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Volume IV

EDITORIAL ANAIS ENSUS 2018

Esses volumes reúnem os artigos aprovados para a sexta edição do ENSUS – Encontro de Sustentabilidade em Projeto. O evento foi concebido para proporcionar momentos de reflexão e discussão sobre um dos temas mais atuais e recorrentes de nossos dias.

Para iniciar essa discussão trazemos à baila a singularidade do homem. Nossa espécie é de fato muito interessante. Como homens, cuja essência é a racionalidade e sobretudo a criatividade proporcionada pela primeira, podemos modificar o meio. Conforme consta no livro “Sapiens”, de Yuval Harari, em sua 29ª edição: “A extinção da megafauna australiana foi provavelmente a primeira marca significativa que o Homo *sapiens* deixou em nosso planeta. Foi seguida de um desastre ecológico ainda maior, desta vez na América, há cerca de 16.000 anos atrás”.

Historicamente, o homem nunca teve uma relação harmoniosa com a natureza, à exceção de alguns poucos povos, que justamente por esse comportamento “atípico” foram fadados ao esquecimento, anonimato ou mesmo extinção. A premissa mais desejada e cultuada desde nossas origens – a melhoria continua ou evolução – perpetuada pela qualidade total com o kaizen, nas teorias de Maslow ou simplesmente na busca por conforto e longevidade, proporcionou ao homem uma corrida feroz contra o tempo e contra quase tudo o que é natural.

Recursos ilimitados foram gastos na tentativa de barrar o percurso natural biológico. Ao longo de nossa história o homem sacrificou toda e qualquer espécie animal ou vegetal em prol da sua própria: mudou o curso das águas para gerar energia; desmatou áreas significativas de florestas para a construção de estruturas de concreto e aço; caçou e pescou muito mais do que o necessário, cultivou a terra, esterilizou e a contaminou neste processo pelo uso de agrotóxicos em massa, e por aí adiante.

Quem dentre nós está disposto a barrar o progresso? Quem dentre nós está disposto a abrir mão das pesquisas que originam novos produtos e serviços que nos proporcionam maior qualidade de vida, longevidade, lazer, satisfação, velocidade na informação, no transporte, tecnologia e menos sofrimento em caso de enfermidades? Quem está disposto a afirmar que os 16.000 anos de progresso, do ponto de vista de nosso planeta foram acompanhados de uma disparidade evolucionária, para algumas espécies há que se dizer involucionária, cujo maior beneficiário fomos nós, humanos?

Uma vez definido que somente uma parcela muito pequena dos sete bilhões de seres humanos do planeta estaria disposta a alterar seu estilo de vida em prol da saúde de nosso planeta, o que nos resta é usar de nossa maior capacidade, aquela que é cultuada como a que nos diferencia das outras espécies; aquela que é anunciada como a grande responsável por conduzir-nos ao topo das espécies de nosso planeta: a criatividade.

E a criatividade é o maior talento de todo profissional que trabalha com projeto. Muito além da matemática, da física ou de qualquer outra ciência, a criatividade é a que nos permite sonhar, nos permite planejar o futuro e fazer simulações (mentais, computacionais, experimentais). Foi pela criatividade que nossos ancestrais aprenderam que não valia muito a pena enfrentar um mamute com pedaços de madeira (ao custo óbvio de muitas vidas). Melhor seria a confecção de pontas nesses pedaços de madeira e seu aquecimento no fogo para endurecer, tornando possível o arremesso ou a caçada em uma distância segura.

Cada vez que pensarmos que algo não é possível, pode-se apelar ao exercício da imaginação. Imagine-se 1000 anos no passado: a vida em um castelo, na ânsia por notícias de alguns familiares que não vê a meses, pensando se vale a pena visitá-los de carroça, vestindo roupas pesadas e desconfortáveis, por estradas de barro, com provavelmente muitos perigos e pouco conforto (hospedarias, mercearias)... imagine-se também com dor de cabeça.

Tal realidade ainda seria pouco alcançada pelo homem contemporâneo. Da mesma forma a mente de alguém da Idade Média dificilmente imaginaria que alguns anos mais tarde ela poderia utilizar um aparelho pequeno para conseguir notícias de seus familiares imediatamente; que poderia talvez ir até eles rapidamente em um carro ou avião, que se fosse de carro poderia parar a praticamente qualquer momento para descansar, beber e comer; que poderia usar roupas leves e confortáveis e que poderia dar um fim a sua dor de cabeça tomando um simples comprimido ou utilizando algumas técnicas japonesas.

Se a criatividade pode nos proporcionar tudo isso de bom, é justamente com ela que temos que contar para o nosso próximo desafio: recuperar nosso planeta. Somos 7 bilhões de pessoas inteligentes que unidas terão todas as condições de superar os desafios. Mas para isso, precisamos deixar de lado as pequenices a que nos habituamos para sobreviver (associadas ao acúmulo de alimentos e benesses em cada vez maior quantidade) enquanto "evoluíamos" enquanto espécie. Dividir, compartilhar, participar passam a ser os conceitos que permitirão a redução do consumo de recursos.

A partir desta reflexão, apresentamos nesse compêndio, uma série de artigos nos mais diversos temas. São pesquisas realizadas em todo o Brasil e no exterior, dedicadas a superar o desafio. Cada pessoa que está se fará presente no ENSUS, do graduando que inicia sua trajetória acadêmica através de uma pesquisa de iniciação científica ao pós-doutorando que está tentando resolver e equalizar detalhes mais complexos, todos temos o que aprender uns com os outros. A essência da criatividade passa pelo respeito mútuo, pela troca de ideias, sugestões, transparência, integração e compartilhamento de conhecimentos em plataformas preferencialmente abertas, onde a propriedade passa a atuar como pano de fundo. Da criatividade assim aplicada, brotará os ramos que conduzirão a espécie humana a um novo paradigma: o de viver em harmonia com nossa casa, o planeta Terra.

Com esse pensamento otimista, desejamos a todos um ótimo evento e uma boa leitura.

Kit de Robótica Educacional vía Invernadero

Kit de Robótica Educacional via Estufa

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Resumen

El artículo presenta el desarrollo del "Kit de Robótica Educacional vía Invernadero" cuyo objetivo es despertar el interés de los alumnos de la enseñanza básica tanto en el ámbito de la robótica como de la educación ambiental. El proceso proyectual aplicado en el proyecto fue Design Thinking. El trabajo muestra las investigaciones realizadas al público objetivo en la fase de inmersión, en la fase de ideación son presentadas las soluciones de invernadero y sus componentes y en la fase de prototipo es mostrado el resultado final y el aplicativo desarrollado para interactuar con el producto. El resultado demuestra el gran desafío de crear un proyecto de alta complejidad con énfasis en medio ambiente por medio de un kit robótico funcional para la enseñanza de robótica que despierte el interés del alumno y que sea adecuado al sistema de enseñanza básica del séptimo al noveno año. El contexto escogido para el producto final fue la escuela como entidad.

Palabras-clave: invernadero; robótica educacional; educación sustentable.

Resumo

O artigo apresenta o desenvolvimento do "Kit de Robótica Educacional via Estufa" que visa despertar o interesse de alunos do ensino fundamental tanto no âmbito da robótica como da educação ambiental. O processo projetual aplicado no projeto foi o Design

Thinking. O trabalho mostra as pesquisas realizadas junto ao público-alvo na fase de imersão, na fase de ideação são apresentadas as soluções da estufa e seus componentes e na fase de prototipação é mostrado o resultado final e o aplicativo desenvolvido para interagir com o produto. O resultado demonstra o grande desafio de criar um projeto de alta complexidade com ênfase no meio ambiente por meio do kit robótico funcional para ensino de robótica que desperte o interesse do aluno e que seja adequado ao sistema de ensino fundamental do sétimo ao nono ano. O contexto escolhido para o produto final foi a escola como entidade.

Palavras-chave: *estufa; robótica educacional; educação sustentável.*

1. Introducción

El proceso de enseñanza de lógica de programación está permeado por diversos desafíos, entre ellos las dificultades de los alumnos en la comprensión del problema propuesto por Falkembach *et al*. (2003 *apud* Gomes y Melo, 2013). Como en la red pública de enseñanza no existe la posibilidad de adición de la enseñanza computacional, la mejor posibilidad es trabajar una perspectiva interdisciplinar uniendo las disciplinas ya existentes en la educación básica, como ciencias, historia, geografía, matemática, artes, biología, química, y física (FRANÇA; TESDECO, 2015).

Según Wolber (2017), la enseñanza de la programación debe ocurrir de modo significativo, placentero y debe ser realizado a partir de la construcción de aplicaciones que tengan utilidades prácticas en el mundo real. Considerando la robótica como un instrumento mediador durante la enseñanza básica, y no el resultado en sí, se vuelve de extrema importancia conseguir relacionar sus conceptos en la vida diaria y los problemas ambientales, como experimentar la filosofía de los 5R's, usándolos en beneficio de la sociedad.

Los aprendices conviven con la tecnología de forma espontánea, para comunicarse, divertirse y para aprender, aunque no se perciban, y por eso la importancia del *mobile learning*, que busca la integración de las tecnologías móviles a los contextos educativos. Cabe al educador apropiarse de esa relación de los alumnos con los dispositivos móviles como forma de apoyo a la enseñanza en el aula (RIBEIRO; MANSO; BORGES, 2016).

Relacionar tecnología y medio ambiente trae una oportunidad de una discusión importante en las escuelas para fomentar el sentido crítico, de modo que se tengan conocimientos que posibiliten analizar, leer, interactuar y explorar un mundo. Con ese objetivo y reconocimiento, fue desarrollado un Kit de Robótica Educacional vía Invernadero durante el Módulo de Proyecto de Producto Avanzado en el primer semestre de 2017.

2. Módulo de Proyecto de Producto Avanzado

El módulo de proyecto 24 del curso de Diseño de la Universidad Federal de Santa Catarina está dividido en 4 disciplinas, siendo ellas: Diseño de Interacción, Diseño e Inteligencia, Materialización y Proyecto 24, donde las disciplinas se integran e interrelacionan, de acuerdo con la figura 1.

Figura 1: Módulo de Proyecto 24. Fuente: PAZMINO; BRAGA; PUPO, 2016

El módulo está dividido en 18 clases, totalizando 288 horas/clase, el proyecto anhela sintetizar saberes de programación, materialización, interacción y proyecto de producto, produciendo como actividad final un modelo interactivo de alta complejidad. La organización similar utilizada en el mercado de trabajo permite que el alumno perciba la importancia de trabajar con los procesos de materialización, programación, compra de componentes y pruebas (PAZMINO; BRAGA; PUPO, 2016).

En el primer semestre de 2017, el tema del proyecto fue desarrollar un kit robótico funcional que fuera usado en la enseñanza de robótica, constituido por piezas que permitan su montaje y desmontaje. Como requisitos, era necesario tener sensores, arduino, placa de comunicación *bluetooth*, manual, concepto de diseño, no tener cables expuestos y tener el control hecho manualmente por Smartphone.

3. Metodología

El proceso proyectual trabajado por el equipo fue *Design Thinking*, un método no lineal, pudiendo ser moldeado y configurado de manera que se adecué al proyecto y con foco en el usuario durante todo el desarrollo. Las tres principales fases son inmersión, ideación y construcción y del prototipo (VIANNA, *et al* 2012).

En la fase de inmersión fue hecha una investigación sobre temas de medio ambiente que podían ser relacionados con la enseñanza de robótica. Para reunir la información fue montado un mapa mental mostrando una mejor síntesis de la propuesta. Posteriormente, fueron realizadas búsquedas de otros temas, que abarcan diversas áreas: robótica, programación, juegos educativos, sustentabilidad, plantas, tipos de encajes, público objetivo y componentes.

Para conocer el público objetivo fue hecha una visita en una escuela que tiene clases de robótica. Fue posible analizar a partir de ese punto que el grupo de edad que suele tener la educación interdisciplinar es de 10 a 12 años y por ese motivo fue escogida. Con el objetivo de hacer un producto con costo bajo, el prototipo debía ser usado en grupo, acarreando un menor costo individual, teniendo en cuenta que la mayoría de las personas con acceso a enseñanza de robótica es de clase media y clase alta.

En la fase de ideación fueron utilizadas herramientas y técnicas de proyecto para ayudar en la generación de alternativas, teniendo como objetivo generar ideas que sirvieran de base para el desarrollo de soluciones que atiendan las necesidades del público objetivo de acuerdo con el contexto establecido en la fase de inmersión. Ya en la fase de prototipado fueron hechos modelos de baja fidelidad y después de los análisis fue construido un prototipo funcional.

4. Cuestión Ambiental

La relación del proyecto con la sustentabilidad surgió durante las investigaciones de temas contemporáneos relacionados al medio ambiente. Las investigaciones mostraron que el modelo de desarrollo humano acelerado está causando alteraciones constantes en el medio ambiente, estando íntimamente relacionadas con el incentivo y aumento del consumo. El consumismo desenfrenado vivido actualmente proporciona el aumento del consumo de productos plásticos y como consecuencia genera una gran cantidad de basura en el área urbana. De acuerdo con NETTO (1990, web), los residuos plásticos llaman más la atención debido a la total inutilidad de los empaques, la resistencia a la degradación y a su ligereza.

Siguiendo el principio 3R (reducir, reutilizar y reciclar), la reutilización como aclara el sitio EcoD (2008), es la segunda alternativa para disminuir la cantidad de basura: encontrar otro uso para aquello que aparentemente no sirve más es, más allá de un estímulo a la creatividad, una excelente forma de ayudar al mundo.

Partiendo del principio de la reutilización, los espacios para vasos dentro de la estufa fueron proyectados para que cupieran en los espacios grande, mediano y pequeño, respectivamente una botella de plástico de 2.5 litros, botella de plástico de 600 ml y un vaso de café de 50 ml.

Por otro lado, en el producto también es posible relacionar el efecto invernadero, por ser uno de los fenómenos que posibilita la vida en la tierra. De acuerdo con Oliveira *et. al* (2009), de toda la radiación que llega a la tierra, apenas la luz visible y parte de las ondas de radio llegan a la superficie de la tierra sin interferencia, en cuanto la luz ultravioleta es absorbida en la estratosfera, provocando su calentamiento. La energía absorbida hace que las moléculas de ciertos gases vibren, promoviendo la producción de calor el cual en parte acaba siendo remitido para el espacio y en parte es responsable por el mantenimiento del sistema vivo en la superficie terrestre. La parte negativa del efecto invernadero se da por el aumento artificial y acelerado de algunos gases que hacen parte de este fenómeno, por ejemplo CFC y CO2. Es posible que un alumno observe la diferencia de temperatura en el medio interno con el medio externo del invernadero, por medio de un Sensor de Humedad y Temperatura del Aire, que muestra los resultados en el aplicativo en tiempo real. De esa forma, el estudiante puede percibir que el efecto invernadero puede ser benéfico cuando es controlado y natural.

Además, el propio acto de plantar y cuidar de la planta son factores importantes abordados en el producto y esencial en la educación ambiental. Contribuyendo con el hecho de que el alumno va a aprender sobre diversas plantas que fueron cultivadas, pudiendo inclusive crear un hábito duradero con esa actividad.

5. Kit de Robótica vía Invernadero

El proceso de investigación como mencionado en el ítem 3, se inició en el público objetivo, donde fue utilizado el método de entrevista con el responsable por las clases de robótica en un colegio particular. Utilizada como una herramienta de aprendizaje y no como una disciplina, la robótica aumenta el raciocinio lógico de los alumnos de la escuela, así como ayuda a percibir obstáculos de aprendizaje que antes los profesores no encontraban con facilidad, como dificultades de comando y lateralidad.

La complejidad de relacionar los temas aprendidos en la clase de robótica con la vivencia del alumno mostró una gran adversidad, ya que muchas veces no era posible percibir esa relación. Reconociendo esta afirmación, una investigación se direccionó para la enseñanza de robótica en conjunto con el tema del medio ambiente, un tema que se vincula con la vida del alumno.

El próximo paso fue una investigación de productos que utilizan la robótica y juegos relacionados al medio ambiente que podían ser competidores y similares, en esta investigación fue constatado que aún no existe en el mercado Brasilero en gran escala, un producto que asocie la robótica con el medio ambiente. Por ese hecho, las investigaciones se direccionaron por dos puntos separados: productos para la enseñanza de robótica y juegos sobre el medio ambiente. De acuerdo con los productos encontrados, fue desarrollado un análisis y lista de puntos positivos y negativos, que mostraron datos que podían ser utilizados en la creación de alternativas.

Después de investigaciones y análisis de productos similares, fueron establecidos requisitos para el producto. Por medio de alternativas hechas por las tres integrantes del equipo mostradas en la figura 2, fue posible seleccionar la mejor solución, y desarrollarla de la mejor forma posible.

Figura 2: Generación de Alternativas. Fuente: elaborado por los autores

En la fase de prototipado el invernadero fue construido pieza por pieza en el software *Solid Works*, incluyendo los diseños técnicos y las pruebas de ensambles. Después de varias pruebas, las piezas finales fueron cortadas en la máquina de corte laser y otras impresas en impresoras 3D. La figura 3 muestra el modelo que fue hecho en la escala 1.1.

Figura 3: Prototipo final. Fuente: elaborado por los autores

Además del invernadero en sí, fue desarrollado un manual, donde el alumno podrá consultar sobre dudas iniciales y aprender un poco más sobre las cuestiones ambientales que el producto busca abordar. En la figura 4 es posible observar dos páginas del manual abordando el efecto invernadero y la reutilización de plásticos.

Figura 4: Informaciones del manual sobre el efecto invernadero y reutilización de plásticos. Fuente: elaborado por los autores.

El invernadero posee componentes que permiten que sea controlada la humedad y la luminosidad. Para poder controlar el invernadero, fue desarrollado un aplicativo que esta descrito a continuación.

6. Aplicación

El uso del invernadero es de apoyo pedagógico para el esclarecimiento de los conceptos de sustentabilidad y de manipulación del invernadero por medio de la robótica. Como dispositivo portátil que es, puede facilitar el aprendizaje en contextos educacionales por su potencial de hacer lo aprendido más accesible, colaborativo y relevante como recomienda a (UNESCO, 2012).

La aplicación fue desarrollada en la *App Inventor for Android*, un ambiente visual de programación en bloques que posibilita la enseñanza de conceptos de lógica de programación básica de manera simple, atractiva y motivadora (GOMES; MELO, 2013). La herramienta requiere conocer los dos principales recursos que la componen: *App Inventor Designer* para crear visualmente la interface y *Blocks Editor* para controlar el comportamiento de los componentes definidos en la anterior (FINIZOLA et al., 2014).

El aplicativo de Kit de Robótica Educacional vía Invernadero funciona a partir de un menú superior de iconos. Después la pantalla de inicio y la de permiso de acceso de datos *bluetooth*, apenas el icono “plantas” queda visible. En ella se encuentra una infografía con las características de los tres tipos de semillas que vienen con el kit y de esa forma el usuario comprende las configuraciones ideales que deben regular su invernadero, como temperatura mínima y máxima, suelo ideal, duración de fotosíntesis, y conoce más sobre el uso de sus plantas. En la última opción del menú hay un icono “montaje” que tiene una infografía simplificada del manual de instrucciones. Esas dos opciones pueden ser accesibles sin estar conectada al invernadero.

Para tener acceso a las otras tres opciones del menú el usuario necesita activar el *bluetooth* del invernadero y encenderla. Esos tres iconos están divididos siempre en secciones (monitoreo, manual y configuraciones) y apenas se puede seleccionar una opción a la vez. En la primera sección es posible visualizar los datos recibidos por los sensores referentes a aquellos iconos y la estufa funciona automáticamente en *looping* conforme la programación que puede ser alterada separadamente por modulo en la tercera sección, como es posible observar en la figura 5. En la segunda es posible encender/apagar las funciones manualmente, excluyendo la necesidad de botones o un control específico para el producto.

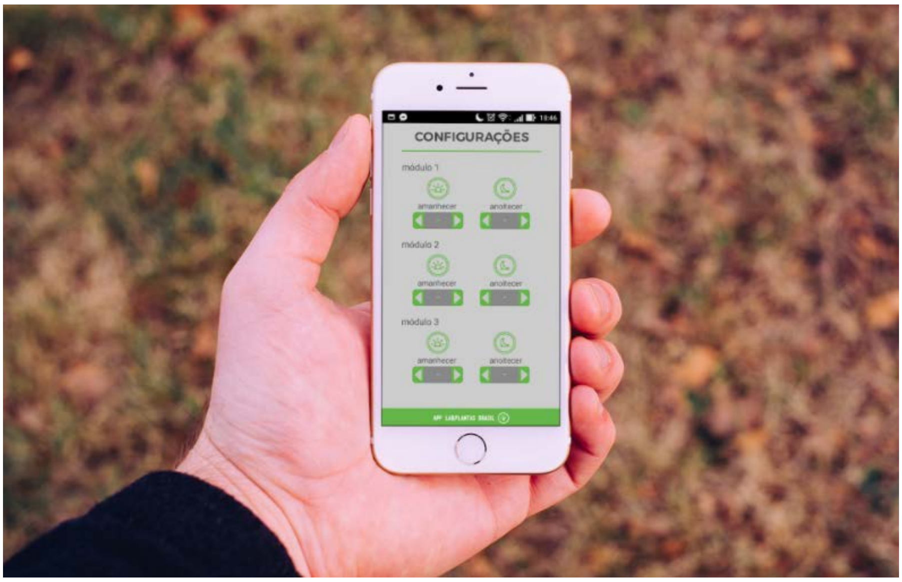

Figura 5: Aplicación. Fuente: elaborado por los autores.

En el icono “temperatura” es posible monitorear la temperatura interna y externa, encender/apagar el *cooler* y la resistencia y alterar los valores mínimos (1 a 15º) y máximos (16 a 35º) de la temperatura interna. En el icono “humedad” es posible monitorear la humedad interna y externa, encender/apagar la irrigación y alterar la opción (húmedo/seco/seco moderado) de la humedad interna. En el icono “iluminación” es posible monitorear se la luz está encendida/apagada en el momento, encender/apagar la iluminación común y la iluminación para la fotosíntesis y alterar el intervalo y el tiempo de duración de la luminosidad.

A partir de eso, el alumno monitorea los datos provenientes de los sensores, comparándolos para entender la materia enseñada en clase y por medio del manual. De esa manera, ellos son responsables por la comprensión del contenido y elaboración del conocimiento. De inicio el aplicativo ya posee sensores predefinidos, sin embargo existe la posibilidad de nuevas actualizaciones conforme más módulos y componentes sean sumados.

7. Arduino y Tecnología

Con el fin de mejorar las metodologías aplicadas en las escuelas para volver el ambiente escolar más interactivo y consecuentemente mejorar el aprendizaje del alumno, están siendo utilizadas nuevas formas de tecnologías (JOLY, 2002). La placa Arduino posibilita diversas maneras de enseñanza pedagógica, no solamente en el área de informática, sino también en las área de matemáticas, música, eléctrico – electrónica y robótica (CAVALCANTE et al. 2014).

El concepto de Arduino surgió en Italia en el año 2005, con el objetivo de crear un dispositivo para controlar proyectos y prototipos construidos de una forma más accesible que otros sistemas disponibles en el mercado (SILVA, 2014). La plataforma Arduino consiste en un sistema *Open-source*, basado en el *hardware* y *software* para las áreas de automatización y robótica. En ella se pueden adicionar diversos tipos de componentes electrónicos direccionados y programados para actividades diferentes.

Para la automatización del proyecto fue usada la herramienta Ardublock, que consiste en bloques de creación de programación, que al final genera el código instantáneamente. Esa Herramienta es para el uso de principiantes, ya que promueve un uso más intuitivo por parte del estudiante del que otras herramientas.

El Kit cuenta con tres módulos independientes unos de los otros, teniendo cada uno su propio funcionamiento y sensores. Está compuesto por más de 30 piezas diferentes, entre componentes estructurales y electrónicos. Entre los componentes electrónicos, están los sensores de humedad y temperatura, bomba de agua, entre otros, así como muestra la figura 6.

Figura 6: Componentes Electrónicos. Fuente: elaborado por los autores.

El producto fue probado y se encuentra en proceso de patente, pudiendo ser producido y hacer parte de escuelas que en sus programas pedagógicos tienen temas relacionados a la educación ambiental y la robótica.

8. Conclusión

El articulo presentó el desarrollo de un producto que une la tecnología con el medio ambiente, la importancia del tema de la sustentabilidad exige que sea transversal y pase por las diferentes disciplinas de escuelas y colegios.

El aprendizaje hibrido (*blended learning*) se utiliza no solo en el modelo presencial de educación, también busca crear nuevas experiencias de aprendizaje vía modelos móviles, para interactuar con esa generación que busca nuevas formas cada vez más dinámicas y con multimedia. El modelo de enseñanza en el cual los alumnos son receptores pasivos de transmisión da lugar al modelo en el cual el alumno tiene un papel más presente y proactivo (SQUIRRA y FEDOCE, 2011).

Con el fin de atenuar los impactos negativos en el proceso de enseñanza y aprendizaje en las fases iniciales de educación de niños, es necesario permitir el alumno experimentar, descubrir, probar y errar sus respuestas (CRISTOVÃO 2008, DELGADO et al. 2004 apud GOMES y MELO, 2013). Con la intención de mejorar los conocimientos en robótica, el Kit de Robótica Educacional vía Invernadero trabaja con componentes con sistema de correlación, posibilitando combinaciones diferentes por medio de la modelación y conforme a la necesidad del usuario.

Los efectos de la contaminación son una preocupación mundial. Relacionar el uso de la tecnología con los conceptos aprendidos en clase y experimentados en la cotidianidad, permiten crear una necesidad en lo aprendido, un objetivo útil en aquel conocimiento. Acompañando el desarrollo de las plantas y su ciclo de vida y monitoreando los ambientes, se espera que el niño/a entienda la importancia de reducir, repensar, reaprovechar, reciclar y rechazar consumir productos que generan impacto socio ambiental significativo.

También los niños/as pueden aprender la importancia del efecto invernadero que puede ser benéfico cuando es controlado y natural y cómo puede afectar el medio ambiente por el aumento artificial y acelerado de algunos gases que hacen parte de este fenómeno, como el CFC y CO_2. El conocimiento por medio de la tecnología puede facilitar el aprendizaje en contextos educacionales por su potencial de hacer lo aprendido más divertido y desafiador.

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Business Model Canvas and Sustainable Product-Service System Design: Proposal for a convergent approach for designing sustainable and innovative business models

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Abstract

This paper presents the results of a research on the applicability of the sustainable product-service system design (S.PSS) and business model design, adopting Business Model Canvas as a main tool. This resource is an essential part of an integrated and modular methodology for research and development (R&D) that was designed to support the development of new materials, products and business models from solid waste, but also useful in other projects focused in sustainable innovation. The methodology included, beyond critical literature review, the construction of the methodological model, including one-page briefs for each tool incorporated in the model. The results pointed out that is possible to combine sustainability and business in a comprehensive and feasible method to improve the quality of R&D projects on solid waste, in a more systemic way.

Keywords: *Product-service system design; business model design; R&D Project.*

1 Introduction

The study here presented is part of a doctoral research developed in the period of 2013-2017, in which we investigated the problem of synthetic textile waste produced by Brazilian garment companies, and how design could contribute to solve it. We found the answer in the form of an interdisciplinary approach that combines different knowledge areas as design, chemistry, materials engineering and business that could convert an environmental passive (the solid waste) in value innovation, in the form of new materials, products and business models. This approach was then materialised as an integrated methodology for R&D called FLOWS Model (SAMPAIO et al, 2015, 2016, 2017), in the module of Process (Figure 1).

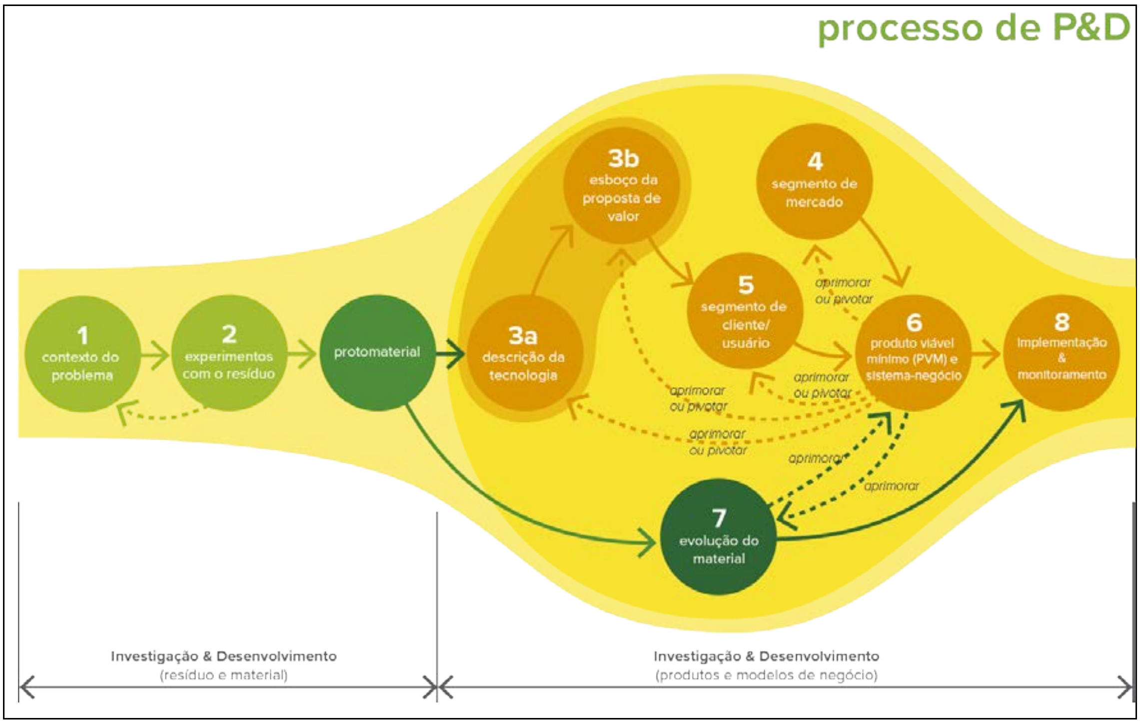

Figure 1: The Process module of FLOWS Model. Source: Elaborated by the author (2017).

Specifically, in this paper we explore how it is possible to develop business models from solid waste that can be, at the same time, environmental and social sustainable and value-centred for the companies and consumers. For this we combined two main approaches, sustainable product-service system (S.PSS) design and business model design, using Business Model Canvas as a convergent tool that made possible to integrate the nine main business components with sustainability principles and methods. The result is a comprehensive and feasible structure that can help the R&D team to develop a complete innovation project, from the solid waste problem understanding to the implementation of final solutions.

2 Methodology

This study required an extensive work to identify concepts, foundations, principles, methods and tools for each of the issues covered by the research; this was made possible by using the critical literature review, mainly based on scientific papers, books and reports, and complemented by secondary sources like business literature, organizations and respected authors websites and blogs, among others.

As a result, different designs for the methodological model were conceived by the author and discussed with his tutors, but here we present only the final structure, in which the Business Model Canvas was integrated. The methodological structure for the R&D process here proposed was partially tested with different design student teams, using quasi-experiment with two sample and two control groups as a main method and, in addition, with other twelve groups. These tests were described in detail in another paper (SAMPAIO et al, 2017), so the focus of this paper is to explore the convergence between the S.PSS design and business model design, that were not the aim of that paper.

3 Theoretical foundations

3.1 Design and value innovation

Design is a central activity to solve problems and explore opportunities, and in this study, was considered in terms of two elements: as a way of how designers think when face a problem (design thinking), and as a practical process to understand it and solve it (design process). Empathy, applied creativity, prototyping and test are the foundations of this knowledge area, which aims to deliver, at the end of the process, benefits, here called values. As proposed by Brown (2010), these values can be for the user/consumer (functional or emotional), for some organization/company (process innovation), but also for the society (social or cultural value) or even for the planet (environmental value).

As proposed by Dorst (2010, apud Sampaio et al, 2014), value is the desired result to be achieved when we deal with “ill-defined problems”, by using an approach called by him “abductive reasoning”; this differs from other areas like natural sciences, in which the aim is to obtain a valid and verifiable answer at the end of the process. Thus, value - and value innovation, for instance - is a central concept that connect design, sustainability and business models in the methodological model here proposed.

3.2 Sustainable product-service system (S.PSS) design

The design of sustainable product-service systems (S.PSS) represents a more sustainable strategy to reduce the environmental and social impacts, if compared to other ways like eco-design and eco-redesign of products, or cleaner production and end-of-pipe approaches. This can occur because S.PSS aim not only to develop cleaner products and processes, but to dematerialize the production and consumption systems, by combining the reduction of resources needed in a system with a focus on the final benefits delivered to the consumers (VEZZOLI, KOHTALA, SHRINIVASAN, 2014).

One of the most significant challenges when designing a S.PSS include the definition, articulation, involvement and management of the different actors in the system, each with its own issues, interests and levels of competence on sustainability matters. Environmental aspects, for instance, demands from the innovation team a focus on the entire life-cycle of the system needed to deliver value for the user/consumer, and not only in the products. This approach, called life-cycle design, includes a set of principles, strategies, guidelines, methods and tools.

As a result, the design of S.PSS can be developed by using a lot of methodological resources, among which the following were integrated in the FLOWS Model here proposed, according to each strategic phase. In the FLOWS Model structure, the S.PSS methods and tools (VEZZOLI, KOHTALA, SHRINIVASAN, 2014) were incorporated in the phase 6 (Minimum Viable Product and System-Business), in the following sub-phases, considering their specific guiding questions (Table 1):

GUIDING QUESTION	SUB-PHASE	METHOD/TOOL
How can I develop the business systems in which the materials and products will be inserted?	System & Business	System Map Stakeholders matrix Customer Journey Prototype Storyboard/Storyspot
How can I include the socioenvironmental aspects of sustainability when developing the products and systems?	Socio-environmental aspects	Sustainability Drivers Checklist Sustainability Simplified Benchmarking Socio-environmental SWOT Socio-environmental Value Curve SDO Checklist System Map Screening Life Cycle Assessment (LCA)

Table 1: Integration of S.PSS tools in the Phase 6 of the FLOWS Process Model. Source: Elaborated by the author (2017).

Each tool is briefly described as it follows:

- System Map is a simplified visual-graphic representation of the system, including the actors and their forms of interaction (work, financial, material, knowledge) needed to make the system work.
- Stakeholders Matrix is a matrix that make possible to identify the motivations and gains expected by each of the actors involved in the system/business model. These motivations are determinant for the subsequent level of involvement in the system;
- Customer Journey is a tool to identify all the touchpoints between the user/customer and the product/service system offered by a company, and the user/customer experience along that;

- Prototype include a wide typology of resources (mockup, model, prototypes), both physical and digital, that make possible to simulate the use/consumption of the product and/or service. The level of detail can vary depending on the phase of the project and the goal defined, but in general prototypes are used to test ideas and learn more about the user/customer when interacting with them, and thus refining the design idea;
- Storyboard/Storyspot are visual-graphic tools that help the R&D team and stakeholders understand the "story" behind the value proposition, from the problem/opportunity to the final solution, by using frames and short descriptions of each of the main scenes. It can be done using various techniques including drawings, photos and even short animated videos. Storyspot is a variation of Storyboard, but puts the entire story in a single image, that is complemented with short text indications of specific aspects or benefits of the system;
- Sustainability Drivers Checklist is a tool useful to identify and verify the priority of sustainability drivers both internal and external to a business model, in terms of three categories: socio-ethical, environmental and economic. It is complemented by a definition of what drivers will be prioritised when designing a new system/business model. This tool was part of the D4S Methodology (UNEP, 2012);
- Sustainable Design-Orienting (SDO) is a qualitative tool based on a checklist, like the previous tool, that allows the R&D team to assess the sustainability level of a given system and others in terms of socio-ethical, environmental and economic aspects. It more complete than the Drivers, and in its software version it is possible to define different weights (Set Priority) for each aspect, and visualize the comparison results in a "visual radar", thus simplifying the communication between the R&D team and stakeholders;
- Sustainability Simplified Benchmarking is a one-page that allows to compare the sustainability performance of a proposed system/business model compared to its competitors. Using this tool implies in the definition of a "sustainability best-practice" company that will be used as reference (benchmark) in the comparison. There is also an extended version of this tool, and both integrate, like the Sustainability Drivers, the D4S Methodology;
- Socio-environmental SWOT is a variation of the traditional and well-known SWOT Analysis, but adapted to identify and assess the strengths, weaknesses, threats and opportunities related to social and environmental aspects of a system/business model. It is also useful to analyse these aspects in the potential or real competitors, being a strategic tool to build a sustainability strategy and positioning for the business model;
- Socio-environmental Value Curve, like the previous tool, is an adaptation of the Value Curve proposed by Kim and Mauborgne (2011) for helping companies to build unique positioning in the market based on value attributes. Here, these attributes include social and environmental values, that must be different from the competitors, and they result in a unique curve for the proposed business model;

- Screening Life Cycle Assessment (LCA) is a quantitative tool (generally as a software) used to measure the environmental impacts of products, processes and services life cycle, according to specific categories (e.g. air pollution, soil depletion, acidification, carcinogenics and others). Screening LCA is a simplified version of the LCA, but even in this case is much more complex to be used than the qualitative tools previously presented, because demands specific knowledge and resources to be appropriately applied.

Each of these S.PSS methods and tools can be chosen by the R&D team depending on the availability of expertise, time, amount of team members, or another variable involved in the project. The integration between the sustainable system subjects and the business ones is made possible by using another strategic tool, the Business Model Canvas, as seen below.

3.3 Business model design: Business Model Canvas and Value Proposition Canvas

Osterwalder (2011, p. 14) explains that business model is a model that "describes the way an organization create, deliver and capture value". Thus, by using simplicity and visuality as guiding principles, he developed a visual representation of a typical business structure, explaining its most relevant parts as well as its integration to deliver a specific value for a group of customers. This model, called Business Model Canvas (BMC, Figure 2), is compound by nine parts: Customer Segment, Value Proposition, Channels, Customer Relationship, Key Resources, Key Activities, Key Partners, Revenue Streams and Cost Structure.

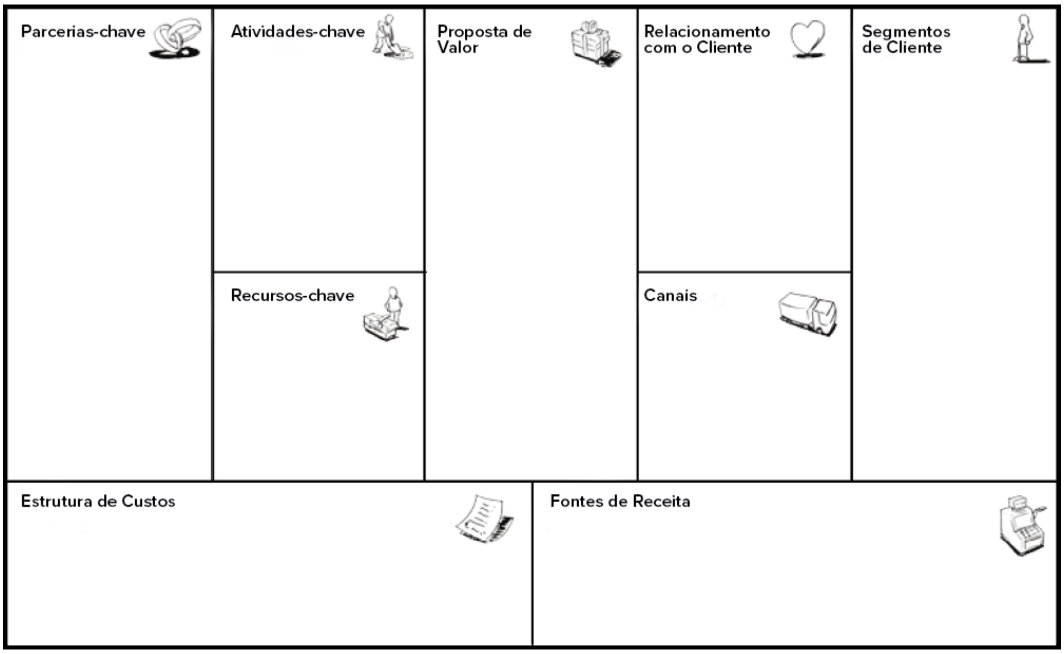

Figure 2. Business Model Canvas. Source: OSTERWALDER, 2010.

This canvas can be used together with another tool, the Value Proposition Canvas (OSTERWALDER, 2014), that emphasize two essential parts of the BMC: The Customer Segment and the Value Proposition (Figure 3).

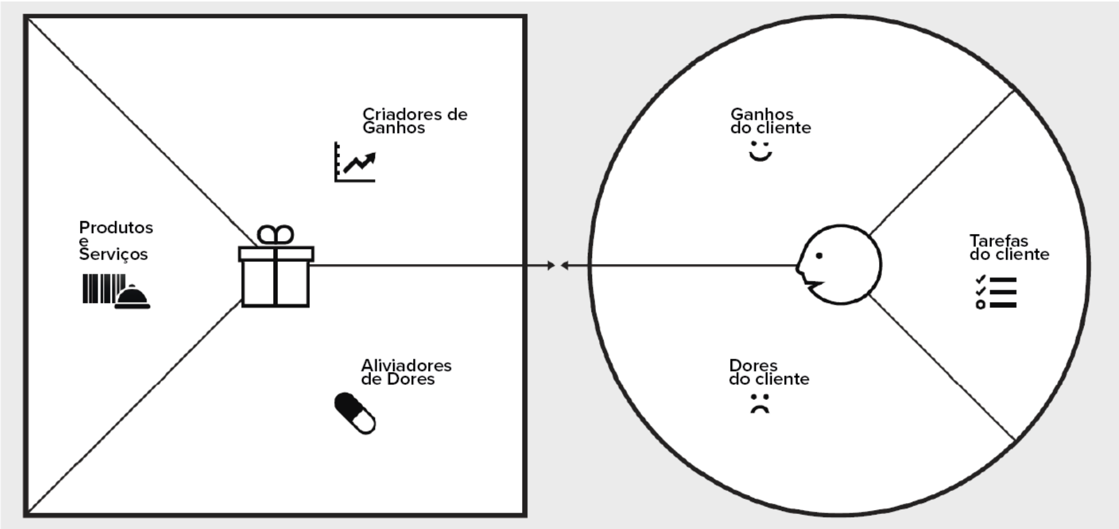

Figure 3. Value Proposition Canvas, composed of two parts, the Value Proposition Map (left) and Customer Profile (right). Source: OSTERWALDER, 2011.

The Value Proposition Canvas is organized in two main parts: The Customer Profile and the Value Map. The first include:

- Customer Tasks: The activities the customer is trying to perform in his life, be they functional, emotional or social, as a buyer, cocreator or giver;
- Gains: What benefits the customer is trying to achieve when performing the tasks;
- Pains: The problems the customer is trying to avoid when performing the tasks, like delays, lack of quality or additional effort.

4 Results

The integration between the Business Model Canvas and the P&D Process of FLOWS Model was designed considering the phases 3a to 8, as shown in the figure 3.

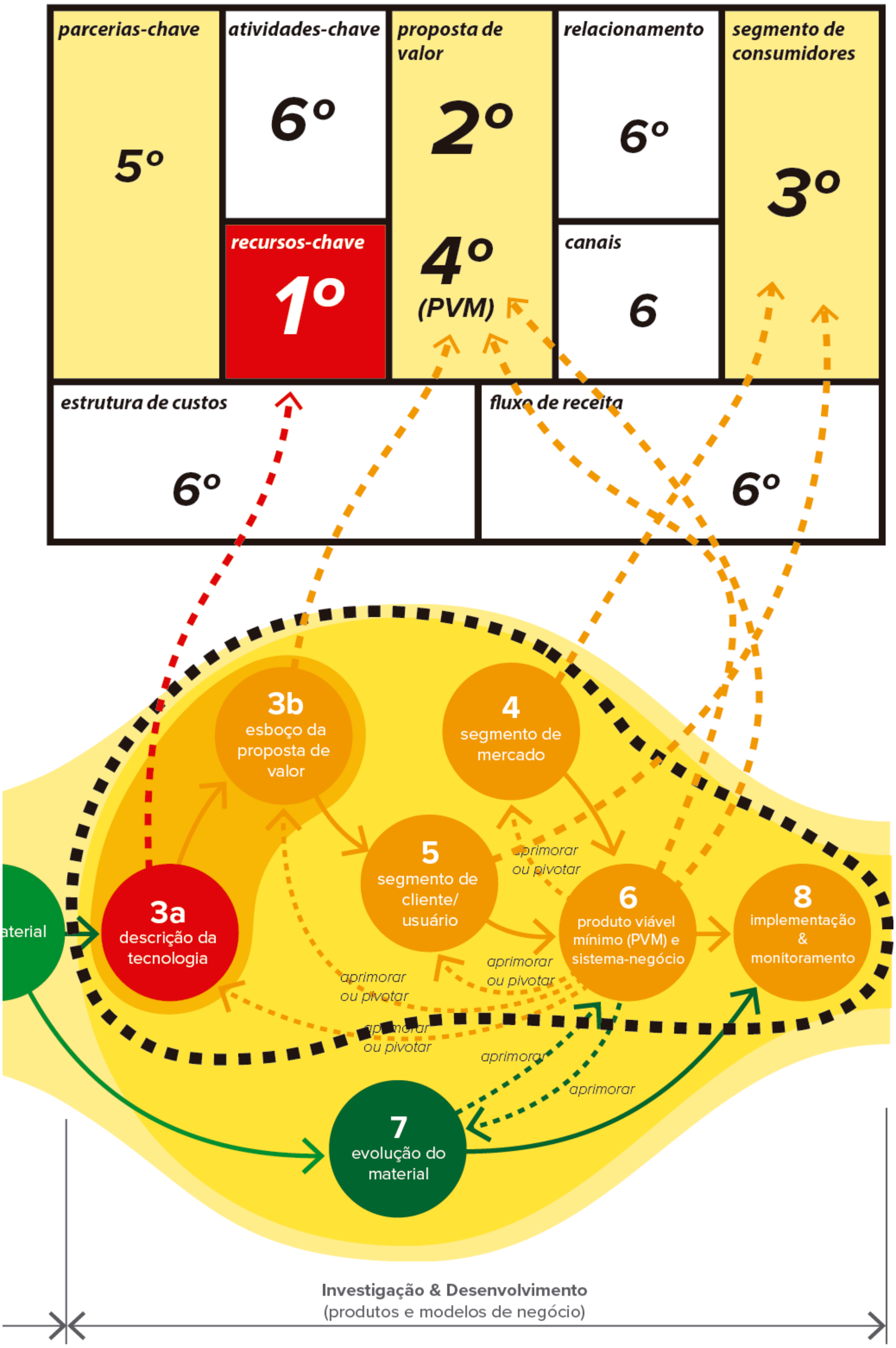

Figure 4. Integration between the Business Model Canvas and the phases 3a to 8 of the Process. Source: Elaborated by the authors.

Specifically, in the phase 6, the integration between the BMC and the S.PSS methods and tools can be described as seen in the Table 1.

	BMC PART / S.PSS TOOL	Customer Segment	Value Proposition	Channels	Customer Relationship	Key Resources	Key Activities	Key Partners	Revenue Streams	Cost Structure
CONCEPT & PROTOTYPE	System Map	X	X	X	X	X	X	X	X	-
	Customer Journey	X	X	X	X	X	X	X	X	-
	Storyboard/ Storyspot	X	X	X	X	X	X	X	X	-
	Mockup, Model and Experience Prototype	X	X	X	X	X	X	X	X	X
EVALUATION & ANALYSIS	Sustainability Drivers Checklist	X	X	X	X	X	X	X	-	-
	Sustainability Simplified Benchmarking	-	X	X	-	X	X	X	-	-
	Socio-environmental SWOT	X	X	X	X	X	X	X	-	-
	Socio-environmental Value Curve	X	X	X	X	X	X	X	-	-
	SDO Checklist	-	X	X	X	X	X	-	-	-
	Stakeholders matrix	X	-	-	-	-	X	X	-	-
	Screening Life Cycle Assessment (LCA)	-	X	-	-	X	X	-	-	-

Table 2. Integrating the S.PSS tools in the Business Model Canvas structure. Source: elaborated by the authors.

Considering this structure, it can be observed and discussed some aspects, as it follows:

- In general, there is a good distribution of tools in two main groups, one for designing the system/business model and other for evaluation and analysis of the proposals;
- All the BMC parts are contemplated with S.PSS tools, except the Cost Structure. This is the only gap to be filled in this integration;

- System Map is one of the most important tools in this integration, because allows the R&D team to build up and visualize the entire system, including the actors and their forms of interaction. So, it must be used with the BMC since the beginning of the project;
- Also, Storyboard/Storyspot and Customer Journey are tools useful to better design the interaction between the user/customer and the system, but with different emphasis: By using storytelling, the first allows the R&D team and stakeholders to better understand the "big picture" behind the value proposition, from the problem definition to the final solution and its benefits (gains or pain reliefs, as in the Value Proposition Canvas); the second, for instance, serve to map and detail the elements (touchpoints) with which the user/customer comes into contact when using the system; Stoyboard/Storyspot also function as a prototype tool, because can used to obtain feedback by the users/consumers and stakeholders;
- All these concept and prototype tools are relatively easy and simple to use by the R&D team, especially that based on visual resources, like System Map and Storyboard/Storyspot, because they simplify the complexity of the system to make it comprehensive by the people, in the same logic of Business Model Canvas;
- In relation to prototypes, depending on the type used and its level of detail (mockup, model, product prototype, environment prototype, system prototype, experience prototype) all the BMC parts can be tested; It is possible to prototype and test virtually any element of the system/business model, even the cost structure, so it is one of the most embracing and important tools in this integration proposal;
- The evaluation and analysis of the social and environmental sustainability issues of the proposed system/business model is incorporated in this structure mainly using qualitative tools, to identify and define the most relevant aspects that affect the sustainability in the system. They include: checklists (Sustainability Drivers and Value Curve), comparative performance studies (Benchmarking), matrices for internal and external influencers (SWOT) and stakeholder's motivations (Stakeholders Matrix). All these evaluation and analysis tools can be used both for the proposed system and for competitors, if necessary;
- Additionally, it is possible to quantify the impacts of the system using a simplified version of the Life Cycle Assessment (LCA), the Screening LCA, using specific software like Simapro, Gabi, Humberto or other. However, the use of this tool is more complex than the qualitative ones, and is recommended only if enough technical knowledge, time and resources are available;
- In terms of complexity, some tools like Sustainability Drivers Checklist, Socio-environmental SWOT and Socio-environmental Value Curve are easier to apply than others, since enough information be available to feed the assessment; Moreover, they also rely on visuality to make the result of the assessment understandable for the R&D team and stakeholders;

- The economic-financial aspects of the system/business model are the less considered in this integrative proposal and shows a lack for specific tools that must be searched in other knowledge areas. This is an essential aspect of the Business Model Canvas, but not well supplied by the S.PSS tools.

In short, and based on the previous structure, we can affirm that is possible to integrate social and environmental sustainability issues when developing a business model; the integration of S.PSS tools in the existent BMC structure showed to be a viable and comprehensive strategy by means of which this can be made possible.

5 Conclusions

As shown in this paper, the integration of social and environmental sustainability in the business models is possible when considering sustainability as a value, because this is a central concept that integrates these two areas. Value is also a central concept for design, is its reason for being, because design always aims to produce benefits for someone, be for people, organizations or the planet. In this context, in this paper we proposed that the Business Model Canvas functionality can be enlarged by including sustainability values in the value proposition, and that this is possible by including the use of S.PSS tools in each of the BMC parts. This can help to ensure greater concern about sustainability when designing a business model, so this proposal is a working progress, and we strongly believe that can now be improved by additional contributions by other researchers in this issue.

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A influência dos requisitos projetuais sustentáveis na estética dos artefatos ecologicamente orientados

The influence of sustainable design requirements on the aesthetics of ecologically oriented artifacts design

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Resumo

Este artigo aborda a estética com foco no desenvolvimento de artefatos industriais sustentáveis, pois as pesquisas sobre o desenvolvimento deste tipo de produto pouco têm contemplado a estética, enfatizando-a como importante para a efetivação de soluções ecologicamente orientadas. Tem como objetivo compreender quais requisitos projetuais atualmente praticados podem interferir na aparência dos produtos, contribuindo para a elaboração de indicadores estéticos que configurem uma nova tipologia de artefatos. Para isto, foi realizado uma revisão de literatura que buscou elencar os principais elementos configurativos dos produtos industriais, seguido por um apanhado dos principais requisitos para o desenvolvimento projetual de artefatos ecologicamente orientados. As informações geradas pela revisão permitiram o cruzamento dos dados entre elementos configuracionais e requisitos sustentáveis, que foram analisados a partir da pertinência e possibilidade de interferência na estética dos artefatos. Como resultado foram gerados 10 indicadores estéticos que podem contribuir para a discussão acerca da efetivação dos produtos sustentáveis enquanto nova tipologia de produtos.

Palavras-chave: Palavra-chave 1; artefatos industriais 2; sustentabilidade 3; estética

Abstract

This paper approaches aesthetics with a focus on the development of sustainable industrial artifacts, because research on the development of this type of product has little contemplated the aesthetic, emphasizing it as important for the implementation of ecologically oriented solutions. Its objective is to understand what project requirements currently in place may interfere with the appearance of the products, contributing to the development of aesthetic indicators that configure a new typology of artifacts. Thereunto a literature review was carried out that sought to list the main configurative elements of industrial products, followed by a survey of the main requirements for the project development of ecologically oriented artifacts. The information generated by the revision allowed the crossing of the data between configurational elements and sustainable requirements, which were analyzed from the pertinence and possibility of interference in the aesthetics of the artifacts. As a result, 10 aesthetic indicators were generated that can contribute to the discussion about the realization of sustainable products as a new product typology.

Keywords: *1; industrial artifacts 2; sustainability 3; aesthetics*

1. Introduction

Among the approaches to aesthetics is that of "science of sensory perception," which studies the understanding of reality through perception and considers everything that is perceived sensorially by the senses to be aesthetic. In this perspective, aesthetic quality can be included in product ergonomics studies, which aim to satisfy human needs, contributing to the proper interaction between users and artifacts, providing psychological comfort. It is expressed by the combination of shapes, colors, materials, textures, among other attributes that aim to make artifacts pleasant. (IIDA, 2005, p.316). It starts from the design needs related to the sensations provoked by the surroundings - environments or artifacts, and with the preferences or values of the individuals. (COSTA FILHO, 2012).

According to Vezzoli (2010, p.49), aesthetics play a fundamental role in the effectiveness of sustainable solutions, since an ecologically oriented product without being perceived as an improvement compared to obsolete solutions, "is not enough." This demonstrates the need for research that can bring strategies in this field, differentiating the products ecologically oriented from the others, thus favoring their recognition by consumers, by means of some own aesthetic.

Walker (2005) addressed this theme in his paper "Unmasking the Object: Restructuring Design for Sustainability," stating that sustainable objects "will be" markedly different from existing products, as well as having a very different aesthetic typology. For the author, "an aesthetic typology is not based on the function of the product, but rather on tactile and visible points of form and finishing", which could connect the aesthetic qualities of the artifacts with their modes of "unsustainable production". Aligned with this thought, the author proposed aesthetic identifiers that collectively would be useful in distinguishing harmful practices from, being able to characterize types of "unsustainable" consumer goods.

The author chose to create indicators that describe the aesthetic typology of conventional products, still based on unsustainable practices, which according to him would have the appearance corresponding to his means of production. However, when analyzing the products considered at present as environmentally sustainable, one notices, in fact, a great similarity with the conventional products, different from what was presented by the author. This is because the products considered environmentally sustainable are derived from manufacturing processes that, although they follow different design guidelines, aligned with sustainable practices, still consist predominantly of industrially produced objects with the same type of conventional product design, therefore, with similar aesthetics.

So, what would be the path to developing a proper aesthetic for environmentally sustainable products? For the authors of this article, the answer lies in the field of design, whose competence is the configuration of artifacts, based on design decisions that can provide the product with a differentiated aesthetic.

In order to contribute to the resolution of the aforementioned question, this article lists the main design requirements adopted for the development of sustainable artifacts present in the literature in order to understand which can interfere in the appearance of the products, contributing to a different aesthetic and thus setting up indicators for the development of an appearance appropriate to this new product typology. With this bias, it is conjectured that the products developed from sustainable practices can also establish aesthetic markers that contribute to their recognition as a more adequate solution to the consumer.

The research is relevant, since in the design there is a centralization of environmental sustainability efforts focused on the adoption of practices that focus during the technical project and the production of these artifacts, away from the project scope other approaches that could also positively impact the quality and acceptance of these artifacts face to the conscious consumers.

Even if the differentiation between ecological and conventional products is of great relevance to the current context, a deficiency in the communication of the attributes related to the former orientation of the products is still perceived, which has the information regarding environmentally sustainable actions restricted almost in its entirety to the use of certification, often misplaced in the product or in the composition / configuration of products made solely from the designer's experience, which does not find theoretical bases that aid in the aesthetic development from this type of artifact. According to Löbach (2001, p.56), the ideal would be to search for more objective data on the needs of the project, through interviews and tests with users, which fostered the establishment of aesthetic aspects in a more rational way.

This article aims to contribute to the discussion about the aesthetics of sustainability, advancing design research to areas that provide a basis for the aesthetic development of ecologically oriented artifacts, through indicators that can be emphasized in the design process, reflecting in appearance of the artifacts its ecological orientation, which in turn can facilitate the recognition of this category face to the consumer, increasingly focused on less harmful solutions to the environment.

2. Theoretical considerations

In order to achieve the objectives of this article, it was necessary to carry out a literature review on the bases for the aesthetic configuration of the artifacts, as well as the search for design requirements driven to ecologically oriented products, which was given through scientific articles and books of the area.

This procedure allowed the construction of a base for the search for aesthetic indicators with potential for the elaboration of an aesthetic proper to ecologically oriented products. For this, the authors sought to connect the requirements presented for the design field to the configurator elements of the artifacts, showing how they can behave to convey through their appearance information regarding the ecological orientation of the products.

2.1 Aesthetic configuration of artifacts

It is possible to seek information for the aesthetic development of artifacts from concepts brought by the author Löbach (2001) in his book "Bases for the configuration of industrial products", in which the author presents the aesthetics applied to the field of industrial design.

Löbach (2001, p.60) states that the configuration of industrial products aims to provide the product with aesthetic functions that enable its perception by people, in addition to aiming to attract people's attention to the product, provoking the purchase. (IBID, 2001, p.63).

In the aesthetics of the object it describes the visual features of the object and its qualities, which can be investigated through empirical aesthetics. The data presented by this model provide the basis for the development of design guidelines applicable by the designer, which makes this professional an emitter of messages in the form of industrial products. (LÖBACH, 2001, p.157).

But for this to happen it is necessary that all aesthetic features of the products be known and enumerated, making it possible to design a new industrial product that meets the values set in the design process by the industrial designer and that corresponds to the aesthetic needs of the user. (LÖBACH, 2001, p.158). According to Walker (2005) to develop some aesthetic typology certain aesthetic identifiers may be proposed, so that to be common to many consumer goods, and thus become collectively useful in distinguishing unsustainable practices.

In this work, it is proposed that the aesthetic indicators for sustainability should be based on the configurational arrangement of the product, which according to Löbach (2001, p.159-160), "is determined by the set of configurator elements" that can influence the sensitivity and ideas of users. The configurative elements can be described as bearers the aesthetic information of a product, and its selection and combination, by the industrial designer, will define the reaction that the future user will present to the product.

For Löbach (2001), "the form of the industrial product is the sum of the elements of the configuration and of the reciprocal relations that are established between these elements". The designer should experiment on the effects that can be obtained with the help of the configurative elements, because only based on such experiences it may be made the right combination between the elements and thus achieve the desired effects. This arrangement, according to the author, comprises the figure that consists of the value before the non-figure, and is composed of the following main elements:

Configurable elements of industrial artifacts
Shape
Material
Surface
Color

Table 1: configurative elements. Source: Löbach, 2001.

The union between these elements and their arrangement will be responsible for the constitution of the "Figure" of the artifact, which refers to "the type of its configurative elements, its set, its quantitative distribution and its relation to the whole." (Löbach 2001, p.166). These in turn entail two factors:

Factors	Definition
Order	• Small number of configurative elements; • Small amount of sorting features
Complexity	• High level of elements • Large number of sorting features

Table 2: factors of the figure. Source: Löbach, 2001.

The conscious use of these elements contributes to the construction of more effective messages face to the public, since according to Munari (2009, p.68), visual communication takes place by means of several messages and may be intentional, through previous elaboration. Dondis (2007, p. 25), the visual elements are manipulated with an emphasis changeable by the techniques of visual communication, in which the solutions are governed by the posture and intended meanings.

2.2 Project requirements for sustainable products

Sustainability discussions have affected many areas of knowledge, including the field of design, which has since sought ways to reduce the impact of the exacerbated production of material goods through design solutions that minimize environmental damage from the production of artifacts. The theoretical contributions in this regard arise through requirements that aim to reduce the use of environmental resources, and are presented by authors involved with this issue, through books and specialized articles.

To enable to understand these requirements, a survey of the main ones was carried out, addressed by Moraes (2010), in the book "Metaproject: the design of the design"; Manzini and Vezzoli (2011), in the book "The development of sustainable products: the environmental requirements of industrial products" and Platckeck (2012) in the book "Industrial design: ecodesign methodology for the development of sustainable products".

To understand them and from them to be able to elucidate paths to an aesthetic proper of sustainable industrial artifacts, it was decided to create "categories", since many of the requirements were presented by more than one author, with different approaches, which would make the execution of the research goals harder. With the categorization, a synthesis of the requirements was accomplished, crucial factor for the progress of the project.

The following are the excerpts found in the aforementioned books and the 7 categories to which they were attributed in this research:

REQUIREMENTS PRESENTED IN THE LITERATURE	CATEGORIZATION
• Use of few raw materials in the same product; Use of few components in the same product; Optimization of the thickness of the product casings; non-use of metal exemptions in	MINIMIZATION

thermoplastic products; not use of information stickers made from materials that are not compatible; (MORAES, 2010, p.69). • Minimize the use of resources in production, distribution and during use. (MANZINI and VEZZOLI, 2011, p.117-134). • Material reduction: product dimensions, reduce volume. (PLATCHECK, 2012, p.106).	Minimization of raw materials, components, thicknesses, dimensions, volume, metallic exemptions, and adhesives / parts incompatible.
• Choice of natural resources and processes with low environmental impact; choice of materials and process with low environmental impact, as well as low impact energy resources. (MANZINI and VEZZOLI, 2011, p.147-168). • Optimize production techniques; (PLATCHECK, 2012, p.106).	LOW ENVIRONMENTAL IMPACT Adoption of low environmental impact processes, materials, techniques and energy resources.
• Extended product life; (MORAES, 2010, p.69). • Optimizing product life: designing durability and reliability; facilitate updating, adaptability, repair, reuse, refacing; intensify use. (Manzini and VEZZOLI, 2011, p.188-208). • Develop products with adequate time of use. (PLATCHECK, 2012, p.106).	EXTENSION OF LIFE Intensify product use from adaptability, ease of repair, reuse and durability.
• Use of compatible thermoplastic materials; (MORAES, 2010, p.69). • Recycling: Adopting cascade recycling, choosing materials with efficient technology, facilitating collection and transportation after use, identifying materials, minimizing the number of incompatible materials, facilitating cleaning, composting and combustion. (MANZINI and VEZZOLI, 2011, p.211-242) • Consider possibilities for reuse, reprocessing and recycling of the entire product or parts of the material. (PLATCHECK, 2012, p.106).	RECYCLING Compatibility and reduction in the number of materials adopted. Facilitate cleaning.
• Ease of disassembly and replacement of components. (MORAES, 2010, p.69). • Facilitating disassembly: Minimize and facilitate operations for disassembly and separation; use systems with reversible joints; use fastening systems that can be easily opened; use easily separable materials when crushed; use easily separable ingredients in already crushed materials. (MANZINI and VEZZOLI, 2011, pp. 243-267)	DISASSEMBLY Facilitate splitting, separation and replacement of components.
• Distribution system: returnable packaging, avoid unnecessary materials; (PLATCHECK, 2012, p.106).	PACKING Avoid unnecessary materials.
• Predict reduction in energy, water or auxiliary materials consumption. (PLATCHECK, 2012, p.106).	USE Reduce consumption of subsidiary resources while using the product.

Table 3: Categories of requirements. Source: author based on the research done

In a first analysis it was observed that the requirements presented by the authors referred predominantly to the configurational elements shape, material and surface, dispensing another crucial element for the aesthetics of the artifacts, the color. To close this gap, we searched for results from a study by Clementino et al. (2017), entitled "Less is more: consumers' perception about the use of color in sustainable packaging", which aimed to understand how the color can be used in sustainable artefacts in order to facilitate consumers' perception about their orientation and, although it takes as its research object only the packaging, could provide indications for future investigations within the field of the aesthetics of sustainable artefacts in general. With this research was added one more category, as set out below:

REQUIREMENTS PRESENTED IN THE LITERATURE	CATEGORIZATION
• Reduction in the variety of colors; reduced saturation and increased clarity. (CLEMENTINO et al., 2017)	COLOR Reduction in saturation levels and color quantity adopted.

Table 4: Additional requirements category. Source: author based on research done

At the end of this process it was possible to obtain 8 categories of requirements related to the project development of sustainable artifacts. But, it was necessary to reflect on which could in fact be attributed to aesthetics, that is, could reflect on the appearance of the product. Thus, the categories of "packaging" and "use" were excluded, since the former refers to a specific artifact found as wrapping of other artifacts, and which does not necessarily interfere with the aesthetics of the products to which it is wrapping, and the second for showing up after consumption of the artifact. The following categories were remained after the requirements analysis:

1. Minimization;
2. Low environmental impact;
3. Life extension;
4. Recycling;
5. Disassembly;
6. Color.

These categories were interpreted as likely to interfere in the appearance of sustainable industrial artifacts, which in turn may contribute to the construction of aesthetic indicators appropriate to this product typology.

2.3 Aesthetic indicators analysis table for ecologically oriented artifacts

The literature review allowed the analysis of the resources currently used to develop industrial artifacts more in keeping with the environmental reality, factors that also show up relevant for the advances in the researches related to the aesthetics of ecologically oriented artifacts, which in turn may contribute to its effectiveness while a new typology of products.

To make this possible, it was necessary to cross the 6 categories of selected requirements with the information on aesthetic development presented by Löbach (2001), in section 2.1. The authors analyzed which categories had the potential to interfere in which configurational element, which generated indicatives from the crossing of the informations, resulting in the following table:

CONFIGURATION ELEMENTS		REQUIREMENT CATEGORIES		AESTHETIC INDICATORS	COMMENTS
Shape	+	- Minimization - Extension of life - Disassembly	=	• Reduction of size; • Reduction in the number of components; • Apparent resistance; • Adaptability*.	*Shapes that favor new uses and repairs (such as modular structures).
Material	+	- Low environmental impact - Recycling	=	• Materials compatible with each other; • Reduction in the amount of materials used; • Adoption of recycled materials.	xxx
Surfaces	+	- Recycling	=	• Adoption of few resurces for finishing*; • No grooves / protrusions**	*Adoption of few resources such as paints, varnishes and other materials that make recycling difficult; **Reduce grooves and protrusions that make surface cleaning difficult for recycling.
Color	+	- Reduction in color	=	• Reduction in the amount of color and saturation employed.	xxx

Table 5: Relationship between requirements and aesthetic elements. Source: author based on research done

In addition to the elements, it was also important to understand how they should theoretically behave to expose the ecological orientation of the artifacts, which resulted in the following arrangement:

Figure	Set, quantitative distribution and relation with the whole
Order	• Small number of configurative elements; • Small amount of sorting characteristics

Table 6: Behavior of the figure in relation to the aesthetic configuration of sustainable artifacts. Source: authors based on their research

The "order" was more adequate in this context since the requirements point to the reduction in the number of configurational elements, which in turn demonstrates the need for a reduced amount of characteristics for ordering.

3. Discussion

From the information gathered in the course of this research, it was possible to understand that the presently practiced design requirements for the development of sustainable artifacts can interfere in the appearance of ecologically oriented products, showing an interesting way to advance the discussion about the aesthetics of sustainable artifacts industrial.

The requirements studied were able to intervene in the way how the elements inherent in the aesthetics of the artifacts behave - shape, surface, material and color, which in turn can allow the development of aesthetic indicatives that dialogue with a large quantity of products produced in the present, configuring an aesthetic typology. This is relevant, since according to Walker (2005), to construct an aesthetic typology the proposed aesthetic identifiers must be common to many consumer goods, and thus become "collectively" useful in distinguishing practices.

The initial sketches, presented in this article, suggest the following aesthetic markers:

AESTHETIC INDICATORS FOR ECOLOGICALLY-ORIENTED INDUSTRIAL ARTIFACTS
Reduction of size;
Reduction in the number of components;
Apparent strength;
Adaptability;
Compatible materials each other;
Reduction in the number of materials used;
Adoption of recycled materials;
Adoption of few finishing appeals on surfaces;
No grooves / protuberances
Reduction in the amount of color and saturation employed
CONFIGURATIONAL ARRANGEMENT
Order

Table 7: Aesthetic markers for sustainable industrial artifacts. Source: authors based on their research

These markers can be used by design professionals as a way to communicate about the orientation of products, and thus their effectiveness as a solution more appropriate to the environment face to the public, distinguishing the ecologically oriented products from the others.

But for the validation of these aesthetic indicators it is necessary to apply tests in products that emphasize these markers, which in turn make possible the understanding about which ones actually contribute to the construction of the sustainable aesthetic typology, besides investigating if those can be applied in different types of industrial products. According to Vezzoli (2010), the aesthetics of sustainability must originate in sustainable values and take various forms, depending on the context and the designer.

4. Conclusion

The application of aesthetics as a differentiator of ecologically oriented artifacts has not yet been widely explored in the field of design, although it is a valuable way to distinguish this new category of products as more appropriate to the environmental reality. The solutions presented in the literature focus on the technical development of the product, leaving aside issues related to how the designer should expose to the consumer the orientation of these artifacts, facilitating their recognition.

The obtained results showed that the design requirements already established in the literature can provide aesthetic indications about the orientation of the artifacts, being possible to be guided in them to the development of a typology proper to the sustainable artifacts, which in turn can contribute to the recognition and consumption of less harmful material goods.

The content presented refers to an initial study, which aims to contribute to the field of sustainability aesthetics, requiring the application of validation tests, but already demonstrates results in favor of the discussion about the aesthetics of sustainability and the role of design in pursuit of distinguishing between the products involved with the environmental cause and the others. This is possible since the products developed under sustainable practices, adopting sustainable project requirements and from these, are able to present indicators that contribute to their recognition as a more adequate solution face to consumer, factor that shall be investigated in future work.

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Sustainability and Fashion in Undergraduate Teaching

Sustentabilidade e Moda no Ensino de Graduação

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Abstract

The article presents the teaching method used in the discipline Fashion and Sustainability, part of the Fashion undergraduate course at UDESC. The method relates to research, teaching and extension studies, aiming to emphasize on the student's active participation. Based on the theoretical principles evidenced by research and extension activities, there was an approximation between students and local enterprises with more sustainable production and consumption purposes in fashion. The Zero Waste week, promoted at the end of October, provided the contact between students and professionals who gave workshops and lectures on sustainable alternatives to fashion. At the end of the discipline, the students raised problems and proposed solutions to the undergraduate fashion course and presented projects for services, products and consumption forms with reduction of socio-environmental impacts. It is believed that the used method, articulating theory and practice, with the active participation of the students, promotes an adequate preparation for the performance in the fashion market.

Keywords: Sustainability; Fashion; Education;

Resumo

O artigo apresenta o método de ensino empregado na disciplina Sustentabilidade e Moda, do Curso de Graduação em Moda da UDESC, método que relaciona pesquisa, ensino e extensão, com o objetivo de obter uma participação sempre mais ativa por parte dos alunos. A partir dos princípios teóricos evidenciados pela pesquisa e das atividades de extensão, houve uma aproximação entre alunos e empreendimentos locais com propósito de produção e consumo mais sustentáveis na moda. A semana Lixo Zero, promovida no final de outubro, proporcionou o contato entre os alunos e profissionais que ministraram oficinas e palestras a respeito de alternativas mais sustentáveis para a moda. No final da disciplina, os alunos levantaram problemas e propuseram soluções para o Curso de Graduação em Moda, e ainda apresentaram projetos para serviços, produtos e formas de consumo com redução de impactos socioambientais. Acredita-se que método *utilizado, articulando teoria e prática, com a participação ativa dos alunos, promove uma preparação mais adequada para a atuação no mercado da moda.*

Palavras-chave: *Sustentabilidade; Moda; Educação;*

1. Introduction

Education is the way to a more sustainable society. The school, from elementary school, must present the student the importance of preserving the environment, which is nothing more than the house he inhabits on this planet. The knowledge and awareness on a more harmonious relationship with nature, develop in the student the perception that environmental degradation causes the degradation of the quality of life of humans and other living beings.

Institutions of education, from pre-school to postdoctoral level, play a key role in shaping citizens so that they know how to use knowledge and technology to create a system where they can have a quality of life without destroying the planet on which they live.

Teaching, research, and extension need to be articulated in the teaching and learning process of sustainability in the context of fashion in educational institutions. In this way, students understand the theory in practical applications and actively participate in real projects to improve social and environmental problems where they live.

There are 28 courses focused on fashion in Santa Catarina's State (BRAZIL, 2017), between bachelors and technical courses. But only 4 courses offer subjects related to sustainability. In the UDESC Fashion course, the Sustainability and Fashion discipline provides knowledge about the conceptual fundamentals of sustainability in fashion, working theory and practice, articulating research, teaching, and extension. From the research and extension, students are presented with cases of local enterprises that aim to produce and consume more sustainable fashion. Among them, the work done with women inmates highlights the social role of fashion.

A foundation for a more ethical and sustainable fashion must have an engagement with socio-environmental responsibility, the generation of fair income and the preservation of the local culture. Fashion is a reflection of its time. Sustainability is the paradigm of the 21st century. When teaching in Fashion courses it is an obligation to train professionals with knowledge about fashion in the context of sustainability.

2. Fashion

The idea of fashion goes far beyond clothing, although this is the most common conception. According to Sant'anna (2005, p. 107), "Fashion, (...) is what is underground to this act [of dressing], as an agent that drives, qualifies, selects and resigns the action of opinion".

Therefore, the costumes are the objects that allow the fashion to express itself. The costume "operates on the stage of the imaginary and is integral to culture" (CAMPOS, 2013, p.45). Through it, we cover and adorn our bodies and signify our subjectivity, constructing representations of our self.

Fashion is an expression and personal reflection. It is a way of thinking the world, translated in the image. It is a way of thinking and conceiving the social world: a web that constitutes society. Dressing up in modern society is dressing up in senses. It is a choice and a daily position in society and culture.

Therefore, it is in the act of dressing that one understands a time, a society and their respective values and ideal behaviors since it is the fashion itself that constitutes the society to which it belongs.

3. Sustainability

Since mankind has mastered scientific knowledge, he has been able to exercise great power over nature, which has given the possibility of modifying the laws and the natural order in which the environment maintains itself.

With the mastery of productive techniques, the man found himself in the need of extracting from the environment raw material frequently, so quickly that it does not give it’s time to recover. Very quickly, this cycle of uncontrolled extraction and production is an evidence of climate change, garbage excess, and poor working conditions, for example, and it has brought the need to think of sustainability.

The concept of environmental sustainability was created in the early 1970s at the United Nations Conference about the Environment, to suggest that it was possible to achieve economic growth and industrialization without destroying the planet. The proposed model for sustainable development was an attempt to harmonize human development with the limits of nature. (SCHULTE, 2011).

Since then, several authors have been studying and writing on the subject, allowing this new thinking to develop and influence political and economic systems. Currently, the concept foresees the concern with the environment and advocates a growth that balances the extraction of natural resources with the fulfillment of human needs. However, the environment is only among three other aspects that make up the process of sustainable development. They are: social, economic and cultural. For a product to be sustainable, therefore, it is imperative that it contemplates the four aspects above and have the least negative impact on them.

The social aspect involves the entire society and the effort spent by the worker, as well as the laws regulating the service. In addition to the fair wage, it is important to consider a work environment that favors the accomplishment of the activities and does not generate physical and psychological harm to the worker. Also, a sustainable production process should take into account general aspects such as education, violence, and leisure, as well as cultural aspects, which must be respected and supported by businesses wherever they produce them. One way to ensure that culture is maintained is to invest and stimulate local crafts, which interfere little in the environment and favor the economic development of the region.

Regarding the economic aspects, a frightening fact explains the need for concern for the economy in sustainable development. According to the Oxfam report, a British NGO that develops programs to reduce inequalities, only eight men have the same wealth as 3.6 million people, who are among the poorest half of the world. The economic pillar encompasses the production, distribution, and consumption of goods produced and establishes that they must be realized in a conscious way, valuing the other three aspects. Companies, in their processes, must promote economic development through the generation of jobs and wealth, distributing it in a way that all are contemplated.

The concern with sustainability has been present in fashion since the 1960s (BERLIM, 2012) when the first reflections on the environmental impact caused by the textile industry appeared in Brazil and in the world.

Change has become the tradition of modern society. Consequently, the speed on which the new presents itself, in the fashion industry mainly, made the cycle of production to be simultaneous to the discard, both in extraordinarily great volumes.

In order to maintain this format, several sectors are mobilized to produce and distribute parts that represent a considerable share of world trade, manufacturing production and employment, especially in poor countries where production is cheaper (RECH, 2008).

The consequences are a surplus of products that impose itself on physical stores and e-commerce, without their real value being questioned, involving, besides the price paid by the consumer, the costs generated to the environment and human lives, both in the pre-production and post-production. Faced with the possibility of acquiring the new, and with it, the performance of a sometimes unreal subjectivity, there is a contempt for the pieces that stayed in the wardrobe or that, as a consequence, end up being discarded and often go to waste.

4. Sustainability in Fashion

By the end of the 1970s, Brazil faced a strong crisis that caused a large number of unemployed, rising inflation as well as foreign debt.

> At a time when major changes were taking place in the economy, signaling the need for urgent measures in the face of the crisis, the textile and clothing sector decided to create the first technical courses in Brazil and ten years later collaborated to create the first higher education courses (PIRES, 2002, p.2).

Until then, the fashion professionals in Brazil were self-taught or graduated in European schools. The first fashion undergraduate course, in Fashion Design, appeared in 1988 at Santa Marcelina College, in São Paulo, one of the most prestigious among the 68 fashion baccalaureate courses accredited by MEC. (BRASIL, 2017).

The growth in the number of courses aimed at fashion in Brazil was due to the acceleration of the economy, with the objective of training professionals able to work in the growing industry. According to Pires (2002), the state of Minas Gerais, for example, went from 200 clothing companies in the 1970s to 4,000 in 10 years.

> What made the segment organize itself and create the Mineiro Fashion Group and the extension course of Fashion Styling & Modeling at the Minas Gerais Federal University (...) becoming at the time one of the most important centers of creation, production and diffusion of fashion clothing in the country (PIRES, 2002, p.2).

According to MEC's website (BRAZIL, 2017), Brazil currently has 129 technological courses focused on fashion, 68 undergraduate courses above mentioned, as well as the academic master's degree in Textiles and Fashion (USP) and the professional master's degree in Clothing Design and Fashion at Santa Catarina State University (UDESC).

Fashion designers will move from work in the supply chain to work at the "center" of change (FLETCHER; GROSE, 2011). The new role of the designer is as a facilitator, developing strategies to transform the industry and the fashion business. If the designer is located in the change center, it will start in his graduation. Therefore, it is notable the importance of teaching sustainability in graduation, so that designers with knowledge in the area can be trained and aware of their role in the sustainable production chain.

According to the e-mec website, the state of Santa Catarina has, in activity, 28 courses focused on fashion, counting baccalaureate and technological courses. Of these, only 4 offer disciplines related to sustainability.

The curriculum of the 51 face-to-face courses and of the 4 distance courses offered by UDESC were verified, of these 55 courses, only 9 offered disciplines related to sustainability, a total of 12 compulsory and 10 electives, totaling 22 disciplines, of which 13 are offered by the course which has an emphasis on sustainable animal production. It should be noted that the artificial production of animals has a greater socio-environmental impact than the fashion, transportation, and civil construction areas, all added together (Cowspiracy, 2014). The most recent discipline is Sustainability and Fashion, offered by the Bachelor degree in Fashion, and the method used is the study object of this article.

5. Sustainability and Fashion at UDESC

Of the disciplines that approach sustainability, in the four fashion courses mentioned above, three are related to the productive process of fashion, such as Sustainable Processes, Sustainable Development and Design for Sustainability. Only one focus on the relations between the Fashion system itself and sustainability, which is offered by the Bachelor of Fashion at UDESC.

The discipline syllabus relates: "Concepts and dimensions of sustainability. Agenda 21. The fashion system in the context of sustainability. Fashion product life cycle. Ecofashion, slow fashion and ethical fashion. Organic materials, reused and recycled. Reverse logistic. Sustainable Fashion Collection Design Project".

In the discipline the concepts of sustainability in the context of fashion are worked out, with practical examples developed at the institution itself, such as the Ecomoda Extension Program projects and the researches "Socioenvironmental responsibility: textile waste as a raw material for new products and income generation" (2015 to 2017) and "Observatory and creation of the textile waste management model: sustainability and solidary economy in fashion" (2017 to 2019). In addition, enterprises with the purpose of more sustainable development, service, production, and consumption of fashion are presented.

In order to emphasize the active participation of the students, a teaching method was used in the subject that articulates the theory (with study of books and articles discussed in seminars) to the practice, with presentation of local enterprises that promote the production and consumption more sustainable in the area of fashion, and the effective participation of students with the proposition of new projects to solve problems generated by the fashion system.

After the theoretical study, related to the themes of the research projects, the extension projects of the UDESC's Ecomoda Program were presented. One of the most relevant extension projects that aroused the interest of the students was the Interlacing Lives project with culture, ecofashion and solidarity economy, carried out with the inmates of the Florianópolis Women's Prison.

The project, with the support of the CCEPC - Community Council of Penal Execution of the Capital - has the objective of contributing to income generation and the re-socialization of women who are deprived of their liberty in the Florianópolis Women's Prison. In the course offered for the inmates are presented: cooperativism, entrepreneurship, and the solidary economy as a proposal for training and work, through courses and workshops with crochet techniques, embroidery, patchwork for application in clothing accessories, decoration, and toys. The project has an emphasis on the reuse and recycling of glass (fusing), fabric (sewing) and other discarded materials. In addition, the demand for viable cultural activities within the prison space (music, theater, parade) will be identified. In the course of the project the works will be exhibited at events and the products developed will be marketed in the Emporium of Solidarity Economy Store, in the Public Market of Florianópolis, to generate funds to continue courses according to the demand of the inmates, seeking to promote economic, social, environmental and cultural sustainability.

During the first phase of the course, from August to December 2017, image 1, the inmates had classes in handcrafted techniques such as crochet, embroidery, patchwork and manual sewing, using reusable textile materials to make clothing and decoration products. In addition to the courses, there was a presentation of music and Renaissance dance with professors Mario Orlando and Valéria Bittar, students of UDESC music course and musician Beto Vaccari, voice/guitar.

Figure 1: Craft work being done by inmate. Source: Prepared by the authors.

The project carried out by the UDESC Extension Program Ecomoda also counts on the partnership of the social department of NGO GIOS - Integrated Social Works Group - the Trama Ética, which from 2018 will provide a room next to the institution, in the center of Florianópolis, with free courses for the inmates graduated from the Florianópolis Women's Prison.

The students who work as interns for UDESC Ecomoda participate in the activities developed with the inmates. Some students develop collections with the participation of the inmates in the execution and finishing of the pieces with embroidery, crochet and other techniques of the local culture. In one of the cases presented, the brand Terezza Handmade, the owner Jamilly Machado, graduated from UDESC Fashion course, reported her experience on working with the inmates.

The students' experience with the presentation of real cases that show expectations, difficulties, challenges, and achievements, giving students a more concrete perspective of a more ethical and sustainable fashion. The cases presented are developed locally, so the students have access to get to know them better and in some cases, they can participate as volunteers or even work together with enterprises or projects.

An example presented and that had the participation of the students is the Collective wardrobe. The artist Carina Zagonel, who created the project, created a space on the street to share clothes, shoes and other objects, which provides the practice of a simple idea of giving and receiving instead of discarding. The closets are placed in public spaces, in points of greater circulation of people, with the agreement of the local residents. The first

Collective wardrobe was placed in 2015 in the Vargem Pequena neighborhood, in Florianópolis, in the north of Santa Catarina Island, where the idealizer lives.

In two years twelve Collective Wardrobes were installed in Florianópolis, among them one at CEART / UDESC, with the proposal of being a collaborative space with the participation of students, teachers, and employees. In the space, organized with the collaboration of the students of the discipline, books, workbooks, fabric pieces and other materials that are left over from the disciplines are also shared. In image 2 the day of the board inauguration of the Collaborative Space was registered, with the participation of the project's creator Carina Zagonel, the discipline's teacher Neide Schulte and the speaker Rodrigo Müller of Moda Doc. Latin America.

Figure 2: Collaborative space. Ceart Collective Wardrobe - UDESC. Source: Instagram @armariocoletivofloripa.

The proposal is to leave things in a good condition that can still be used. It is a place to acquire things without buying them; an opportunity to get things saved for years that are no longer used. According to Carina Zagonel, the idea is an invitation to share, after all, to put an unused object at the disposal of all, is an incredible demonstration of love and care for the planet and all the lives contained in it.

Another important case was the presentation of the director of the first documentary film about sustainable fashion and crafts of Latin America, Rodrigo Müller. It is a film about the awakening of conscience, about the horizontalization of the world and the opportunity that Latin America has to rediscover itself and value its identity. The film's basic premise is to spread and promote existing and real solutions to the fashion industry problems and to guide possible paths for innovative companies that work towards sustainability (based on the four pillars: social, cultural, environmental and economic). It also aims to value local crafts and enable reflection to make fashion consumers aware and responsible for their choices.

The diretor, Rodrigo Müller, states that:

> It is urgent to carry out education and awareness-raising work for the general public and develop the notion of conscious consumption. The consumer must get out of the media influence and start giving himself the right to question, research, choose and ask. It is he who, in a way, has the true power. It has the power of "demand" and the market seeks to respond to "demand". However, this is a cycle that feeds back to the moment when it is the market that provides information on consumption without independence. "Mass keeps the brand, the brand keeps the media and the media controls the mass." George Orwell. MODA.DOC LATIN AMERICA aims to change the perception of fashion consumers. However, the proposal is not just to think about how it is in the present, but to consider what it will be in the future. (MÜLLER, 2017)

The Zero Waste Week UDESC, promoted in the last week of October 2017, brought students closer to professionals who gave workshops and lectures presenting more sustainable alternatives to fashion. The most sought workshop was natural dyeing and eco-print, taught by designers Nara Guichon and Roberta Kremer,

In the last unit of the discipline, the students, in teams, identified problems related to the fashion undergraduate course and offered solutions. One of the problems raised was that of the fabric pieces generated in the sewing workshop, which are discarded. The team proposed the reuse of the pieces in workshops with the community and the inmates of the Florianópolis Women's Prison through the Ecomoda Extension Program. In the first half of 2018, a team of students will carry out the proposed project.

The teams also developed projects for services, products and consumption forms with reduction of socio-environmental impacts. With the method used, articulating theory and practice with active participation, it is believed that students will be better prepared to act in the fashion market.

6. Final Considerations

In the discipline Sustainability and Fashion, there was the articulation between research, teaching, and extension, as well as the active participation of the students in socio-environmental projects and actions. It is believed that this method is fundamental in the teaching and learning process of sustainability in the context of fashion.

The basis for a more ethical and sustainable fashion is in the engagement with social and environmental responsibility, in the generation of fair income and in the preservation of culture. This knowledge must be built together with the students of the fashion courses and applied in practice in community actions.

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A three-dollar cardboard panel solar cooker for low-income communities

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Abstract

Brazil is a tropical country which has an average of 250 sunny days per year. Unfortunately, very little solar energy is used for both heating water, and for food cooking with solar cookers. Traditional cooking process demands fuel consumption while solar cooking takes advantage of the abundant, free solar energy. This article proposes the use of affordable panel solar cookers, with a sustainable design, based on waste materials, such as cardboard and potato chips metallized plastic bags as alternative materials to commercial reflective aluminum foil or reflective plastic films. Our work is an example of the feasibility of simple, fast and low-cost solar cooking apparatus and techniques dissemination among underprivileged communities

Keywords: *Solar Energy; Affordable Solar Cookers; sustainability, waste materials*

1. Introduction

The use of solar cookers is an ecologically important and correct alternative to fossil fuel or firewood usage in food cooking. About two-thirds of the world population (more than 4 billion people) depend on firewood to satisfy their energy needs on a daily basis. This represents annual tropical forest deforestation in the order of 30,000 to 40,000 km^2. Natural forest logging occurs more frequently in tropical regions, which are the most favorable regions to use solar energy, where the sunlight incidence reaches, in some cases, a potential of 1 kW.m^{-2}.

The widespread use of solar cooking brings environmental, social and economic benefits, with special positive impact on low-income families living in rural or suburban areas. Predatory deforestation generated by the harvesting of firewood could be mitigated, contributing to the fauna and flora preservation. In addition, the burden of collecting firewood would be replaced by other activities, while the energy cost for cooking purposes would be dramatically reduced worldwide.

Figure1: Solar cooking in low-income communities in Kenya. Source: http://solarcooking.wikia.com/wiki/Kenya

2. Types of solar cookers

2.1 Panel solar cookers

This article proposes to disclose a **Panel solar cooker** model, which are affordable and simple to assembly and use. These solar cookers are usually made from cardboard panels, which can be recycled from used cardboard boxes. Reflective surface coatings can be made of aluminum foil, metallized plastic films used in gift bags, potato chip bags, among others. They are fixed to the cardboard with homemade or white glue. The panels are folded in a way to focus sun heat towards the cooking pan spot. This type of cooker presents lower yield temperatures (up to 150 ^{0}C). Nevertheless, they are efficient to promote food cooking, as this process demands minimum temperatures around 82 ^{0}C. For improved efficiency, the pan used in Panel solar cookers must be wrapped with a plastic oven bag capable of standing 300^{0}C, or covered with a clear glass dome (Pyrex type, Figure 2). The cover acts as a greenhouse trap and retains the heat, significantly increasing thermal cooking efficiency. Solar cookers make cooking process slower than conventional cookers, they also use little to no water, since the food cooks in its own water or steam. In addition, slow cooking is a healthier way of food preparation, as it preserves nutrients. Panel solar cookers are not suitable for frying. On the other hand, they can bake breads, cakes and other baked goods with virtually no carbon footprint.

Figure 2 A panel solar cooker showing a pan covered with a clear glass dome – https://homeplaceearth.wordpress.com/2011/06/28/solar-cooking/

2.2 Box solar cookers

Cardboard, wood or plastic boxes might be used to fabricate Box solar cookers (Figure 3). The glass cover provides a suitable greenhouse effect, and a lateral flap or reflector concentrates the solar thermal energy inside the box.

Box solar cookers have higher thermal yields than panel cookers. They may reach 150^{0}C, making them suitable for baking, but not for frying. Construction is more money- and time-consuming, and requires re-orientation along the day to ensure optimum sun exposure. These features difficult their use in solar cooking workshops.

Figure 3 A panel solar cooker - http://solarcooking.wikia.com/wiki/Minimum_Solar_Box_Cooker

2.3 Parabolic solar cookers

Undoubtedly, Parabolic solar cookers are most powerful solar cookers. Their shape provides accurate convergent focus, allowing cooking temperatures over 300^0C and shorter cooking times. They are directional, requiring angle adjustments every 15 -20 minutes. By using this type of solar cooker, it is possible to cook, fry, and bake with yields equal to or greater than the thermal energy of a conventional gas stove. They can be constructed with various materials: glass fiber, molded plastic, cardboard, polished aluminum in a support structure, etc. Nevertheless, they are more expensive and more difficult to build, which brings some difficulties in introducing them in day-by-day usage in low-income communities or in solar cooking workshops. Figure 4 shows a parabolic solar cooker ready to use.

Figure 4 A parabolic solar cooker – source: the authors

2.4 Vacuum tubes solar cookers

A new generation of high performance solar cooker sis based on vacuum tubes with large diameters, good insulation, and reflectors to concentrate heat in focus (Figure 5). As these cookers are expensive, they are not suitable options for large use among underprivileged populations.

Figure 5 A vacuum tube solar cooker –https://www.treehugger.com/clean-technology/new-gosun-solar-cooker-bigger-and-better-and-still-absolutely-brilliant.html

As we can see, there are many designs for solar cookers. Each one of them may be useful, depending on the application intended. In our evaluation, Panel solar cookers present the best set of characteristics to be presented for a Do-It-Yourself project using affordable materials. Therefore, we chose the Benhard Muller pattern to introduce Panel solar cooking to the Community of Morro da Cruz, Porto Alegre, Rio Grande do Sul State-Brazil. Our findings suggest that this type of solar cooking apparatus can pave the way to further development of solar cooking techniques in low-income communities.

3. Methodology

3.1Subjects

Eight residents (three male and 5 female) of Morro da Cruz low-income community, Porto Alegre City, Rio Grande do Sul State, south Brazil, accepted an invitation to learn how to make their own cheap cardboard solar cooker. They received all material necessary to make a solar cooker by donation. All instructions on how to make and use the solar cooker were given to the subjects, either in written and by oral presentation. All subjects accepted to participate on the workshop from the beginning to the end.

3.2 Materials and methods to build a Fun Panel solar cooker

Originally proposed by Teong Tan, Fun Panel solar cooker is the model of choice when it comes to make powerful panel solar cookers. This model was further improved and scaled up for better results. In this study we chose Benhard Muller pattern (Figure 6) to build a Panel solar cooker suitable to be implemented as an eco-friendly, affordable cooking option for needful communities. The model consists of two rectangles, which can be fold to make two L-shaped parts joined by adhesive tape. Main parts of the apparatus are: two folded tabs; a pan area to hold the pan, and a support made with a shoes box.

The materials you need to build a funnel cooker are:

- 2 cardboard or polypropylene (PP) sheets of 85 cm x 60 cm
- 2 reflective sheets of the same size, like aluminium, Mylar, S-ReflecT or similar
- 95 cm of rigid textile reinforced tape to connect both halves
- glue (or double-sided adhesive tape) to stick the reflective sheets onto the cardboard or PP.

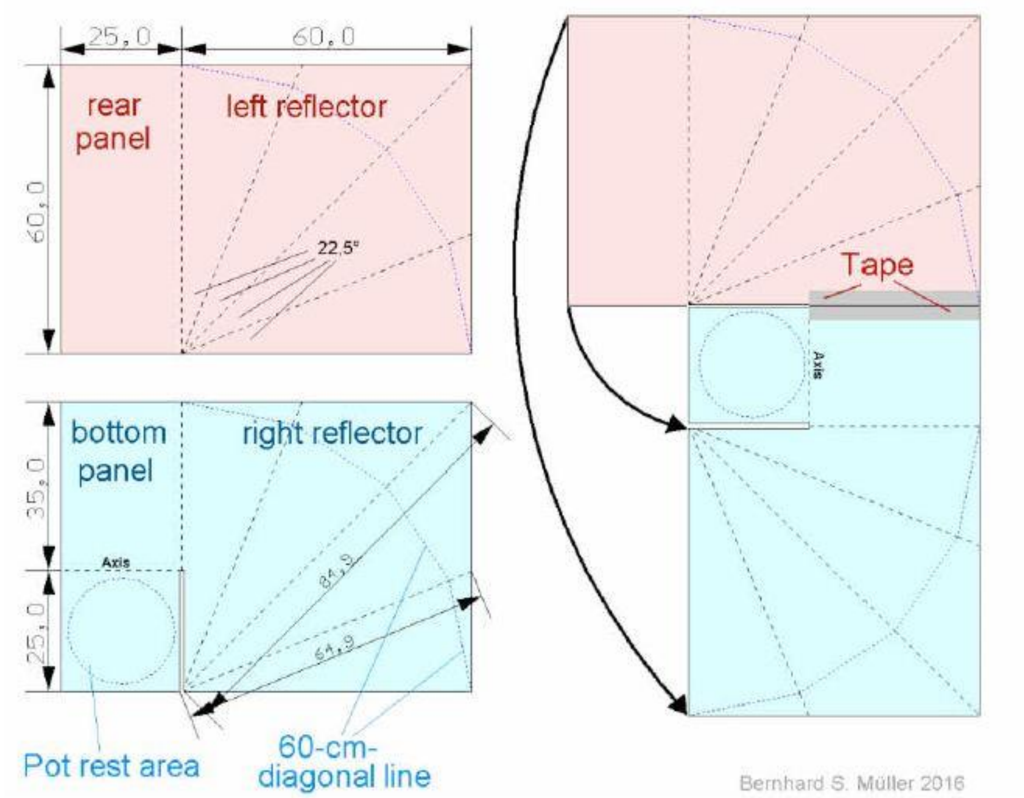

Figure 6 – Fun Panel solar cooker pattern – Bernhard Muller

The cardboard used in the Panel solar cooker can be waste material. For example, LCD TV packages usually have adequate dimensions to make a good Panel solar cooker. Large cardboard boxes, in sizes superior to 60 x 60 cm, are also good alternatives.

The reflexive material can be made out of waste potato chip bags, metallized biaxially-oriented polypropylene (BOPP) sheets used in gift bags, or aluminum foil, but with less reflexibility and poorer mechanical resistance.

Reflexive material can be glued to the cardboard with homemade glue or white glue. However, best results are achieved with double-sided tape, as the reflexive cover presents less wrinkles and better reflexivity.

The instructions provided to the subjects were:

a) Cut two cardboard rectangles, in dimensions showed in the pattern (Figure 7).

b) Cut the two reflexive sheets, in the same size of cardboard rectangles. For best results, apply double sided tape in the edges of cardboard, with vertical glue lines, as shown in Figure 8.
c) Apply double-sided adhesive tape in the cardboard sheets.
d) Stretch reflexive film over the cardboard sheets.
e) Fold and join the two "L" sheets to make the Panel solar cooker, as shown in Figure 9.

Figure 7 – Cardboard sheets and metallized BOPP plastic reflexive sheets. Source: The authors

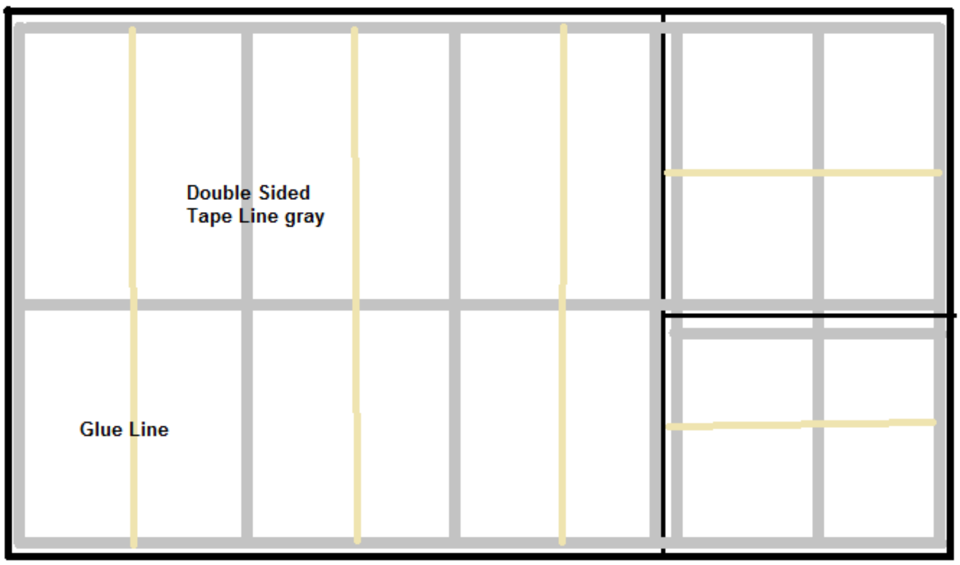

Figure 8 – Schematics on double sided tape and glue line to glue reflexive the sheet on the cardboard. Source: The authors

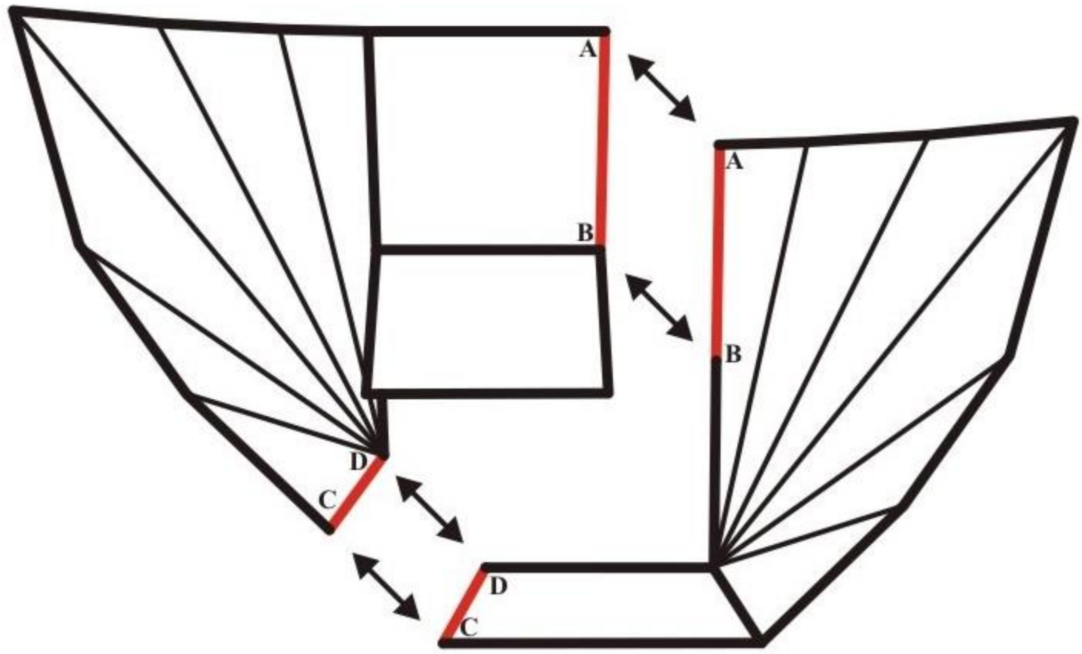

Figure 9 – Schematics on how to join the two "L" sheets makes the solar cooker. Source: The authors

4. Results and Discussion

Subjects were able to follow Procedure "a" without further assistance from the instructors. Figures 10 to 12 show photographs of the subjects following the constructing instructions for the Panel solar cooker manufacturing. Figure 9 shows the execution of Procedure "b". The special double-sided tape is attached to a paper that acts as protective coating, in order to avoid tape adherence loss due to the contact with air.. This paper must be removed before applying reflexive plastic material, to expose the glued surface for an effective adherence. Subjects were encouraged to perform this procedure in pairs.

Figure 10 – Applying double-sided adhesive tape in cardboard sheets – Source: The authors

Figure 11 shows the execution of Procedure "c" and 'd'. Special care must be taken in stretching the reflexive sheets to avoid wrinkles, which may decrease reflexivity. Resulting good quality panels are shown in Figure 12.

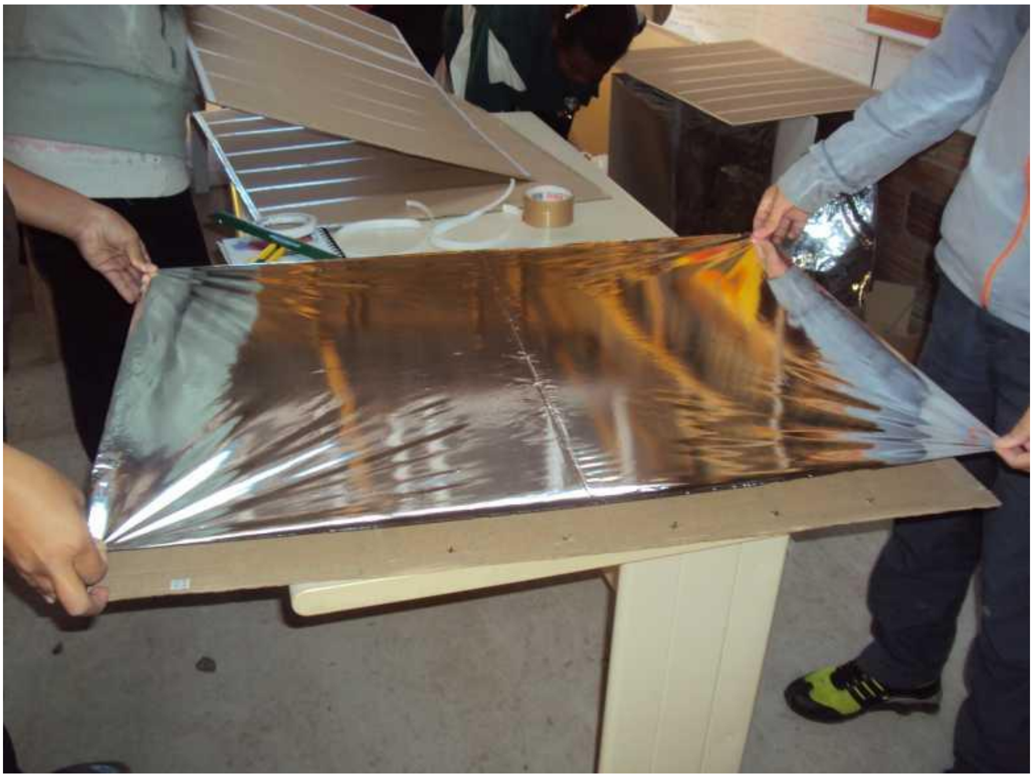
Figure 11 – Stretching reflexive film to glue in the cardboard sheets. Source: The authors


Figure 12 – Two cardboard sheets covered with reflexive films. Source: The authors

After following Procedure “e”, the subjects were able to assembly their own Fun Panel solar cooker (Figure 13). A shoes box was used as pan support. . A 1m long, 4mm in diameter metallic bolt was used to keep the cooker open.

Figure 13 – An assembled, ready-to-use Fun Panel solar cooker manufactured in the Morro da Cruz Workshop. Notice the shoes box used as pan support. Source: The authors

Figure 14 shows the final results of the Morro da Cruz Workshop. In two hours, the pairs of residents easily built their own Panel solar cooker and were oriented on how to use them. However, further efforts must be done in order to implement the effective use of solar cookers on a daily basis. Additional instructions must be passed on to the community members regarding solar cooking techniques applied to simple recipes, such as cooked white rice, chicken breast, or pasta; and baked goods.
Solar cooking demands black pans to improve heat absorption and achieve better Greenhouse effect. Thus, community members might be instructed to paint common aluminum pans or glass preserve jars in black, and use plastic oven bags to cover their pans.

Another important aspect to be considered is the need to recruit sponsors to provide the basic materials needed, adequate working space and appropriate workshop furniture, e.g. large size sturdy tables. Such facilities are not readily available in most low-income communities.

Figure 14 – Workshop in Morro da Cruz poor community – Porto Alegre - RS. Source: The authors

5 Conclusions

Our findings revealed that the Fun Panel solar cooker could be fast and easily manufactured by a group of eight members from the Morro da Cruz low-income community, suggesting that this pattern might be a good starting point to disseminate the use of thermal solar energy for cooking and baking as an alternative to fossil-fuel-based conventional cooking.

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Bioplastics taxonomy: Concepts and definitions from the perspective of productive sustainability

Taxonomia dos Bioplásticos: Conceitos e definições na perspectiva da sustentabilidade produtiva

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Abstract

The present article corresponds to the first part of the research on the economic and technological performance of polymers qualified as 'bioplastics', based on the parameters of sustainability. The main objective of the research is to analyze the bioplastic production scenario, aiming at explaining uses and applications of this group of materials in substitution of synthetic plastics. This part of the research adopted as a methodological line the taxonomic analysis, where concepts and definitions about the types of bioplastics and their relations with the environment will be presented and discussed, especially with regard to origin, processing and disposal. As a conclusion, were established, at first, some thoughts about the technological potential of bioplastics for the manufacture of products.

Keywords: *Bioplastics 1; Biobased plastics 2; Biodegradable plastics 3; Natural Polymers 4; Classification of Polymers 5*

Resumo

O presente artigo corresponde à primeira parte da pesquisa sobre o desempenho econômico e tecnológico dos polímeros qualificados como ‘bioplásticos’, tendo como base referencial os parâmetros da sustentabilidade. O objetivo central da pesquisa é analisar o cenário produtivo dos bioplásticos, visando explicitar usos e aplicações deste grupo de materiais em substituição aos plásticos sintéticos. Esta parte da pesquisa tem como linha metodológica a análise taxonômica, onde serão apresentados e discutidos conceitos e definições sobre os tipos de bioplásticos e suas relações com o meio ambiente, principalmente, no que tange à origem, processamento e descarte. Como conclusão, foram estabelecidas, a princípio, algumas reflexões a cerca das potencialidades tecnológicas dos bioplásticos para a manufatura de produtos.

Palavras-chave: Bioplásticos 1; Plásticos biobaseados 2; Plásticos biodegradáveis 3; Polímeros Naturais 4; Classificação de Polímeros 5

1. Introduction

The history of technology shows that polymer materials have always participated in the production of the most varied types of utensils. Among the several examples found, the use of lacquer with dyes (mineral fillers) for the production of paints stands out; amber (fossilized lignin) for the manufacture of decorative ornaments; the use of bone, horns and hides for the production of game; the latex (natural rubber) was used for the production of utensils or as a waterproofing agent; several artifacts use vegetable fibers (cellulose) and animal fat (fatty acids), obtaining a material similar to the composites; fibers derived from animals, such as wool and silk, are transformed into yarns and fabrics.

Besides the production of various artifacts and utensils, it is also possible to find examples of the use and applications of natural materials in the construction of houses, such as: the use of bamboo as water pipes and the technique of mud that joins clays, cellulose fibers and gums for the production of bricks for “taipa” or even for construction in “Pau a pique”. These materials were used in an *in natura* way or submitted to basic improvements that over time were improved, from the modifications in the characteristics of the natural materials, allowing gains of properties and, consequently, new uses and applications. Most of these examples used materials categorized as natural organic or inorganic polymers, most of which are organic, this is "biopolymers", as they came to be called.

With the advent of industrialization the natural polymers modified or not have gained more space in the manufacture of products, as ‘cellulose’ and ‘shellac’ (KATZ, 1984). These materials had significant importance both in the industrial and environmental context, since if on the one hand they enabled the development of the plastic transformation industry, demonstrating the diversity of use, on the other they replaced the ‘ivory’ and the ‘tortoise shell’ in the manufacture of objects. In the mid 19th century, there was an industry dedicated to the production of polymer products (plastics, rubbers and composites), based mainly on the chemical modification of natural polymers. Among the main polymers used in this period are latex-based materials (Ebonite and Gutta-percha), vegetable and animal gums and resins (Casein, Lignin, Chitin etc.) and, mainly, cellulose derivatives as ‘Cellulose Nitrate’ and ‘Cellulose Acetate’.

Polymers of natural origin have actively participated in industrial production until the invention of “synthetic polymers” derived from petroleum. The decline in the use of natural polymers was caused by the growth in the demand for industrial products and by the technological evolution itself that demanded a greater supply and better performance of the raw materials. Despite the limitations of use and application, some natural polymers remained active in the 20th century, participating in some productive segments. However, from the late 1970’s, there was a resumption of interest in the natural polymers, with a view to obtaining materials with “ecological footprint” and were called “biopolymers”.

The first experiments were aimed at verifying whether biopolymers could replace synthetic polymers with the same quality and supply. Among the studied materials, polysaccharides (starches) obtained from α-glucose, derived from renewable sources, showed real possibilities of industrial applicability, encouraging other lines of research destined to the polymers with the environmental approach. Introducing new technological proposals in addition to the recycling processes of synthetic polymers, as a resource to reduce the impact caused to the environment, of which two research lines stand out: 1- the production of polymers from renewable sources ("green polymers"); 2- and the production of "biodegradable polymers".

These "new" polymers would arouse the interest of certain industrial segments, especially those with low value-added products, where the life cycle is extremely short (disposables, packaging and films). Other segments were also interested in research in this group of materials, such as the medical area, due to biocompatibility for the production of drugs, prostheses, stents and catheters. In addition, segments using expanded polymer or composite technologies have sought biopolymers for biomass production as an alternative to composite recycling techniques using synthetic polymers.

These aspects have lately stimulated the research and development of new materials, as well as discussions about the validity of these materials in social, technological and economic contexts. Therefore, this research is divided into three parts (conceptualization, technology and economics), with the general objective of analyzing the productive panorama of materials qualified as "bioplastics", in order to compose a prospective framework for application in manufactured products in relation to the precepts of sustainability. Because of the variety of existing denominations, this part of the research is intended to study the concepts and definitions applied to bioplastics, with the purpose of proposing understandings about the possibilities of use and application of bioplastics.

2. Classification in (Bio)polymers

It is not too much to remember that polymeric materials are macromolecules, obtained by repeating smaller molecules that will form molecular structures. However, it should be noted that not all macromolecules are polymeric materials, as not all polymers have ideal mechanical properties for the manufacture of products. In order for a polymer to be processed, it is necessary to present a significant amount of elements (mers) forming the molecular chain, that is, they must have molecular weight (Mw) between 10^3 and 10^6, allowing their application as an engineering material.

Polymeric materials, in general, form a complex group in terms of definitions and conceptualizations, since they are subject to several constraints in their molecular structure. For this reason, the taxonomic classification method has been used to define the groups of parameters that characterize the polymeric materials. Based on the classification system presented by Mano & Mendes (1999), some classification criteria stand out because they are directly linked to the origin of the polymers and the transformation of the material into manufactured products. However, there are other classification criteria, no less important, but will be omitted in this work. Therefore, were selected the following classes:

A- Classification by origin in:

- **Natural polymers-** are found in nature and generated by reactions of spontaneous polymerization (biogenesis); examples: cellulose, lignin, chitin, latex, proteins, polysaccharides, casein etc;
- **Synthetic polymers-** are produced artificially under controlled polymerization conditions, and can be generated by various polymerization

methods; examples: Polyethylenes, Polypropylenes, Poly (vinyl-chloride), Polyurethane, Polybutadiene, etc;

B- Classification by Fusibility and / or solubility in:

- **Thermoplastic polymers**- present linear or branched chains allowing thermal actions for conformation;
- **Thermoset polymers**- are polymers that have three dimensional or reticuled chains with the presence of the cross-links, rendering them infusible or insoluble.

C- Classification by the mechanical behavior in:

- **Elastomers** - are polymers that exhibit elasticity, presenting low deformation at room temperature when subjected to traction;
- **Plastics** - they are polymers that exhibit mechanical behavior in long strips, exhibit mechanical behavior from flexible to rigid, especially when thermoplastic;
- **Fibers** - are polymers that presents high ratio between the compliance relation;

Other classifications are commonly employed in polymer studies, but are classifications by ‘market convenience’, as: ‘economic’ and ‘industrial’ (CERQUEIRA & HEMAIS, 2003). The economic classification attributes to the polymer value in relation to the distinctions and market applications, from the qualification in groups ‘commodities’, ‘pseudo-commodities’ and ‘specialties’ (*Op cit*, 2003), these latter two also qualified as, in general terms as 'engineering plastics', given the indexes of their properties. The industrial classification qualifies the polymers in relation to their technological applicability in: homogeneous (homopolymer) or heterogeneous (copolymers or 'blends'), composites, cellular (expanded), compounds, films/films and fibers. In general, these classifications consider the behavior of polymers due to the existing variety of technologies and diversity of applications in manufactured products.

Mano & Mendes (2013) propose a new classification, with scientific basis, to relation the nature of the polymers, in "Geopolymers", "Phytopolymers" and "Zoopolymers", as:

- **Geopolymers**- are natural mineral organic or inorganic polymers (polycarbonates - graphite and diamond, polyoxides and polysaccharides). These polymers are the main components of rocks that will give rise to other materials, such as silicates (glass and ceramics);
- **Phytopolymers**- are organic, naturally occurring polymers of vegetable origin (polyacetals, polyamides, cellulosic fibers, etc.). These polymers are the formers of all vegetables in the form of resins and fibers;
- **Zoopolymers**- are natural organic polymers, occurring in animals (polyesters, polyamides, polyacetals, and nucleic acids) that form the most diverse types of tissues present in organisms.

Although these three classes refer to natural polymers, only polymers of an organic nature can be called biopolymers because they are linked to plant or animal life. All polymers, whether natural or synthetic, are obtained by condensation (polycondensation) or addition (polyaddition) polymerization processes. However, natural polymers display complex systems, called “biogenesis”, being replicated making it difficult to repeat in artificial conditions. Figure 1 shows the scale of molecular complexity present in some natural and synthetic polymers, starting from polyethylene as the simplest and DNA as more complex.

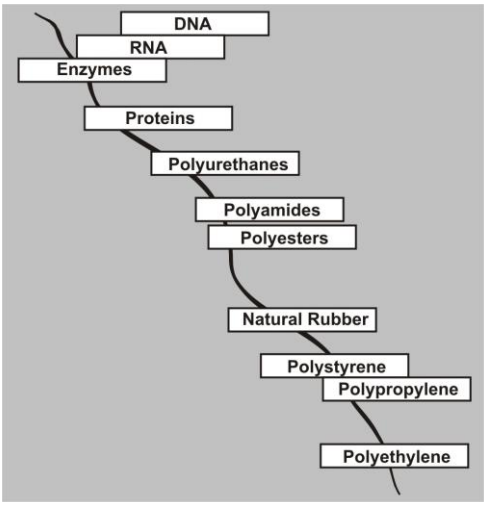

Figure 1- Molecular Complexity Scale (Based: Mano & Mendes, 2013:37)

Recently, other groups have been based on environmental criteria, defining specific classes according to the sources of production, whether renewable or non-renewable, or, in relation to the type of decomposition, in: degradable, degradable and biodegradable. These polymers were grouped into two functional classes: 1- “biobased polymers”, when they are obtained from renewable sources, mainly derived from plants; and 2- “biodegradable polymers”, when their degeneration occurs spontaneously in the environment without causing damage to the environment.

These 'new classes' of polymers have been applied, more often to the 'bioplastics' materials, to qualify groups of polymers plastics, derived from renewable sources or when they are considered environmentally degradable. However, it is observed that the broad application of the term bioplastic still presents certain incongruity and has led to certain misunderstandings, among them the use as a synonym for biopolymers or even natural polymers.

3. Concepts and definitions in ‘Bioplastics’

It is possible to observe in the bibliography referring to the topic bioplastics definitions that seek to qualify this category of materials, demonstrating that besides the great interest for the development of these polymers, there is the intention to understand how they work in economic, technological and environmental terms. This is evidenced when we observe certain groupings that adopt concepts, often based on superficial information, focused mainly on promotional attributes of marketing, for example the called 'green plastics', in reference to the use of renewable sources recourse on the incorporation of phytopolymers in the final material. It is a consensus among several organisms that materials known generically as bioplastics maintain direct relationships with aspects of ‘biomass’ production, both in obtaining 'base polymers' and in renewing the 'polymeric material', being classified into two groups – "biobased" and "biodegradable".

The 'European Bioplastics Association' qualifies bioplastics in two categories, namely: 'biobased' and 'biodegradable'. This classification considers the relationship established with the parameters of productive sustainability, defining as biobased the "plastics derived or partially derived from renewable sources", usually of vegetable origin. While the biodegradable ones correspond to the polymers that have specific chemical characteristics that in the presence of certain conditions are possible of environmental integration.

While, the 'International Union of Pure and Applied Chemistry-IUPAC' defines Biobased as polymers derived from monomers obtained from biomass. Whiles the 'American Society of Testing of Materials –ASTM' conceptualizes biobased polymers as materials "... whose carbon in their composition comes from renewable sources and not from fossil sources ..." (*Apud* MEI, 2016: 31), offsetting the impact of carbon emissions.

3.1 Biobased plastics

The biobased polymers (plastics) are obtained by means of synthesis systems using biofuel derived hydrocarbons (ethanol, methanol etc), usually from sugarcane, maize, manioc or other polysaccharide plants. The called "green plastics", as Polyethylene-PE, Polypropylene-PP, and Poly(ethylene terephthalate)-PET of vegetable origin have the same characteristics and properties as their peers derived from petroleum and can be applied in the manufacture of products homogeneously or integrated into 'conventional plastics', thus reducing dependence on petroleum products. Some vegetable oils, too, are used for biobased production. The best example is the production of 'pre-polymers' derived from castor (*Ricinus communis*) oil for the production of Polyurethanes for the resins and cellular (expanded) plastics, composites and other applications.

The other category of bioplastics refers to the biodegradability of the polymers. Typically, this characteristic is associated with biopolymers. However, it should be noted that the degradation condition of the polymer is a property that derives from its chemical structure, regardless of its origin, petroleum polymers such as polycaprolactone - PCL are biodegradable, while 'green plastics', even if they are of biological origin, behave as their petrochemical equivalents, that is, they are not biodegradable.

Biopolymers are defined by IUPAC itself as "polymers produced by living organisms", such as: starch, cellulose, chitin, gums and others, which are derived from renewable sources of animal or vegetable origin and which are degradation in the environment by biological action. However, a significant part of the biopolymers requires chemical modifications in their structure to acquire technological properties, that is, that can be transformed into products. Just as biodegradability will in many cases not be spontaneous and will depend on favorable physical conditions to cause the decomposition of the polymer product, usually obtained in composting systems, generating energy (Biogas) and organic fertilizers.

In addition to biopolymer modification technologies, there are other processes to obtain 'bioplastics' with biodegradable characteristics, such as the use of microorganisms that consume sugar causing the polymerization. In figure 2, colony of bacteria *Burkolderia* *sacchari* is verified with the formation of granules of Poly(hydroxyalconoato)-PHA polymer in its interior.

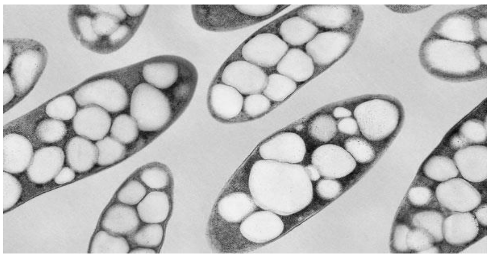

Figure 2 - Bacteria Burkolderia sacchari existing in the cane growing soil used for the production of biodegradable polymers, such as PHA, PHB and PTT.
(Source: https://materialdesigns.wordpress.com/2010/07/15/green-plastics-from-grass)

On the other side, some biopolymers do not present plastic conditions (mass and/or molecular weight) that allow their use in transformation, but are widely used in industry as additives for conventional plastics, acting as plasticizers, substrates, while others are used with great frequency in the food industry, as thickeners, binders, or even generating edible plastic products (gelatins, gums, albumin, etc.)

Therefore, the biobased plastics refer to the conditions of obtaining the polymers, in response to current problems to reduce the demand for petroleum and the emission of greenhouse gases. On the other hand, biodegradable plastics refer to the conditions of post-use and disposal, as well, in response to the flaws present in the reverse logistics system in conventional recycling systems, mainly in reference to low value added products. The figure 3 shows in simplified form the origin of qualified polymers with biobased.

3.2 Degradation, Oxidegradation, Biodegradation and Oxo-biodegradable

Most of the materials used in the manufacture of industrial products are susceptible to degradation by physical or chemical action and in the case of polymers the degradation ratios also occur, in a different way. Among the most common criticisms regarding the use of polymer materials is pollution caused by inappropriate disposal and time for decomposition and integration into the environment.

3.2.1 Degradation

According to the type of polymer, composition and environmental conditions degradation may occur at different times, and may be relatively rapid, six to eight months or extremely slow, taking up to hundreds of years, because the polymers are stable chemical structures. It should be noted that total or partial degradation of the material does not mean integration into the ecosystem, as there is a need for biological compatibility between the degraded material and the environment without contaminating or saturating.

The polymers (elastomers, plastics or fibers) are subject to degradation by action of oxygen (oxidation), exposure to ultraviolet rays, action of solvents (and other substances), to mechanical stresses cause degradation to the material. These actions subject the polymer to a degeneration process by breaking the intermolecular bonds forming the polymer chains and, therefore, the material to degradation.

In general, the degradation process of the polymers consists of levels, which begins with the gradual loss of properties, leading to ‘microcracks’, until the fragmentation occurs and, finally, the formation of small-solid particles called as 'microplastics', being imperceptible when deposited in the environment. Therefore, degradation corresponds to the irreversible alteration of the structure, with losses of properties and performance in relation to environmental conditions.

3.2.2 “Oxidegradation”

The oxidegradation is derived from the incorporation of metallic base additives (iron, cobalt, nickel, etc.) to the synthetic polymers, with the purpose of accelerating the oxidation process together with the action of UV rays on the structure of the material, caused by the known phenomenon such as ‘ageing’ of the plastic product.

The oxidegradation principle has been widely used as a 'solution' for several products, mainly those of large production, low value added and/or short life cycle, such as: plastic bags, packaging, films, etc., where traditional recycling processes become difficult to consolidate given the dispersion in disuse. However, there are several criticisms regarding the application of oxidegradable plastics, mainly in relation to the use of synthetic polymers derived from petroleum and the deposition of residues generated during the decomposition process (dyes, metals, etc.) in nature.

Oxidation degradation, too, is a principle used for water-soluble plastic materials, such as poly(vinyl alcohol)-PVA used in bags and packaging. Other water-soluble plastics come from natural polymers (gums, cellulose, gelatin) modified or applied *in natura* and, in function this characteristic, have restrictions of use and application.

Although several suppliers of raw materials and products claim that the ‘organo-metallic’ additives are inert and non-polluting, there are controversies regarding their use for the constitution of bioplastics, due to the lack of biological activity in the oxidegrading process. Among the plastics that incorporate with called ‘environmental additives’ are the PEHD, PELD, PS, PVC e PP, all plastics commodities, large scale production and applied in a wide variety of products segments.

3.2.3 Biodegradation

In order to reduce post-use impacts, the biodegradation is defined by the United States Environmental Protection Agency as "a process in which microbial organisms alter the structure of chemicals (including polymers) introduced into the environment by metabolic or enzymatic action. "

Unlike the oxidation process, the biodegradation is not related to the use of additives or other substances that cause the decomposition of the plastic product, but to the chemical structure of the polymer itself. This characteristic is present in most biopolymers obtained by microbiological or biotechnological action, as Poly(hydroxy-alkanoates) - PHAs, PHBs; Poly(lactic acid) - PLA; or even of petrochemical origin, as polycaprolactones - PCL, for examples. The biodegradation present in some polymers has been exploited for the production of various medical products due to their ‘biomimetic properties’, that is, they can be absorbed by the organism allowing the interaction with live cells, as well as in certain types of packaging.

For a polymer (plastic) to be qualified as biodegradable it is necessary to first present environmental integration and provide "organic recycling" conditions by means of composting or biomass production and, in case of disposal in the environment, they can decompose without causing damage to the ecosystem. This process of degradation approaching the biodegradable plastics to the 'Cradle to Cradle' concept presented by McDonough & Braungart (2010) when commenting on the need to establish eco-efficient procedures for the economic-productive system.

Biodegration is established through levels of environmental interaction until the total absorption of carbon into the environment. The standard ASTM D 6954-4 establishes tests for the evaluation of 'biodegradability', from three levels: Level 1- Evaluation of oxidative degradability, from the loss of mechanical properties and alteration of molecular weight; Level 2 - Evaluation of the biodegradability in a certain time interval and in uncontrolled environment (nature) and controlled (composting) to verify the occurrence of residues or solid particles; and Level 3 - Evaluation of the 'ecotoxicology' present in the soil and the possibility of fertilization by the decomposition of the material.

3.3.4 "Oxi-biodegradable"

Currently, it is possible to verify a series of products with indications of 'oxy-biodegradable' polymeric material, mainly in plastic bags, disposable products and cosmetic packaging. Despite the ecological appeal, this type of polymer material has been the subject of debates and discussions about its effectiveness and environmental efficiency.

The concept of 'oxy-biodegradation' corresponds to a process that associates 'oxy' and 'biodegradation' with the purpose of accelerating the process of degradation and 'supposed environmental integration'. However, according to European Bioplastics (2015), products that use this technology adopt procedures and specifications outside the standards and requirements set by most environmental organizations, limiting themselves to testing the material by the process of 'physical degradation', without assessing integration issues and the toxicity of 'micro-fragmentation'.

The European Commission for Environment has been discussing the application of self-described 'oxy-biodegradable polymers' and their impacts on the environment. These discussions have three basic assumptions: 1 - whether there is biodegradation by fungi and bacteria (composting); and 2- if the additives used cause damage to the environment; and 3- whether the conventional recycling processes suffer some sort of technical problem. Therefore, the issues related to oxy-biodegradable plastics still raise doubts as to its use, since oxy-biodegradation without biocompatibility is considered to interfere with environmental conditions, even if degraded products.

4. Discussions on the conceptual sustainability of Bioplastics

In order to minimize the inconvenience caused by the inappropriate disposal of plastic products; reduce dependence on petrochemical derivatives for the production of synthetic polymers; facilitate the recycling of waste from polymeric materials, including composites; develop ecoefficient solutions in manufactured products, the polymer industry, especially that related to the plastic transformation segment, has shown an interest in materials with an ecological approach due to inherent aspects of the production chain, mainly in meeting the expectations of segments consumers downstream.

The natural organic polymers or biopolymers, besides to offering technological answers to environmental issues, have made possible innovative solutions for certain productive sectors. The biopolymers (on condition the bioplastics) have also shown real possibilities of replacing (or reducing) the consumption of petrochemical plastics. However, this category of polymerics act in different situations in the plastic supply chain, that is, in obtaining the polymer - biobased plastics; and in the post-use of the polymer product - biodegradable plastics. Unlike the polymers of petrochemical origin that are fully inserted in the plastic supply chain, including recycling activities. In order to subsidize part of the analyzes and discussions, the classificatory flow (figure 3) was elaborated on polymers qualified as bioplastics, from bibliographic sources.

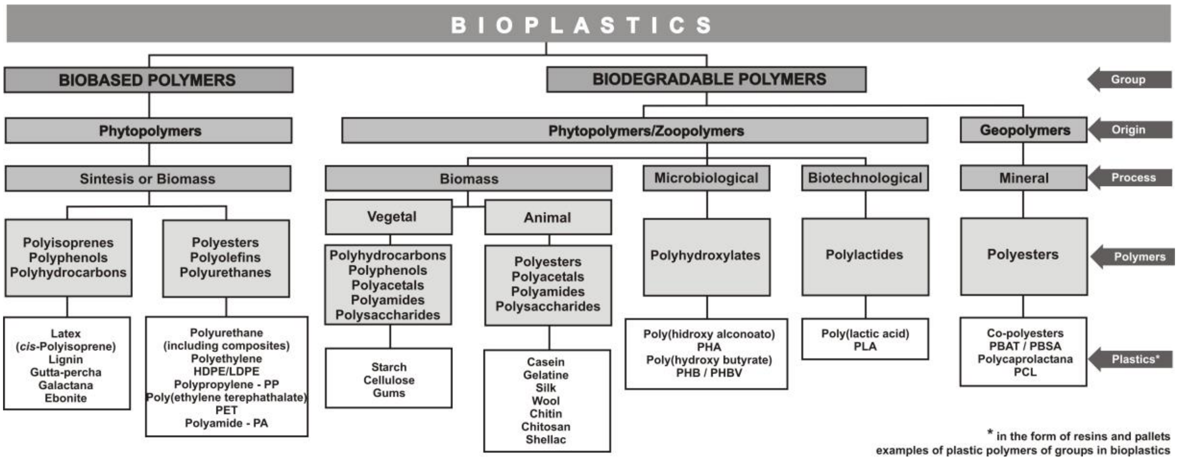

Figure 3- Organization chart for obtaining plastic polymers from renewable sources (Source: own elaboration, 2017 basead on the European Bioplastics)

It is noteworthy that, in world conditions, the biobased plastics already participate in a significant way in the production plastics, resulting in the reduction of the consumption of “petrobased”. This group presents identical properties and applications of the plastics petrochemicals. For example: a ‘biobased Polyethylene’ is equal (and compatible) with a ‘petrobased Polyethylene’, its use being limited only by the supply to the market. However, the same cannot be said for biodegradable plastics. This group of bioplastics still presents doubts as to its applicability in relation to the disposal in the environment, to the detriment of the advantages of the recycling and regeneration processes applied to the conventional plastic polymers.

As shown, some plastics use metal oxides to accelerate the degradation process, while others require certain environmental conditions (composting) to allow biodegradation to occur, these being the main criticisms made in detriment to the recycling and regeneration processes applied to the conventional plastic polymers.

Biodegradable polymers may take approximately 90 to 300 days to incorporate into the biomass and in the case of oxidegradation solid waste will occur through the "micro-pollution", imperceptible, but contaminating the medium in which it was deposited. Therefore, discarding the material in the environment already corresponds to an unsustainable practice, to the detriment of the process of selective collection (reverse logistics) for recycling and/or regeneration. This is the main argument for the development of new recycling technologies (mechanical, chemical or energy) for conventional or biobased plastics and, more recently, the use of organic recycling (composting) technology for biodegradable plastics in order to produce biomass , thus maintaining the economic cycle of the active material and out of the environment - circular economy.

5. Final considerations

Although the conventional plastics have been inserted in the productive scenario since the decade of 1930's and, currently dominate the production of consumers, there are a number of criticisms regarding its environmental performance due to its petrochemical origin or its deposition in the environment. However, it is practically impossible to think of a world without plastic products and it is for this purpose that studies and research on the application of biopolymers have gained strength in supply chain plastics.

The search for technological solutions in addition to the recycling processes made possible innovations in the field of plastics, especially bioplastics that are biobased or biodegradable from renewable resources.

From the classification studies on the flow of bioplastics, it was possible to show two discussions about the use of this group of polymers with focus on productive sustainability: The first question concerns agricultural relations involving the production of biofuels necessary to obtain hydrocarbons for the production of biobased polymers; and the second refers to the levels of biodegradability / biocompatibility in relation to the discharge in nature, against the point of recycling and regeneration processes.

Bioplastics - biobased or biodegradable -, can be applied to a large number of products, provided that certain cautions are taken regarding the specification of the type of selected biopolymer, because in certain cases the properties of the material can be compromised due to several aspects, from premature wear to attack of micro-organisms and in both cases the life cycle will be compromised.

Finally, the bioplastics already occupy a significant space in the world production of plastic products with approximately 57% in biobased and 43% of biodegradable in certain polymers (European Bioplastics, 2017), participating in many segments of products, such as: packaging, domestic utensils, agricultural and livestock products, medical and hospital products, electronic components, among others. Although bioplastics have been available commercially for more than 30 years, in Brazil they still cannot compete directly with conventional plastics due to insufficient supply to market demand, relatively high production and marketing costs and lower performance and properties for application certain product segments.

Therefore, this part of the research had the purpose of analyzing the classificatory structure of the bioplastics in order to establish relations of obtaining the biopolymers. Therefore, the present article does not intend to exhaust, since the research is still in progress, but it was tried to clarify some technological aspects referring to this group of materials.

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A integração das tarefas de sustentabilidade com o proceso de desenho do projeto.

- Estudo de casos -

The integration of green-building tasks and project-design process.

- Case-study comparison -

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Abstract.

The development of a green-building project following a specific reference standard such as LEED, brings new conditions and restrains for all subjects involved in the process. Such changes affect technicians, owners, bureaucracy and also the management tasks either during design or construction phases. Within this scope, the management of sustainability-related activities plays a key role for the optimization of the design-project development. This research analyzes the design process of two different case-study projects undergoing the same green-building certification from the project management perspective. In both project sustainability-related activities were performed throughout the design process however, in one of them such activities were integrated to the building-design development and in the other they were not. The projects selected for the scope of the research is a new nursing home complex located in Northern Italy and an office building project in Barcelona (Spain) currently pursuing the LEED certification. A new methodology was created in order to analyze the project and evaluate the effects of detected project-management issues under three different points of view: costs, time and building sustainability. Such "issues" were identified by researchers on the basis of the LEAN-definition of "waste". The scope of the research is to demonstrate a positive relationship between integration of the process green-building tasks and successful development of green-building projects within the European construction environment. The results showed that integration of green-building tasks through the development of the design process can considerably affect the cost, schedule and sustainability of the project design.

Keywords.

Green-building; project management; integrated process; LEAN; process waste; LEED.

1. Introduction.

The importance of sustainability within the construction business has been increasing dramatically during the last decades [1] (P. Hansford et al. – 2013) and, as some research studies point out, "an increased emphasis must be placed on the processes and competencies required to deliver high-performance buildings" [2] (Horman et al. – 2006). Currently, many researchers focus on understanding different aspects of delivering green-building projects in order to minimize waste, maximize value, and reduce cost. During the last years several research studies analyzed different project management issues related to green-building developments. Their main goal is to optimize the project management process for developing green-building projects focusing on different aspects, such as, counterfactual analysis [3] (Klotz et al. - 2009), LEAN processes [4] (Lapinski et al. – 2006), piloting evaluation metrics [5] (Korkmaz et al. – 2010).

As Lenfle points out in a recent study, "the links between studies devoted to project management and innovation management are complex and marked by a relative lack of communication between the two fields" [6] (Lenfle – 2008). Moreover, during the last years project management practice has evolved into a business process and got detached from the practical aspects of the job tasks [7] (Kerzer – 2013). The scope of this research is to develop a practical comparison between projects with different levels of integration for the development of green-building tasks.

The concept of sustainability has been standardized internationally through the implementation of different protocols but the majority of the research studies have been developed on the basis of common project management processes that refer to the United States construction industry [8] (Lopez & Sánchez – 2010). Recently, sustainability has become a key aspect of the construction field [9] (Enache, Pommer & Horman – 2009) and this includes also project management. However, despite their demonstrated benefits, green buildings are not yet perceived as attractive projects because most people associate green features with expensive technologies that add cost [10] (Castro-Lacouture et al.).

2. Scope of the research.

The scope of this research is to analyze the effect of process integration for green-building design delivery within the European Community.

The whole research is based on the comparison of real case-study projects and has been carried out through three different stages:

- Data collection and process illustration;
- Process Analysis and detection of project-management issues;
- Estimate of the impact of project-management issues on project costs, schedule and sustainability.

The projects selected for the case-study is a new nursing-home complex located in Trento, Northern Italy, and an office building located in Barcelona, Spain, both certified under the LEED protocol, with a total budget of approximately 1o Million Euros. The choice of these case-study projects was made on the basis of the following statements:

- Direct access to project information and contact with all technicians involved in the project;
- Simultaneity between research and project design development;
- Project sustainability referring to LEED credits as benchmark for evaluation.
- The choice of real case-study projects helped researchers testing a new methodology for the analysis of the project management issues in green-building developments. The intent is to develop, with future research, a deep hands-on analysis where specific problems related to specific activities and circumstances could be identified and, possibly, prevented.

2.1. Deliverables and potential benefits of the research.

The present research has two main outputs:

- The endorsement of the new methodology developed by researchers in previous investigations for analyzing sustainability-related issues within the development of a European green-building design project.
- The evaluation of the impact of process integration for sustainability-related tasks within the design process in terms of costs, time and sustainability features.

3. Methodology.

This study focuses on the practical implementation of a methodology developed during a previous investigation where researchers analyzed a single case-study project and developed a method to estimate the entity of project management problems generated by the lack of process integration [11] (Orsi & Guillamón, 2016).

Following the original scope, researchers focused on identifying project management "problems", defined on the basis of the "waste" definition of the LEAN philosophy. In simple words, any type of activity performed during the process that in spite of consuming resources doesn't bring added value to the final product [12] (J. Liker - 2003). Five types of problems were considered for the purpose of this research: waiting (process delays), transportation (unnecessary displacement of people or materials), extra-processing (re-manufacturing and reiteration), costs (unforeseen costs for project-related tasks), defects (project weaknesses that didn't allow the achievement of the expected LEED certification).

Project-related information were collected with two different methods: project documentation analysis and personal interviews. Project owners provided all project documentation such as technical reports and drawings and included all information related to each phase, activity and event affecting the project design phase from the early preliminary design stage until the final executive phase. Interviews were made by researchers personally to technicians and personnel involved in the project. The interview process was standardized by using a common procedure for all interviewees. Each subject recognized all the problems they encountered during the design development and indicated them in the list of project activities developed before.

The results obtained from the data collection process allowed researchers to identify the project priorities or, in other words, the independent variables that had to be considered for the scope of this research. Such independent variables are:

- Time deviation: intended as the delay suffered by all sustainability-related activities of the project impacted by any of the project management issues during the design-phase development.
- Cost deviation: intended as all additional costs caused by project-management issues for the development of sustainability-related activities.
- Sustainability deviation: intended as the loss of certification points, under the LEED reference standard, caused by project-management issues for the development of sustainability-related activities.

Problems, as defined above, were identified by all subjects involved and were gathered together in several "categories of issues" which represent the dependent variables researchers aimed to focus on. The categories of issues identified for the purpose of the present research are listed below:

- *Misunderstanding of Commissioning Authority's (CxA) tasks and process.* Project designers and owner didn't understand the role of the Commissioning Authority and in spite of the suggestions of the LEED consultant the design was carried out without the CxA help until the very last stage.

- *No appropriate clauses in bid documentation.* No specific clauses were introduced in order to determine how and for which compensation LEED-related services would have been performed. During the later design and construction phases the costs of such services were subject to fluctuation on the basis of the construction cost variation.

- *Systematic cuts to budget due to change-orders and delays.* The delay of the project design phase brought to price increase and big deficits in the project budget which involved also the sustainability-related aspect.

- *Lack of knowledge about energy modelling role and process.* The mechanical engineers in charge of the design development developed an energy model that could not be interfaced with the LEED-required software. Another energy modeler had then to be contracted in order to partially or totally redevelop the original model however, the second energy modeler was brought in too late in order to have significant impact on the project because by the time the energy model was finished the final design had already been finished and approved with little or no margin for modification.

- *Lack of project manager supervising the whole project*. A project manager for sustainability-related and LEED-related issues was contracted from the beginning but no general project manager was overviewing the whole process. This brought to a lack of coordination between subjects involved and consequent fragmentation of the process.

Problems related to project schedule and therefore to time variance were analyzed and evaluated with the use of a project management software, Microsoft Project. The list of activities was used to create a Gantt diagram for the whole project. Problems were accounted as activities and identified with different colors depending on their relationship with time, costs or sustainability. For the purpose of the present research only issues related to green-building activities were taken into consideration. Duration of each activity was defined on the basis of the data collected from the project documentation.

Issues related to project costs and therefore cost variance were estimated using data collected from two different sources, cash-flow volume documented by project files and cost information acquired during the different interviews with technicians. Cost-related information for each problem was provided as Euros amount or as number of extra hours spent to solve the problem. In case of the hourly-based information researchers estimate the corresponding Euros amount multiply the number of hours by the average hourly salary for a middle-range professional technician with a short-term consulting contract in Italy [15] (Il Sole 24 Ore - 2015). The cost analysis was developed for all dependent variables described above. The Gantt diagram was used to link each problem to groups of project tasks, total problem costs were then estimated afterwards using simple Excel sheets.

Sustainability variance was determined on the basis of the LEED protocol score. Prior to each project start the design team performed a kick-off meeting with all subjects involved in the project and filled up a LEED checklist where all credits considered “potentially achievable” were listed taking the whole LEED credit list as an optimum reference. During the project development some of those credits were not achieved because of project management issues and researchers focused on those credits the project could not obtain due to sustainability-related project management issues. The problem representation procedure had to go through a iterative process in order to have a set of results that could be graphically understandable and summarize the results. Different filters were applied in order to eliminate unnecessary information and bring only the most important to the eyes of the reader.

4. Results.

Information resulting from the present research were divided into three groups respectively related to the three independent variables previously identified.

Time variance was estimated on the basis of the bar-chart results developed using Microsoft Project. Within the bar chart, sustainability-related problems were accounted as normal activities with predecessors and successors and their duration was estimated on the basis of the data collected through project documentation and interviews. Critical path was then calculated on the basis of the scheduling concepts [13] (Harris, R.B. – 1978) along with free-float and total-float of each activity. The duration of all sustainability-related problems included on the project critical path were accounted for the total loss of time.

The calculation of cost variance was based on two different types of costs: direct costs and indirect costs. The term “direct costs” refers to all expenses, caused by the sustainability-related problems that the owner had to add to the original budget in order to complete the design process. The term “indirect costs” researchers identified two types of quantities:

- All additional costs caused by the sustainability-related problems that technicians had to bear with no additional compensation to their professional fee.
- All additional costs caused by the effects of the sustainability-related problems which affected third parties and later project development phases.

Direct and indirect cost calculations were performed for each dependent variable considered by researchers generating a cost-variance table linking dependent variables (problem categories) with problem-related activities. On each table the horizontal axis represents the dependent variables, the vertical axis the problem-related activities and the numbers represent the cost in Euros that each specific activity had in order to solve each specific problem.

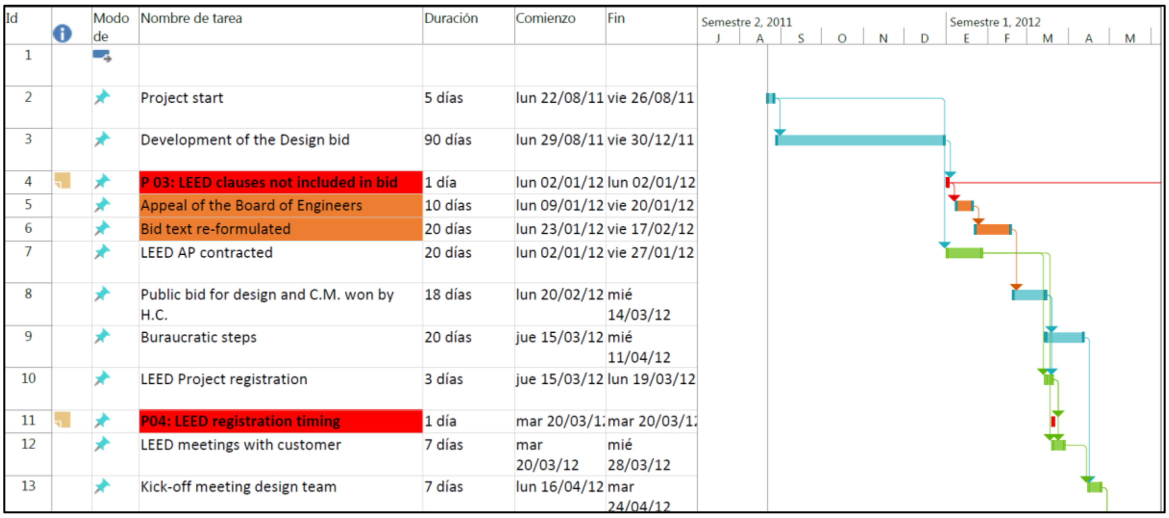

Figure 4.1: snapshot of the project Gantt diagram showing problems (red), problem-related activities (orange), sustainability-related activities (green).

Sustainability variance was estimated on the basis of the LEED protocol. Taking the whole possible score identified at the beginning of the project as a reference, researchers focused on all LEED points that finally couldn't be achieved due to project management issues related with sustainability (which are included in the problem category list cited above). Below are summarized the results of both case-study projects.

RESEARCH SUMMARY TABLE						
DEPENDENT VARIABLES / INDEPENDENT VARIABLES	Lack of integration between technicians	Commissioning Authority tasks & process	No appropriate clauses in bid documentation	Systematic cuts to project budget	Energy Modelling role and process	TOTAL
THE NURSING-HOME PROJECT						
Additional Time (Working Days)	37	39	18	40	41	**175**
Additional Total Costs (€)	5730	38500	36700	9400	10500	**100830**
Green Value (LEED points)	2	1	0	4	7	**14**
THE OFFICE BUILDING PROJECT IN BARCELONA						
Additional Time (Working Days)	1	6	0	6	10	**23**
Additional Total Costs (€)	9800	3100	1500	9300	5100	**28800**
Green Value (LEED points)	0	0	1	0	2	**3**

Table 4.1: table summarizing all results for dependent and independent variables related to both case-study projects.

5. Case-study comparison and cross-case analysis.

After completing the analysis on the case studies the researcher focused on comparing the results obtained. In order to do that we separated the analysis for each independent variable: time variance, cost variance and sustainability variance.

First independent variable: time.

Whether the nursing-home project suffered a delay of almost a 30%, the office buildings was completed with a delay of less than 5%. According to the results and information retrieved through the interviews and document analysis the cause of this problem was the process fragmentation as defined under the Lean approach (Liker, 2003).

One key-difference between the first and the second case study is the perception of the importance of time. According to the information retrieved, for the first case, time and sustainability were often sacrificed to the benefit of the cost. The lack of importance given to the time variable is demonstrated by the delays suffered during the completion of the first two case-study project. On the contrary, for the other case-study time was a major issue. Subjects interviewed for these cases declared that the schedule deadline was included as a major contractual clause from the beginning of the design phase and therefore any delay would be considered as an exception almost the same way as a contractual breach.

This different perception of the importance of time within the process development, as well as, the different management associated with it, led the projects to have different delays both from the variance perspective as well as in absolute value.

Second independent variable: costs.

The cost-variance also registered substantial differences from case to case. Following the idea cited above about the importance of each variable the researcher highlights that, in terms of absolute values, the projects that suffered the greatest cost variance was the ones having the independent variable "cost" as the most important of the three. As already cited above for the time-variance paragraph, each project owner had a different order of priorities for each of the three independent variables. For the nursing-home project the most important was always the "cost" variable mainly because, as explained above, it depended on a public funding which had already been approved and could not be changed. However, this project also had "time" as the least important variable and, according to the analysis, these two variables are heavily related one to the other. Most of the issues that generated the cost variance depended on delays which imposed change orders, project remanufacturing tasks and other expensive activities. Therefore, is important to notice that cost variance and time variance depend one from the other or, said in other words, from the project management perspective, also during the design phase of a green-building project, time is money.

Cross-case analysis: sustainability.

For all projects analyzed for the scope of this research sustainability was never considered as the priority. None of the project budgets was ever modified for a sustainability-related problem and this had severe consequences on the final level of sustainability of the project. However, the researcher noticed a substantial difference between the way the LEED procedure was developed in the two projects. For the office building project sustainability was an integrated aspect of the design that was constantly upgraded, modified and adapted to the new schedule and budget needs. For the nursing home project however, sustainability was developed more as an outsider activity which had to be considered just once-in-a-while during comprehensive meetings with all technicians involved. This detachment of green-building activities from the design-development phase caused a growing gap between what should have been done and what could be done leading to a withdraw of many green-building features and tasks.

6. Conclusions.

Importance of process integration for the development of green-building projects.

The analysis of the results highlighted the positive relationship between process integration and development of green-building projects which has to be perceived from a broad perspective. Integration intended as physical integration, in which each component can physically interact with each other, and timely integration where technicians involved interact on a frequent basis with each other. Promoting this broad concept of integration in relationship with the development of green-building projects has a great potential impact on the business especially at an international scale where subjects involved have different backgrounds, benchmark and procedures.

This leads to the first contribution of the present study: the quality of the project sustainability features could be improved by enhancing the integration between subjects involved in the design process.

Positive relationship between green-building features and project management.

Researcher demonstrate the existence of a relationship between the level of project integration and sustainability for the development of green-building projects. The cross-case analysis showed that both fields are mutually linked and that the efficacy of one can impact the success of the other. Following the literature review researchers focused also on the strong relationship between project management and process integration (Jainendrakumar, 2015). The relationship between project management and green-building development can also be seen as the relationship between two subjects which goal is to optimize the use of available resources. Let these resources be mainly time and costs for project management and water, energy and others for sustainability. Finally, all resources can be spent and both project management and sustainability focus on spending them the best possible way.

This leads to the second contribution of the present study: the relationship between project management and green-building projects which also supports the relationship between sustainability and affordability.

Green-building activities as critical tasks for the scheduling process.

The analysis of different case studies led researchers to identify a parallelism between design activities, (including architectural, mechanical, structural design) and sustainability-related activities. As cited above, for the nursing home project such activities were not integrated in the design process on a frequent basis but were considered only sporadically for global meetings. This didn't happened for the second case study where results were sensibly different. Researchers saw that the schedule developed for design-related tasks did not always coincide with the sustainability-related one and, being the LEED certification a long process with no specific deadlines, these activities were never considered in the global planning procedure and therefore, even if behind schedule, were never considered critical. This was the cause of several problems, such as, the misunderstanding of the CxA role or the lack of use given to the energy model. Considering sustainability-related tasks as critical activities within the global design planning and goal may prevent future issues for both sustainability features, budget and time spent. This is the third contribution of this study which follows the original idea of Horman related to the priority of sustainability-related tasks (Horman, 2006).

7. Limitations.

Time analysis:

Estimating the delay of single activities resulted sometimes difficult because depended from tasks which dependency could not be calculated. Therefore, for the purpose of this research activities with undefined scheduling features were considered not individually but as part of groups of activities (milestones) whose start and ending point could be determined univocally.

Cost Analysis:

Indirect costs estimate was often ambiguous because could not be linked to written documents nor to any specific project activity. Information related to indirect costs were collected through interviews to subjects who sometimes could not identify project management wastes.
Researchers only analyzed the cost of the problems they had related information of, there might have been other extra costs that couldn't be estimate because nobody appointed them as problems and so researchers didn't even know the existence of.

Sustainability Analysis

For the purpose of the present work researchers took into consideration only a single green-building protocol, LEED. This protocol represents only a fraction of the green-building construction market and therefore results of the present research have to be considered partially valid.

Finally, as a general limitation for the work, researchers specify that avoiding the causes that determined the problems mentioned above is a necessary condition but maybe not sufficient to avoid the waste. The problems listed above have been calculated with reference to an optimum and ideal situation characterized by zero waste in terms of time, costs and sustainability. Researchers do not have evidence that such waste can be fully avoided. In order to validate this thesis, researchers would need to analyze other projects where appropriate means and resources are implemented in order to prevent wastes listed above. This, along with other ideas listed below, represents one possible field for the development of future research works.

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