality, but also the package refilling, reduce the environmental impact in 58%, in spite of using polypropylene as product raw material (Montoya et al., 2014).

On the other hand, the university does not have an adequate management of its solid waste (Ideam, Unicef and Cinara, 2005), mainly due to a lack of recycling culture by the university community as well as material mixing, which prevents them from being used for recycling or for composting. It is then pertinent to propose a pilot research project to promote and adequate solid waste management in order to minimize its presence in the university; it is also pivotal to demonstrate the project to other organizations.

Table 1. Project lessons learned

LESSONS LEARNED	Ecodesign	LCA	Circular Economy	Activity
SolMar Project (CEFET-RJ, Brasil)	*** It will be further developed	Clean energy and product development	PET bottle	Collaborative team work
Ecodesign Project (Universidad El Bosque, Colombia)	New formats, materials, usability	Product components	PET bottle	Collaborative community team work

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10. CONCLUSIONS

It is already clear that the model followed by the economics of disposal (linear production) is not environmentally sustainable. Therefore it is necessary to seek and discuss alternatives that provoke changes not only in the linear productive system, but also in the awareness of individuals regarding this environmental issue. In this sense, the present work attempted to brought two examples in different Latin America countries, possibilities of Circular Economy approach.

From different projects perspectives, ecodesign and life cycle assessment in academic activities become closer to Production Engineering. It is expected that more projects like the aforementioned in this research, can be conducted in different educational institutions. As a result, it will enable new studies to be developed stimulating the debate on the subject and contribute with good practices to Circular Economy.

Considering Tziganuk et Gliedt's (2017) conclusions, competencies and frameworks can help prepare students for practical experience outside of academia (Wiek et al., 2011). Furthermore, professors should craft these frameworks to aid the process of incorporating the skills students need to become sustainability professionals (Widener et al., 2016).

This paper addressed and discussed critical aspects of ecological crisis and the need to find an appropriate course of action to deal with it. Regarding the crucial role of education in the environmental crisis, some ideas emerge as promising. The present study showed evidence of promising links between Life Cycle Assessment and Higher Education Institutions in a Circular Economy approach.

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